# Managing Lake Basins

## Practical Approaches for Sustainable Use

(Final Report for GEF-Medium Sized Project: Towards a Lake Basin Management Initiative)

Front and back covers to be a single, continuous stylized map of the world with lakes indicated in their native languages. Logos on bottom.

Additional Front Matter will include:

Publication Data
List of Tables
List of Figures
List of Boxes
List of Acronyms and Abbreviations
Dedication?

Executive Summary (also to be published separately)

Back Matter will include several Appendices, a Glossary and a CD-ROM of Volume 2 (Experience and Lessons Learned Briefs) and Volume 3 (Thematic Papers). An electronic copy of Volume 1 (this main report) will also be included on the CD. The CD will have a search mechanism.

# Table of Contents

# Foreword

Lakes and reservoirs are vital to the economic development process. They contain about 90 percent of the earth's surface storage of liquid freshwater; are critical elements of the earth's hydrological system; form vital ecosystems for aquatic biodiversity; and provide livelihood and social, economic and aesthetic benefits that are essential for improving the quality of life of the basin communities. Yet they have not received sufficient attention in the global water policy discourse. Increasingly, human activities are profoundly impacting their ecological integrity. Lakes are closed systems with relatively long retention times, which can trap pollutants for extended periods. They have complex dynamics and characteristics, and are particularly vulnerable to a range of anthropogenic stresses. The science of limnology has improved considerably in the past few decades, but our knowledge of how to effectively use science to inform public policy and the management of lakes remains limited. To address the knowledge gap, the World Bank partnered with the GEF, UNDP, UNEP, Ramsar Bureau, USAID, BNWPP, Shiga Prefecture, ILEC, LakeNet, and lake stakeholders to implement a cooperative project to review lessons from the experience of lake basin management at 28 lake basins around the world. Appendix B summarizes the project's objectives, methodology, and implementation arrangements. This report is a key output of the project.

This report builds on the World Lake Vision presented at the Third World Water Forum, which highlighted key principles of lake basin management, and the recommendation of the World Bank to develop a Lake Basin Management Initiative (see Ayres et al 1996). It also supports the implementation of the World Bank's Environment Strategy and Water Resources Sector Strategy. It is also an important contribution to practical approaches to sustainable lake basin management, supporting the Millennium Development Goals (MDG) on sustainable water resources management.

The project has produced four major benefits. First, it has ***focused on practical lessons learned*** from lake basin management efforts around the world. Although much work has been done to share scientific and technical experiences on lakes—as evidenced by the number of international, government, and academic conferences and publications—less attention has been devoted to analyzing the effectiveness of alternative management approaches, including the policy, institutional, economic, and social dimensions of lake management. A strong scientific knowledge base is critical to sustainable management, but little has been done to draw practical lessons from the implementation of water and environmental policies and institutional reforms, or from involving people in lake basin management programs around the world. This report directly addresses this gap and should help strengthen the human capacity for improved lake and reservoir basin management at the local, basin, national, and global levels.

Second, the project has ***created new knowledge***. It supported the preparation of lake briefs focusing on experiences and lessons learned for 28 lakes from East, Central, and South Asia; Eastern and Western Europe; Eastern, Central, and Southern Africa; and North, Central, and South America. In addition, the project produced 17 thematic papers on specific lake management issues. Additionally, knowledge was generated and shared by more than 200 lake stakeholders and participants at the three regional workshops held in Burlington, Vermont, USA in June 2003; in Manila, Philippines in September 2003; and in Nairobi, Kenya in November 2003. Knowledge creation and sharing was also supported by a project-implemented electronic forum that linked global stakeholders in the review of the lake briefs, thematic papers, and this final report.

Third, the project fills an important gap in lake management experiences on ***tropical lakes, saline lakes, and lakes in developing countries***. A temperate zone bias was avoided by the inclusion of many lakes from tropical, arid, and semi-arid regions. Further, the project included a particular focus on lakes from developing countries where lessons have not yet been adequately synthesized or disseminated. Saline lakes are also included in the project.

Finally, the report ***derives lake management lessons from internationally funded projects***, principally Global Environment Facility (GEF)-financed lake basin projects, as well as lake projects financed by the World Bank and other agencies and governments. Over the last decade, the GEF has provided the most significant financial support for lake basin management projects through its three implementing agencies (World Bank, UNDP, UNEP). The experience gained from the national and international lake projects reviewed in this report has provided a wealth of new information from lake environments that have not been studied well. The GEF has recognized that analysis and dissemination of past lake basin management experiences will guide ongoing and future programs on these lakes, as well as in other lakes and reservoirs.

At the broadest level, the report's intended audience includes communities, technical staff and policymakers working on lake basin management, particularly the staff from government and nongovernmental agencies, research and policy institutions, and funding agencies. The report will be most useful to decision makers. This report also provides guidance for the GEF, the World Bank, and other GEF implementing agencies such as UNDP and UNEP for current and future lake basin management programs.

# Acknowledgements

This Main Report is a key output of the GEF Medium Size Project—Towards a Lake Basin Management Initiative: Sharing Experiences and Lessons from GEF and Non GEF Lake Basin Management Projects. The project was implemented by the World Bank and executed by the International Lake Environment Committee (ILEC), with support from LakeNet, between March 2003 and December 2004. The project was implemented as a cooperative program supported by a partnership of multilateral and bilateral agencies, local governments, non-governmental organizations, academic and research institutions, individuals, and # resource persons and # stakeholders from 28 lake basins from Africa, Asia, Europe, and Americas. Project implementation was supported by funds from the GEF, USAID, and the government of Shiga Prefecture in Japan, the Bank Netherlands Water Partnership Program, ILEC and the World Bank.

Project Implementation was led by Rafik Hirji of the World Bank and managed by Masahisa Nakamura of ILEC. An international project Steering Committee consisting of representatives from various organizations including Stephen Lintner, Chair (The World Bank), Barbara Best (USAID), Peter Bridgewater (Ramsar Convention), Alfred Duda (GEF), Sean Khan (UNEP) and Dann Sklarew (UNDP) provided overall guidance to project implementation, and the preparation of the main report.

The ILEC and Lakenet Project Management Team and Secretariat also included Hiroya Kotani, Genjiro Furukawa, Thomas Ballatore, Victor Muhandiki, Chiharu Uyama, and TBD from ILEC, and David Barker, Lisa Borre and TBD from LakeNet. Richard Davis, Kisa Mfalila, Sharon Esumei, Diane Flex, Robin Broadfield, Siree Malaise and Samson Kaber from the World Bank supported data collection and project administration.

The 28 lake basin management briefs and 17 thematic papers on specialized topics related to lake basin management formed other substantive outputs of the project. The papers and the authors are listed in Appendix C and provided on the attached CD-ROM. Additionally, Appendix D lists over 200 key stakeholders who reviewed the draft lake briefs and thematic papers at three regional workshops for 12 lakes from Americas, Europe and Central Asia held in Vermont, USA (June 2003), 8 lakes from East and South Asia held in Manila, Philippines (September 2003) and 8 lakes from Eastern, Southern and Central Africa held in Nairobi, Kenya (November 2003). These workshops were organized with support from St. Michaels College in Burlington, Vermont, Laguna de Bay Lake Development Authority in Manila, Philippines, and Pan-African START Secretariat in Nairobi, Kenya. Regional co-ordination of the Lake Briefs was provided by Thomas Ballatore of ILEC (Asian Lake Briefs), David Barker of LakeNet (North American, South American and European Lake Briefs) and Victor Muhandiki of ILEC (African Lake Briefs). Draft and final lake briefs and thematic papers and the main report were posted on the project supported electronic forum for public comment. The final draft briefs for the 14 GEF supported lake basin management programs were also reviewed by the respective implementing agency task managers.

The Main Report was prepared by a team, led by Masahisa Nakamura who served as Senior Editor/Report Editor, and was composed of Thomas Ballatore, David Barker, Lisa Borre, John Dixon, Walter Garvey, Victor Muhandiki, Masahisa Nakamura, James Nickum, and Walter Rast. While working together as a team, each chapter had one or more lead authors as follows: Chapter 1 (Biophysical Characteristics) Ballatore and Muhandiki; Chapter 2 (Human Use of Lakes) Nakamura and Davis; Chapter 3 (Institutions) Nickum and Nakamura; Chapter 4 (Policy) Dixon; Chapter 5 (People) LakeNet; Chapter 6 (Infrastructure) Ballatore, Chapter 7 (Role of Information) Rast and Ballatore; Chapter 8 (Financing) Dixon; Chapter 9 (Planning) Nakamura, Davis and Garvey; and Chapter 10 (Towards the Future) Garvey and Nakamura. Appendix A on Economics was prepared by Dixon. Walter Rast and Richard Davis were the technical co-editors of the Report.

Many others also contributed: TBD for preparation of maps; TBD for editing of the Lake Briefs; TBD for Desk Top Publishing; TBD for production of the CD containing the Lake Briefs and Thematic Papers. Add other acknowledgments as appropriate.

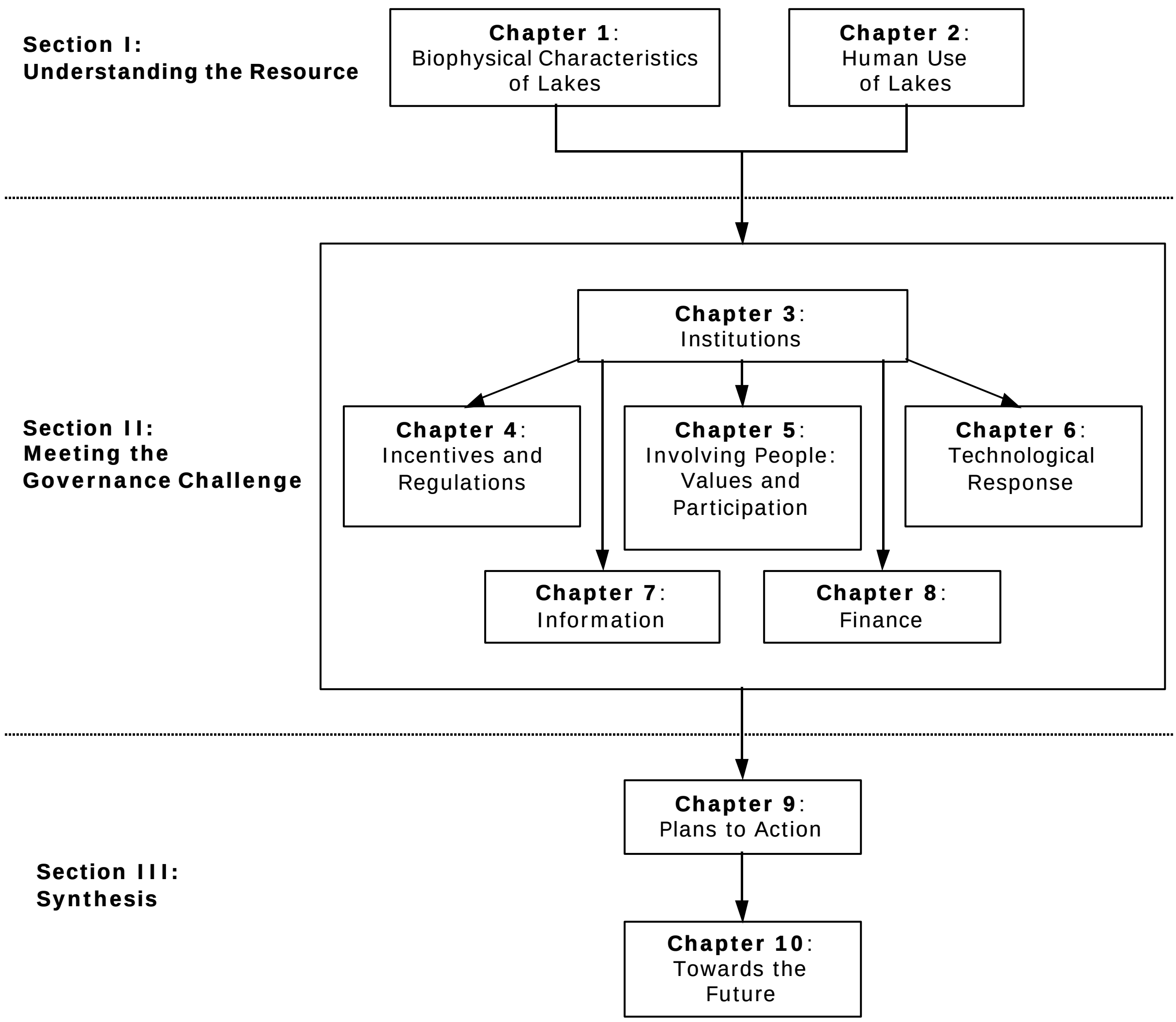
Preparation of the Main Report was supported by a series of Working Group Meetings of the core team members and other lake basin stakeholders including Oyugi Aseto, Adelina Santos-Borja, Eric Odada, Sonia Davila-Poblete and Sven Erik Jorgensen.

Michael Glantz from the National Center for Atmospheric Research and Nick Davidson from the Ramsar Bureau peer reviewed the final report.

The Project Managers are very grateful to the funding agencies, steering committee members, and all contributors including consultants, authors, reviewers, workshop organizers and participants, and other supporters of the project and its outputs.

## Structure of the Report

The report is organized in ten chapters under three sections. Section I includes two chapters that provide the background for understanding the challenges facing lakes, and their potential values and uses as a key resource for sustainable livelihoods and development around the world, as well as for maintaining important life-supporting ecosystems. Section II, with six chapters, forms the core of the report. It presents the key lessons learned on the main themes of lake management from the 28 case studies and 17 thematic papers: institutions, incentives and regulations, involving people, technology, information, and financing. Section III, with the final two chapters, is a synthesis of the report. The chapter on planning brings all the themes of Section II together and discusses how lake basin management is carried out in practice. The final chapter presents guidelines for taking action to improve the conditions of a lake and the people and nature that both depend on it.



## Section I. Understanding the Resource

This section is comprised of two parallel chapters: the former (Chapter 1) discusses biophysical aspects of lakes and the latter (Chapter 2) looks at how lakes are used and how those uses have typically been developed and governed. Both chapters are written with a prototypical lake in mind and we hope that the story told will resonate with people everywhere. Taken together, these two chapters provide the background necessary to understand the challenges facing lakes, and their potential values and uses, as a key resource for promoting sustainable human livelihoods and development around the world, as well as for maintaining important life-supporting ecosystems.

# Chapter 1: Biophysical Characteristics of Lakes

## Extent and Global Distribution of Lakes

Lakes are widespread and plentiful: considered collectively they contain more than 90% of the available liquid freshwater on the earth's surface (Shiklomanov 1993). Although there is no definitive count, there are at least several million lakes on the planet. Most are small and often located in remote areas. Several hundred lakes are over 500 $km^3$ in surface area, however, making them major features of the global landscape.

Lakes are found on all continents of the world, even on Antarctica, which is home to many saline surface lakes, and even some lakes buried under kilometers of ice (e.g., Lake Vostok). The distribution of lakes is governed primarily by variations in geology and climate: geology in the sense that the land surface must contain a depression capable of storing water; climate in the sense that there must be a balance between the amount of inputs (precipitation) and outputs (evaporation, leakage to groundwater, outflowing rivers) for the water to accumulate to large volumes. Where these two factor come together most clearly, such as in the glacial deposit areas of North America and Europe, lakes are hyper-abundant. Humans also construct artificial lakes by damming flowing rivers. These reservoirs and impoundments are most often built in regions of the world that lack substantial numbers of natural lakes, and are used primarily to address recurring problems of water shortages (drought) or excesses (floods).

## Lakes and Their Basins

Because of their unique properties, lakes occupy a significant niche in the global hydrologic cycle, the means by which nature supplies water throughout our planet. A lake is first and foremost a natural ecosystem, containing a large volume of water, and a mixture of interacting living and non-living components. In fact, there is no way to separate the influences of either component on the other.

A complete lake system, however, consists both of the depression in the land surface that contains the water (the lake itself), as well as the land surface (drainage basin; see Box 1.1 on terminology) which surrounds the lake. Although water can also enter a lake from underground sources (groundwater flow), the major water inputs are usually from surface inflows (i.e. rivers, streams) and direct precipitation. The water entering a lake from its drainage basin picks up and carries materials from the land to the lake, making lakes good reflections of land-use and other human activities in their catchments.

The concept of the linkage between a lake and its surrounding drainage basin is of fundamental importance in lake management. Problems with lakes can originate within the lake itself (such as over-fishing), be transmitted to the lake from its upstream drainage basin (such as agri-chemicals from irrigation areas), or in a few cases come from outside the drainage basin (such as acid rain). Use of the lake's resources can also impact on downstream communities. Thus, recognition of this fundamental interrelation between the lake and its upstream and downstream drainage basin is an essential part of effective lake management efforts. In this document, we will discuss the management of the lake and its resources and so will focus on the lake and its upstream drainage basin, as articulated in Principle 2 of the World Lake Vision (World Lake Vision Committee, 2003):

> *"A lake drainage basin is the logical starting point for planning and management actions for sustainable lake use."*

A further discussion on drainage basins, as well as an illustration of common types, is illustrated in Boxes 1.1 and 1.2.

**Box 1.1. Watershed, Catchment, or Basin?**

Water somehow gets into a lake. In some cases, like Lake Victoria—a large, relatively shallow great lake—most of the water enters as direct precipitation. For most lakes, however, the large majority of water enters as precipitation runoff from surrounding land. For decision makers, what is happening on that surrounding land is tremendously important because it has profound effects on the lake itself. Therefore, it is widely recognized today that lake management cannot stop at the lakeshore but must extend to the surrounding land, and even beyond in cases where atmospheric transport is important.

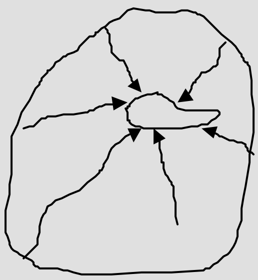
The problem is finding a common term for that surrounding land. Nowadays, several terms are used almost interchangeably. The first is “catchment”. The meaning is intuitive—the catchment is the area around a lake that “catches” precipitation, which then drains to the lake (noting of course evaporation, evapotranspiration, seepage to groundwater, etc. that occur along the way). A similar term is “drainage basin”, which maintains the intuitive flavor of “catchment”—namely, it is the area from which water “drains” to the lake. “Watershed” used to mean the boundary between two catchments (or drainage basins!) but has become synonymous with the catchment itself, not just the infinitely thin dividing line around the edge of the catchment. “Basin” literally is like a wash basin—the area covered only by water—in this case, the lake itself. However, this use of the term is not common among policy makers and “basin” too has come to be simple shorthand for “drainage basin”. Finally, “lake basin” is a drainage basin with a lake in it. Naturally there are catchments, drainage basins and watershed without lakes in them; lake basins must have a lake to live up to their name!

This may seem quite confusing, but is actually simple—all the terms really mean the same thing—the land surrounding a lake. In this report, we try to use “drainage basin” but all the terms are inevitably used at different places in this report and in the lake briefs and thematic papers.

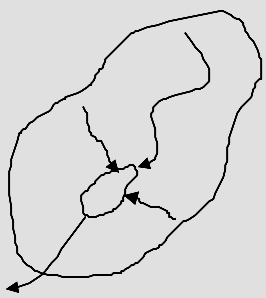
1

**Box 1.2. Common Types of Drainage Basins**

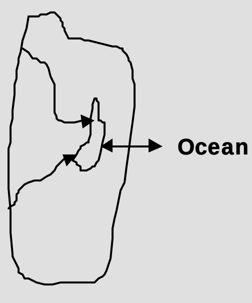
There are a wide variety of drainage basins types—each with profound effects for lake management and use. Some of the more common types are illustrated below.



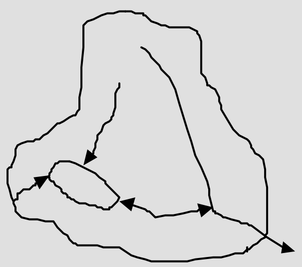
**Closed Drainage Basin** (endorheic basin)—A closed basin with no water outlet (river, stream). Water leaves the lake only through evaporation or seepage to groundwater. This high rate of evaporation generally leads to higher salinity (total ionic concentration) in a lake. Thus, most lakes in closed basins are either saline (total ionic concentration >3 g/L) or are becoming so. Examples of closed basin lakes include the Aral Sea, and Lakes Chad and Issyk-Kul.



**Open Drainage Basin** (exorheic basin)—An open basin with a water outlet(s). Water leaves the lake by one or more rivers, allowing ions (components of salinity) to be flushed. Thus, the water remains “fresh” (i.e., low salinity—drinkable). Most lakes in this report are in open drainage basins. Examples are Lakes Champlain, Constance and Dianchi.




**Coastal Drainage Basin**—A drainage basin with flows to and from the ocean. Fresh water typically enters the lake through rivers draining to it. The lake sometimes drains (via a river) to the ocean; sometimes the ocean drains to the lake. This can lead to complex salinity relationships. Examples include Lake Chilika and, to a lesser extent, Laguna de Bay.



**Mixed Flow Drainage Basin**—A drainage basin with flows that reverses depending on the season. In contrast to a coastal lake, the flows typically come from a freshwater river. This reversal of flow leads to large fluctuations in lake water level and area. Tonle Sap is an example of this type of lake. In this case, the size of the lake's drainage basin is seasonal, since the connecting river inflow is seasonal.

## Characteristics of Lakes

The fact that the word "lake" is applied to such diverse waterbodies as Lake Baikal (1,637 m deep, 31,500 $km^2$ of surface area, and 25 million years old) and Lake Baringo (2.5 m, 108 $km^2$ of surface area, and a few thousand years old) indicates that, in spite of the tremendous diversity of lakes around the world, they share some common characteristics. These characteristics are examined below with the implications for management noted.

*Long Retention Time*

Rivers flow—lakes don't. Specifically stated, rivers are lotic (flowing water) whereas lakes are lentic (standing water). Of course, that is an over-simplification—lakes have outlets and their water is flushed, but the period of flushing is quite long, reaching over hundreds of years for some lakes. This flushing period is called the retention time (or hydraulic residence time) and is equal to the volume divided by the outflow. For most lakes, the volume is so massive it dwarfs the flow, leading to long residence times. For example, Lake Malawi contains around 18,400 cubic *kilometers* ($km^3$) of water, but the flow out of the lake (through rivers and evaporation) is just 66 $km^3$ per year. With that much water, Lake Malawi, like most other lakes, is a permanent feature of the landscape on the human-time scale.

Long retention time has several important implications. One is that lakes are relatively stable. Even in severe droughts, lakes still have some water in them: their large volumes mask short-term variations. There are exceptions of course, usually of lakes in closed basins like the Aral Sea, which is known to have dried up 3 times in the last 2 millennia. Nevertheless, most lakes hold and can absorb large amounts of water, buffering both floods and droughts. Acting as a "pool" of water, they present a flat surface allowing for easy navigation. Additionally, long-retention time implies a slow rate of flow which allows for more time (than in a river for example) for suspended materials to settle to the bottom—this means that lakes act as sinks for many materials. Also, by simply being around for a long time, they foster civilizations and can become symbols of a culture (like rivers, of course).

Another implication is that long-term stability coupled with relative "isolation" provides sufficient conditions for complex ecosystems to evolve in lakes. Just as islands can be viewed as "islands of land in an ocean of water," lakes can be characterized as "islands of water in an ocean of land." Both situations represent isolated ecosystems within which area-unique biological communities can develop and evolve. Lake Malawi provides an example of what millions of years of relative isolation, coupled with natural selection, can accomplish—over 500 endemic (native) fish species exist in this lake. However, this biodiversity can be rapidly destroyed, as demonstrated by the major loss of fish community structure in Lake Victoria. This illustrates the important point that lake ecosystems are very resilient when faced with stresses that have existed over evolutionary-time scales but they are extremely vulnerable to "new" stresses (usually anthropogenic) that the ecosystem has never faced before.

Finally, and most importantly for management, once a lake is degraded, it takes a very long time—if ever—to put things right. The implication is that before a decision is taken that adversely affects a lake, one must be really sure that is a wise course to take because turning back the clock is very hard, very costly, and often, just plain impossible. The loss of fish species in Lake Victoria is a clear example; the long-term release of toxic chemicals from sediment is another. Thus, the long retention time of lakes leads to lags in response that makes them poorly matched to the human management timescale.

*Complex Dynamics*

In addition to long retention time, lakes are complex systems: what you put into a lake is not necessarily what you get out. And what you get out depends on how much was put in, when, and in what order. This complex response is termed "hysteresis" and is illustrated in Figure 1.1.

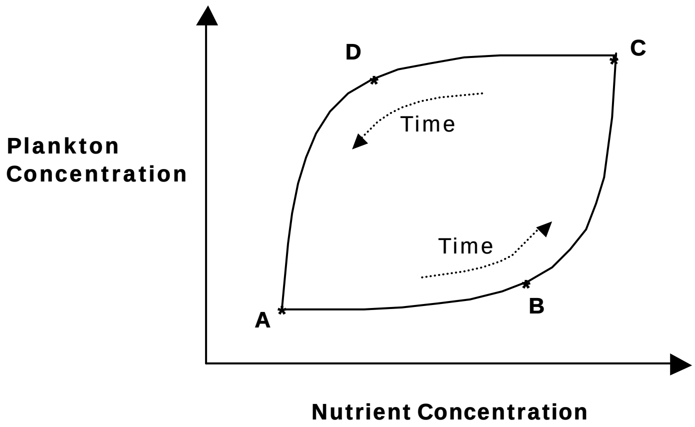



Figure 1.1. An example of complex dynamics of a lake.

Imagine a relatively pristine (oligotrophic) shallow lake lying at point A in Figure 1.1. Nutrient concentration is quite low, so the concentration of plankton living in the lake (an indicator of trophic state) is also low—there is not enough food to go around. As human population around the lake grows and as incomes increase, nutrient loading to the lake (and therefore concentration in the lake) inevitably increases, but the plankton concentration increases only slightly (to point B), reflecting the ecosystem's natural capacity to absorb external influences and neutralize them. Then, with only a slight additional increase in loading, the lake ecosystem changes dramatically, with a sudden increase in plankton density—often exhibited as an algal bloom (point C). The algal bloom is an easy-to-see sign that something is going wrong in the lake and that uses are being impaired; consequently, local people call on politicians to implement policies to decrease nutrient loading.

Reducing the nutrient load requires changes in human behavior—that requires political will—and like most things political, it only lasts until the next election. The difficulty for a decision maker is that the lake cannot simply go from C back to B. There are likely to have been irreversible changes to the ecosystem (in this case, phytoplankton have replaced macrophytes as the dominant species), so the path is usually from C to something like D. That means sacrifice over a long period without much to show for it, i.e. plankton concentrations are still high; blooms are still occurring. That is a tough road for a decision-maker to walk. Chapter 7 talks about the role of information and illustrates how science can be used to find where a lake lies on the graph (between A and D). Science can also offer shorter paths from C back to A through things like biomanipulation and in-lake restoration methods.

The complex nature of lake ecosystems also gives rise to various indirect effects such as biomagnification. Biomagnification refers to the increase in concentration ("magnification") of certain compounds in organisms ("bio") as one goes up the food chain (i.e., as organisms at lower positions in the food chain are eaten by organisms at higher positions in the chain). Compounds such as PCBs and dioxins are extremely soluble in fat (lipophilic) and therefore remain in the bodies of organisms that consume them. Those organisms may get eaten, indirectly transferring the lipophilic compound to the predator. The Laurentian Great Lakes provide a good example of this phenomenon (See Table 1.1). As shown in the table, the concentration of PCBs increases up the food chain. This implies that organisms higher up the food chain (including humans) are exposed to higher concentrations and therefore are at higher risk.

Table 1.1. Biomagnification of PCBs in the Laurentian Great Lakes

| **Organism** | **PCB concentration (relative to conc. in phytoplankton)** |
|---|---|
| Humans | ? |
| Herring Gull Eggs | 4960 |
| Lake Trout (a large fish) | 193 |
| Smelt (a small fish) | 47 |
| Zooplankton | 5 |
| Phytoplankton | 1 |

(Adapted from USEPA and Government of Canada, 1995)

Note that for a decision maker and any one eating Lake Trout (or Herring Gull Eggs!), this is a real problem. It is ironic that while the lake's complex food chain makes existence of valuable fish like the Lake Trout possible, the same complexity leads to indirect effects like biomagnification that may make the fish dangerous to eat.

*Transmissivity*

Lakes integrate; they are the mixing pots of nature. They receive inputs from their catchments (and beyond), mix the inputs together, transform them and spread them out again. Additionally, fish, water and even pollution are able to move around more or less freely in all directions. This property—transmissivity—is the third key characteristic of lakes.

One important implication of transmissivity is that a problem at a lake is shared by most users. Rivers provide a simple counter-example: pollution at one point in a river immediately flows downstream, often leading to a disconnection between those causing the pollution and those affected by it. This can result in upstream-downstream conflict. The transmissive nature of lakes means that one user's effect on another is spatially spread out and shared, including by the original user. This is very similar to global warming: the effects of one person's emission of greenhouse gases are felt by all, including the emitter.

Another implication of transmissivity is that most uses of lakes (see Chapter 2 for a full description) are non-excludable; that is, it is costly to exclude users from accessing a given lake resource. As Box 1.3 describes, when access to resources is costly to control, open access is the default regime. This is not desirable because open access, combined with human nature, invariably leads to overuse and destruction of the resource base. It is important to note that this physical property of lakes—transmissivity—profoundly affects a social issue—how the use of lake resources is managed.

Overall, these three defining characteristics—long retention time, complex dynamics, and transmissivity—when taken together, make lakes what they are: beautiful, valuable, complex, but also vulnerable and difficult to manage. Lessons learned on how societies govern resource use—how they control access to various lake resources—is the remainder of this report.

**Box 1.3. Some "common" terms and their meaning: common-pool resources, common property and the commons.**

Most readers have likely heard of the "tragedy of the commons", an idea made popular by a 1968 article in *Science* by Garrett Hardin. This article captured the spirit of the times and has gone on to trigger a massive research effort on environmental management. The problem is that the term "commons" used by Hardin was misleading because it is often assumed to refer to common property; however, Hardin's main point was that **open access** to resources usually leads to overexploitation, something shown clearly in the lake briefs. To avoid confusion, we define below some terms used in this report.

**Common-pool resources** are resources for which one person's use takes away from another's use and for which it is hard to exclude other users. The table below compares common-pool resources against other types of resource by examining two characteristics: rivalry and excludability. Rivalry (also sometimes called subtractability) means that one person's use of a resource subtracts from the amount available to other users (e.g. someone catching fish reduces the amount someone else can catch—at least over the short-term). For non-rival goods, one person's use does *not* affect another's (e.g. everyone can enjoy the climate-moderating or aesthetic benefits derived from a lake). Excludability refers to the cost of controlling someone's access to a resource. Non-excludable goods have a positive cost for restricting access.

| | Excludable | Non-excludable |
|---|---|---|
| Rival | Private good | Common pool resource |
| Non-rival | Club good | Public good |

Many of the resources provided by lakes are common-pool; good examples are fishing, water extraction, and the use of the lake as a sink for pollutants. Some uses like flood control are public goods. For almost all uses, it is costly (but socially desirable) to exclude users.

Access to a given resource of a lake can either be open (open access) or closed (private, common, or government property). **Common property** is a type of institution that gives the rights of use of a resource to a defined group. That group usually has rules specifying how the group's members can use the resource. Lake Naivasha is an excellent case of a riparian group (Lake Naivasha Riparian Association) using the lake as common property. Private property and government (public) property are also widespread ways that societies have developed to control access to "open access" resources.

The stand-alone term **"commons"** is often used as short hand for either common-pool resources or for common property, often leading to confusion about what is being discussed (i.e. the nature of the resource or the type of property regime governing its use?). Some may think of the "commons" as a shared, public resource often with no control over access.

Overall, it is important to clearly distinguish between the characteristics of a resource and the characteristics of the management regime governing use of the resource. Also, one must note that a lake may provide various resources, each with different characteristics, but many sharing a common-pool or public good nature. Therefore, it is misleading to speak of a lake, as a whole, as a common-pool resource: it is clearer to specify which use of the lake is being referred to.

# Chapter 2. Human Use of Lakes

## A Lake; its Development and Management

*The Story of a Lake*

*People settled around the lake shore many millennia ago. While the population was low, the resources that it offered were abundant and there was little conflict between different settlements over use of these resources. The fish caught by one community did not seriously impair the ability of another community to obtain fish; the water drawn for domestic use did not noticeably lower the lake level. But, as the lake's population increased, some of these resources came under pressure. This happened first with the fish. Following some years of low rainfall, fish catches began to decline and those fish that were caught were smaller than before. The more experienced fishermen realized that this was because the wetlands were not being flooded and the fish could not breed successfully. Conflicts started to break out between different communities about access to the best fishing grounds. Fortunately, the rains returned before these conflicts became unmanageable, the breeding grounds became available and the fish populations recovered.*

*Nevertheless, the incident caused the leaders of the fishing communities to agree on some rules of access to fishing grounds that would reduce tensions. Each community had the right to send only a specific number of boats to these areas. Also the wetlands were agreed to be off limit during the period when they were flooded and the fish were spawning. Any transgressors would be judged by an assembly of the leaders of the lakeshore communities with those found guilty being banned from fishing and even expelled from their community.*

*A more difficult problem arose many years later with the influx of a group of farming families into the catchment feeding into the lake. As they prospered and grew, these families cleared increasing areas of land. The land began to erode during the wet season and the wetlands at the entrance to the lake began to silt up. Again fish breeding was interrupted and fish numbers began to decline. However, the farmers did not accept the claims of the fishing communities that they were causing the siltation of the wetlands. They believed that the rivers were always silty during the wet season and that the decline in fish catch was nothing to do with them. Although this caused bad blood between the farmers and fisherfolk, it did not lead to violence because other fish breeding grounds were still operating and the fisherfolk were able to compensate by moving further offshore, and building fish traps and fish ponds. Nevertheless, a distance developed between the two groups that was never bridged and to a large extent they led separate lives.*

*Over time, the lakeshore communities expanded into towns. The town people, while not relying directly on fishing for their incomes, continued to identify with the lake. They were proud of its scenery, enjoyed its waters for recreation and used it for easy transport of their goods to other destinations. They also used it to dispose of their wastes. Rubbish was dumped in creeks to be eventually flushed into the lake. To keep up with the amenity offered by other towns throughout the country, the local council installed sewage removal and primary treatment of the effluent to remove the worst of the organic matter. The resulting effluent was then disposed of in the lake at a convenient distance from the town.*

*A major expansion of the region occurred many years later when the national government decided to develop a large irrigated cotton growing area upstream of the lake to take advantage of increasing European demand for cotton. The development was widely welcomed by the region's business interests (they had lobbied strongly for it), and the town councils were briefed on the plan and endorsed it. Of course, the land had to be* *expropriated from the farmers who had settled there many generations earlier but, in compliance with national laws, the government intended to provide them with alternative agricultural land some days travel away. Many of the town people and the fisherfolk were uneasy about this development but had no means of finding out much about it, let alone influencing it. They felt little solidarity with the farming communities and actually felt quite relieved when the irrigation area went ahead. New, wealthier farmers appeared and the old groups were moved away.*

*At first the new irrigation area appeared to cause no problem. The region prospered with the additional income and the towns grew rapidly to provide necessary services. A government agriculture office was opened in the major town and many new people arrived to take advantage of the employment opportunities in the irrigation area.*

*However, after some decades problems started to appear in the lake. Dense mats of weeds began to grow around the mouths of the town creeks and spread into the boat harbours. Waterweeds even began to appear near the fish pens. Since the region had long ceased to be dependent on the fishing industry, this was seen more as a nuisance than a major problem by many people. In fact, some entrepreneurial women harvested the weeds to use for weaving. More alarmingly to most people, the water near the towns quite quickly and unexpectedly turned dirty and had a musty smell. Many of the townspeople, particularly the older residents who remembered the beauty of the lake when they were younger, were seriously upset and complained to the town council. The fishermen were also worried, but for a different reason. They had trouble launching their boats through the weeds and they had trouble selling their fish because of the widespread perception that the fish were dirty and tasted bad.*

*There was a strong local opinion that the problem was caused by the upstream irrigators although the government officials in the Agricultural office claimed that it was nothing to do with their industry and that the problem resulted from the expansion of the towns. Under pressure, the government promised to upgrade the sewage treatment plant for the town to remove nutrients from the sewage since this could be completed within three years. They also promised to launch a scientific investigation into the causes of the problem.*

*Commentary*

This story, while only a microcosm of all that can occur in lakes, illustrates many important features of lakes and their management. It shows that:

- At the broadest level, lakes provide a variety of uses or values to people and these values change over time, from initial subsistence values through to later aesthetic and cultural values;
- There are potential limitations on the use of these resources as the demand for them increases—this can appear as simple over-exploitation of fish, or as a more subtle overuse of the lake's capacity to absorb wastes;
- Competition for these resources intensifies and authorities—sometimes local leadership groups, sometimes more distant governments—intervene to resolve conflicts;
- Rules of behavior are discussed and agreed, and structures (councils, government departments) are established to administer and apply these rules;
- Uncertainty is central to management; unpredictable natural variations in rainfall can cause problems; some conflicts are not neatly resolved; there are different views about the causes of eutrophication; etc;
- Knowledge, both local experience (e.g. the importance of fish breeding areas) and scientific knowledge can play a central role in making management more effective;

- Lakes are not worlds unto themselves. The difficulty of managing lakes without involving groups from the upstream catchments, for some problems, is illustrated by the siltation problem;
- Also the importance of influences from outside the region is illustrated by the effect that international markets had on development of the irrigation area;
- The choices that a decision maker faces are heavily constrained by other developments—the town's sewage treatment system was originally introduced for aesthetic and sanitary reasons, and subsequent actions to reduce nutrient loading to the lake had to take account of the existence of this point nutrient source; and,
- Finally, the need for a coordinated, planned approach to take account of these linked influences so that the overall benefits are maximized is hinted at.

This story is also shown in diagram form in Figure 2.1. The upper part of the figure shows the change in values supplied by the lake and its catchment over time. During the expansion phase there is a steady increase in values as an increasing number of resources are used—fish, water supply, transport, aesthetic enjoyment, recreation, etc.

Two development interventions, the introduction of improved fishing techniques (D1) and the introduction of irrigated agriculture (D2), lead to significant increases in the values extracted from the lake basin. At the same time (lower part of the figure) there is a gradual deterioration in the state of the lake from the side effects of these and other developments. At some point (V1) this deterioration in the lake's environment—increasing nutrient levels, spread of weeds and algae, unsightly and smelly water—begins to affect the value of the resources that can be extracted from the lake and overall production plateaus and then begins to decline (V2). Remedial actions (C1) such as upgrading of sewage treatment plant and the ban on use of phosphate-based detergents lead to improvements in water quality and the values extracted from the lake increase again. While there are cases in which the degradation of lake environment is small and the response to the restoration efforts is rapid, most often, the degradation may turn out to be more extensive than expected and the restoration efforts may prove to be extremely costly and time-consuming (R1), if not impossible (R2). The management authorities and the communities often do not have the resources to invest in conservation/remediation interventions (either structural or non-structural) to the point where the lake returns to pristine conditions. Nevertheless, at the end of the story, the communities may be better off than they were at the beginning.

While the above story illustrates many important features of lakes and their management, each lake possesses unique features, as is shown in the 28 lakes briefs. Each lake has its own set of resources values, its own set of problems and its own set of potential management actions. In the above story, the government accepted that the town sewage was the most likely cause of the algae and aquatic weeds and agreed to invest in remedial upgrade works because of the high value the townspeople placed on a clean and enjoyable lake. In other towns, it is possible that the townspeople would not have the same pride in their lake and would rather see the funds spent on further development investments. Such judgments depend on the values that people place on the resources of each lake, the physical characteristics of each lake that lead to biophysical manifestations of problems, and the socio-political characteristics of the decision processes for each lake.

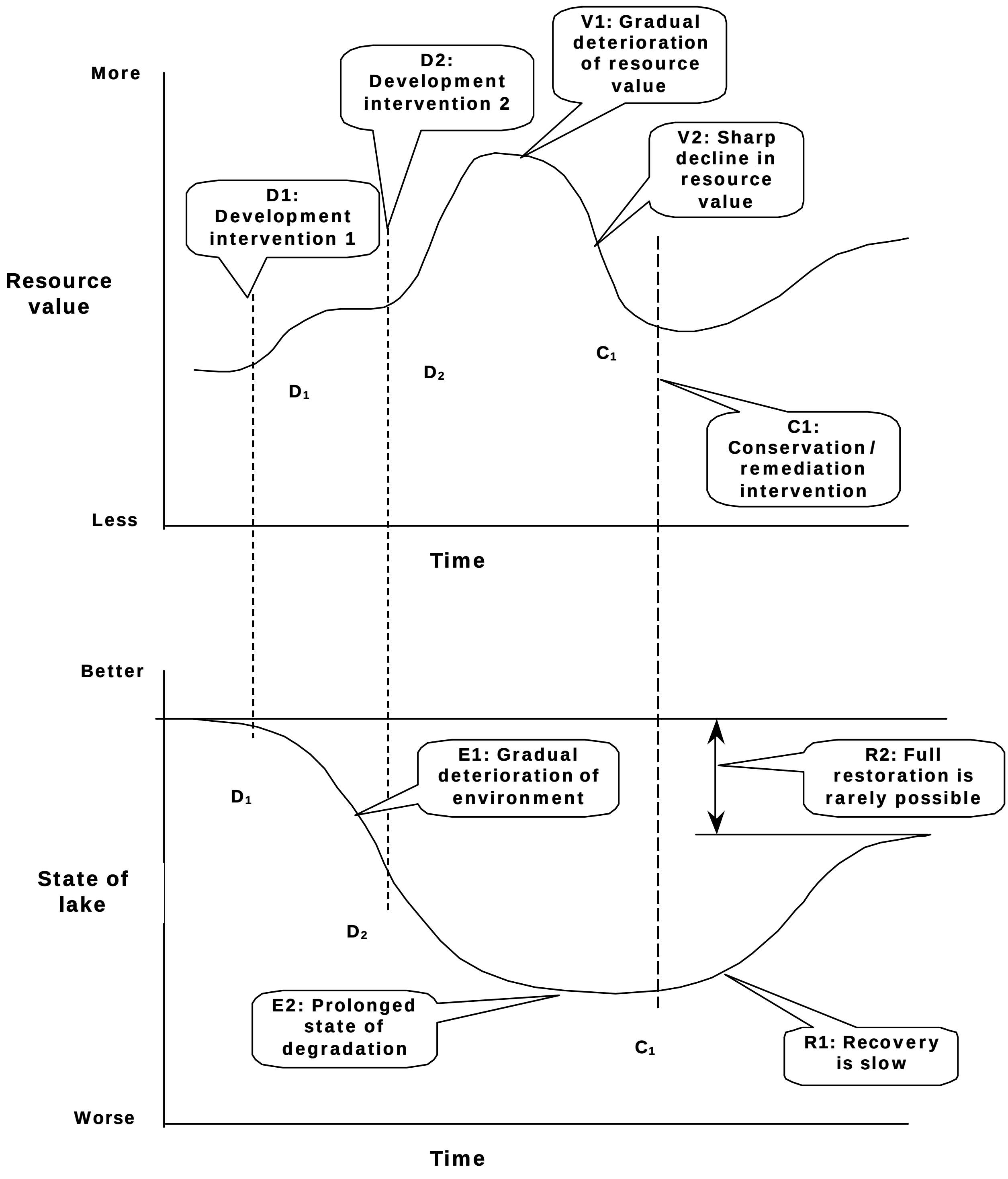



Figure 2.1. Changing resource value through development and conservation/remediation interventions.

**Resource Value of Lakes and Lake Basins**

The wide range of uses of lakes and their catchments are amply shown in the 28 lakes briefs. These various uses all contribute to the total value of the lake. Among the uses cited are the following:

- "…direct use of the lake for fisheries in net present value terms … is then some PhP30.5 million" (Laguna de Bay).
- "…a potential source of water supply for Northeastern Estonia and the Estonian capital Tallinn" (Lake Peipsi).
- "…provides water supply for domestic (in the dry years), and industrial and agricultural uses" (Lake Dianchi).
- "…biodiversity offers a resource base for tourism attraction" (Lake Baringo).

Many lakes also provide valuable services to nature, such as serving as habitats for aquatic fauna and flora. These services are also part of the total value of lakes and their basins. One such service is the provision of genetic materials, e.g., for improving fish strains used in aquaculture. Another such service is as regulator of extreme hydrologic events such as floods and droughts.

The value of lake water and the resources in the lake-basin ecosystem can be divided into "use" and "non-use" values, the terms that are typically used by economists to divide the totality of the goods and services from any resource.

Use values are divided into direct use and indirect use values. Direct use values are those that come directly from using various parts of the lake ecosystem. These include both "consumptive" uses and "non-consumptive" uses. Consumptive uses are those that occur when the user actually consumes the resource (e.g. catching fish or waterfowl, harvesting of reeds and other plants, diversion of water for human use or irrigation). This categorization of types of values from lakes is shown in Figure 2.2.

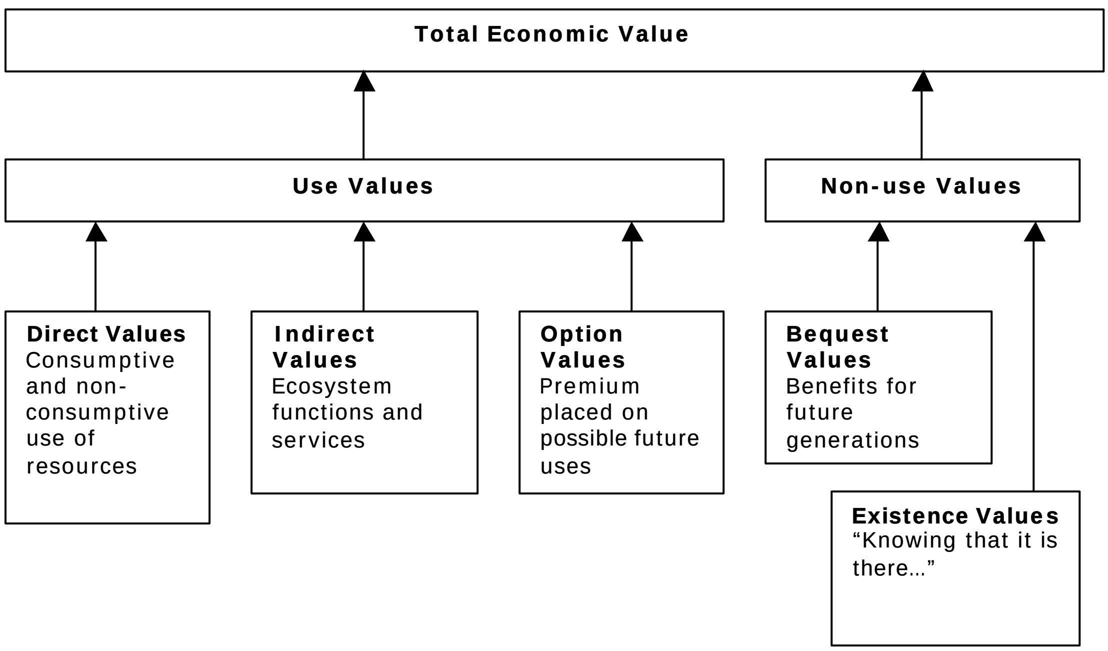



Figure 2.2. Categories of Uses of Lake Resources

Lake fishermen in the story were engaging in a consumptive, direct-use of the lake's resources. A key point about consumptive uses is that use by one person reduces the amount available for others to use, called 'rivalry' by economists (see Box 1.3 for further discussion). In contrast, non-consumptive direct uses do not reduce the amount of the resource available to others. Non-consumptive uses include certain types of recreation, aesthetic and amenity values, or general ecosystem services. The later residents of the town who enjoyed the aesthetics of the lake were engaged in non-consumptive, direct use of the lake resource. Boating and sailing are also non-consumptive, direct uses. In these cases the “users” does not actually consume the resource, or reduce the availability of the resource for other users.

Of course, in the extreme, you can have so many people using the lake in a non-consumptive, direct use manner that congestion sets in and crowding can reduce the “benefit” that each user receives. Congestion can be observed within a particular use sector or among sectors. An example of the former would be when lake-based recreation became so crowded that all the recreators experienced decreased enjoyment. An example of the latter would be when expansion of the water intake structures to service the town’s water supply started to interfere with the fish cages. In general direct uses of the resources in the lakes and their basin are both easier to identify and easier to measure, both qualitatively and quantitatively, than other parts of lake values.

Indirect use values are also often important and include most services provided by healthy ecosystems (e.g. maintaining water quantity or quality; moderating flooding; providing a sink for effluents). Indirect use merely means that the beneficiary is located somewhere else (usually downstream) and receives a benefit from the lake ecosystem. For example, downstream populations will benefit from these ecosystem services provided by the lake, and will enjoy them as direct use values (again, they may be either consumptive or non-consumptive). In Japan, for example, one important benefit from Lake Biwa being maintained as a sound ecosystem with good water quality is the indirect use value accruing to the people living downstream of the lake in Osaka and Kyoto. Similarly, in Lake Toba, an indirect beneficiary of the lake water includes various industrial facilities including an aluminum smelting plant that are dependent on cheap hydropower produced by the Asahan River hydroelectric plant. Indirect use values are often harder to measure and value than the more easily observed direct use values.

Obviously the line between direct and indirect use values gets blurred in many cases—lakeshore communities that extract lake water as a source of drinking or municipal water should probably be labeled as “direct” users of the lake and its resources, even if the consumers receive their water in a pipe and do not know where it comes from!

There are also important non-use values associated with lake ecosystems. Non-use values are as the label suggests—values that people receive but without any use—direct or indirect—of the lake or its resources. These non-use values include the benefit people receive from knowing that the lakes are there and are healthy (e.g. the benefits that Armenians derive from knowing that Lake Sevan in Armenia continues to exist), and the value associated with leaving an intact and healthy resource for future generations. These two types of non-use value are referred to as “existence values” and “bequest values”.

An additional category of value is referred to as Option Value—the benefit that people receive from knowing that the resource will be there in case they want to use it in the future. This is a hybrid between Use and Non-use Values and is usually listed under Use Values as a form of "deferred use". Use values are often reflected to a greater or lesser extent in prices—payment for water supply, in fish prices, etc. However, the two types of non-use values (bequest values and existence values) as well as option value are rarely reflected in market prices simply because, by their very natures, they are not traded in markets. The consequence is that they are commonly overlooked by decision makers. However, they may be very important to the people concerned and are therefore valid components of the total value of the lake (see Appendix A for more details on the formal economic analysis of lake resources and the concept of Total Economic Value).

It is also important to note that, in general, lake values are often over-looked by decision makers for two major reasons: lack of information and institutional weaknesses. Because of the pervasive nature of externalities (see Box 2.1 for definition), many benefits from improved lake management affect someone else, often at some distance. Actions in the upper basin affect both the quantity and quality of water that drains into the lake, and actions along the lakeshore and in the lake affect the water that leaves the lake, and the ecology of the lake. For smaller lakes it may be easier to actually see the links (as in Lake Dianchi or Toba for example) while for very large or international lakes it is harder to understand all of the actions that affect the lake resource (and are in turn affected by the lake's water quality).

The second constraint to recognizing lake benefits is an institutional one—government ministries and agencies are held responsible for and are rewarded for the actions that they take that affect their differing resources. The Fisheries Department is accountable to the fishermen and fish catch, even if fishing activities ultimately affect the welfare of downstream water consumers and agriculture users also. Since these groups fall "outside" the area of responsibility of the Fisheries Department, benefits and costs that occur elsewhere are largely ignored. A similar case exists with agricultural authorities in the upper watershed. Lake basin management authorities are designed to overcome these two problems but, even if they have a broader knowledge of the resource, they usually lack any effective management authority at the sectoral level. Therefore the institutional management challenges remain (and are discussed in Chapter 3).

**Typical Problems Facing the World's Lakes**

Problems can be defined as the impediments to obtaining desired values from lake resources. Ironically, problems often arise from the side effects of the use of lake resources. The proximate causes of these problems can arise from both the direct exploitation of lake resources as well as from human activities taking place within and outside of the lake basins that have little to do with the direct use of the lake resources. Thus, the farmers who settled in the catchment above the lake caused problems for the fishermen, even though they (the farmers) were not using lake resources directly. This type of problem would be classified as an externality since the farmers received the benefits from soil cultivation and the downstream fishermen bore the costs. Externalities are particularly important for lakes and rare expanded on later in this chapter and in Appendix A. Downstream users too can cause problems for users of lake resources. For example, downstream irrigation schemes can place demands on water from the lake that restrict developments around the lake.

The root causes, as discussed in the World Lake Vision, generally include:

- Increased demands for developing and using lake resource due in part to population growth and economic development
- Limited public awareness and understanding of human impacts on lakes
- Insufficient governance and accountability systems
- Inadequate mechanisms for managing international lake systems.

The lake briefs show that lakes around the world experience diverse problems. From a biophysical perspective, these can be categorized as water quantity, water quality and ecological problems. Water quantity problems arise when there is either too much or not enough water to meet human uses. Flooding because of increased runoff of cleared catchments and lake drawdown because of excessive water withdrawals are clear examples. There are numerous water quality problems ranging from sedimentation, to the presence of toxic substances, to excess quantities of nutrients. Ecological problems arise because lakes, amongst their other functions, provide habitats that support various biological organisms and communities which are the basis of many of the ecological services that people require from lakes. Note that under the above definition a change in water quantity, quality or ecology is, by itself, not a problem unless it represents a loss of value to someone.

Problems with lakes have been documented in a number of earlier reports including the "Survey of the State of the World's Lakes," compiled in the late 1980s and early 1990s by ILEC and UNEP. Based on this work, Kira (1997) concluded that lakes face a number of widespread and continuing problems including eutrophication, acidification, toxic contamination, water level changes, salinization, siltation, and the introduction of exotic species. These and other problems continue to be identified in the lake briefs commissioned for this report (Table 2.1). The table identifies the primary causes and their effects on lake uses and values, and identifies lakes in this project exhibiting these problems. More detailed information can be found in the National Research Council (1992), UNEP (1994), Dinar et al. (1995), Ayres et al. (1996), Nakamura (1997), Duker (2001), Jorgensen et al. (2003) and the Experience and Lessons Learned Briefs in the attached CD-ROM.

Table 2.1. Some typical problems facing the world's lakes

| **Problem** | **Cause** | **Impacts on Lake Values** | **Example from this Study** |
|---|---|---|---|
| *Biodiversity loss* | Many kinds of human impacts, including most on this list | Loss of ecosystem function; loss of option value for future use | Lake Victoria |
| *Climate variability* | Natural and anthropogenic causes | Changes in hydrological balances of lakes | Lake Chad |
| *Eutrophication* | Excessive nutrient input | Algal blooms, excessive macrophyte growths, loss of water transparency, taste and odor compounds, algal toxins | Lake Dianchi |
| *Exotic species* | Natural, intentional, or unintentional introduction | Food web changes, loss of biodiversity | Laurentian Great Lakes (zebra mussel) |
| *Overfishing* | Unsustainable exploitation of fish for sustenance and commercial purposes | Decreased fish catches, loss of biodiversity | Lake Malawi |
| *Pathogens* | Fecal contamination from domestic and livestock sources | Waterborne diseases | Lake Ohrid |
| *Salinization* | Diversion of inflow, discharge of saline waters from irrigated lands, runoff of salts from deforested land | Ecosystem degradation, loss of freshwater supply | Aral Sea |
| *Siltation* | Soil erosion from cultivation and deforestation | Decrease in lake volume and flood control capacity, destruction of aquatic habitats | Lake Baringo |
| *Structural impacts* | Lakeshore development (e.g., embankments, weirs, roads) | Destruction of littoral communities in lake | Lake Biwa |
| *Toxic contamination* | Industrial effluents agricultural and urban runoff, atmospheric deposition | Toxicity to fish and disruption of endocrine system, bioaccumulation in fish increases risk to humans and other predators | Laurentian Great Lakes (DDT and PCB contamination) |
| *Water level decline* | Diversion of inflow, over-withdrawal of water | Secondary salinization, ecosystem degradation | Lake Naivasha |

These problems are not unique to lakes—they occur in most waterbodies. However, the special characteristics of lakes, described in the previous chapter, influence the way in which the problems are manifest in lakes.

The relatively **long retention time** of lakes means that many problems can take a long time to become apparent. This is particularly true where the problem arises because of long term change to some component of the lake that is not visible. For example, toxic contaminants can build up in the sediments over many years before they cause a problem by entering the foodchain. Similarly, alterations to the lower levels of the lake's foodchain because sediments in the water cause changes in light regime may not be immediately apparent to the users of the lake. By the same token, these problems can take a long time to correct in lakes, a point taken up in the next section on management responses.

The **complexity of lake dynamics** also influences the way in which problems become apparent. This is readily seen in the case of eutrophication where a steady buildup of nutrients can apparently cause little problem in lakes until a critical point is reached. At that critical point the lake can abruptly switch into a different state with reduced use and non-use values. In the case of Lake Victoria, nutrients had been building up in the lake water and sediments for decades without apparent effects until the early 1990s when, quite suddenly, the basis of the lake's ecosystem shifted. Cyanobacteria dominated the base of the foodchain, much of the lake became turbid and blooms of potentially toxic cyanobacteria became common in the near shore areas of the lake. It is known, from experience in other lakes, that it is very difficult (if not impossible) to shift such a lake back to its previous state (see Figure 1.1).

The **transmissivity** of lakes simply means that problems can seldom be localized with lakes. The fluidity and mixing of the water ensures that physical, chemical and ecological problems become apparent, to some degree, throughout the whole lake and downstream waters. Floods affect all of the lake's shoreline; pollution spreads beyond its source to affect much of the lake; and biological problems, such as introduced species, can spread throughout the lake. However, there are often limits on the extent to which problems can spread throughout the lake. Deep lakes are often stratified and the bottom waters do not readily mix with the top waters, and large lakes are not completely uniform across their surfaces.

**Box 2.1. Transmissivity and Externalities**

The transmissivity characteristic of lakes means that externalities are a particularly important source of problems in lake management. Externalities occur when the action of one individual (or group) affects the welfare of another individual (or group) and the latter group is not effectively consulted (or compensated) during decision-making. In the case of lakes, the flow of water from the catchment to the lake readily transmits problems from upstream to downstream (as in the example of the farmers and the fishermen); the transmissivity of the lake means that many people around the lake can be affected by the actions of a few.

Externalities are commonplace in the lake briefs. Upstream forest clearance results in increased sedimentation in Lake Baringo. The introduction of water hyacinth in Lake Victoria hinders lake transportation and fishing. Tonle Sap water levels are affected by changes in the Mekong River annual flows, and some of these changes have their origin in China or Laos. These externalities are all transmitted by the fluidity of water: many are local, but some are international.

Externalities as usually thought of as negative and so cause problems. However, they can also be positive. For example, reforestation in the upper watershed around Lake Sevan has improved water quantity and quality in the lake over time. In all cases where externalities exist, however, there is a "break" between the person taking the action and the people where the impact is felt. And since there is no link, normal market signals (that is, prices) do not reflect these links and their impact.

Problems caused by externalities can be overcome by "internalizing the externalities"—that is, by including benefits and costs, wherever they occur (this speaks to correctly defining the boundary of the analysis) and whomever they affect (a social-welfare perspective). This is easier said than done. With sufficient foresight and recognition of the issues, however, it is possible to do such an analysis and thereby make better decisions about management alternatives. In addition, even if some of these impacts cannot be formally valued in economic terms, just recognizing them and including them qualitatively in the analysis is an important first step.

**Response to the Problems: Management Interventions**

The story at the beginning of this chapter illustrates that there are two types of management interventions in lake management, one for **development** of lake resource values and the other for **conservation/remediation** of the same. As shown in Figure 2.1, the cumulative impacts (i.e., the problems arisen) of development interventions often necessitate introduction of conservation/remediation interventions. Intervention measures in either case can be structural (e.g., construction of water intake structure as versus sewerage system), or non-structural (introduction of new fishing technology vs. new regulatory provision for the control of effluent discharge). For the purpose of this report, we confine ourselves to management interventions for conservation/remediation (C/R interventions) of resource values.

Therefore, the story of this report—how conservation/remediation interventions are carried out—is the story of how lake uses are governed by society. "Governing" is defined (Oxford English Dictionary) as "control(ing), influence(ing), regulat(ing), or determin(ing)...the course or issue of events." The sort of governing acts common in the 28 lake briefs include:

- forming organizations that provide continuity of lake management, including development of plans, representation of the goals of different groups, implementation and management of structural investments, and enforcement of decisions (Chapter 3)
- developing rules, including police powers as well as financial incentives, about sharing the lake basin's resources and limiting externalities for other users (Chapter 4)
- changing peoples values so that the net benefits gained from the use of a lake basin's resources are maximized (Chapter 5)
- engaging people in management through devolution of responsibilities (Chapter 5)
- introducing technological measures to reduce or ameliorate adverse impacts (Chapter 6).

Just as the characteristics of lakes have an effect on the way in which problems occur, they also have an influence on how to manage those problems. The **long retention time** of lakes—particularly for larger and deeper lakes—necessitates that their management be anticipatory, committed, and well-planned over the long term. A good understanding of the physical, chemical and biological processes occurring; long-term goals supported from the highest political level to the local communities; and well worked out, long-term plans will be needed if lake management is to be successful. The instruments of management—institutions, people, laws, rules and regulations, finances for operations, investments in infrastructure, knowledge for efficient interventions—all need to be established and supported for the long term but, at the same time, be flexible enough to adapt to changing values and new knowledge. In fact, the long timescales involved in lake management argue for the existence of institutions in order to give permanence to management beyond the shorter timescales of individuals. One other implication is the need for secure financing to make sure that structural and non-structural interventions are effective over the long term.

The **complex dynamics** of lakes also argues for drawing on the best available scientific knowledge and, if necessary, mounting research programs to obtain chunks of knowledge that are critical to management. However, there needs to be a proper conceptual model of these dynamics worked out in advance in order to make sure that the research is truly focused on the critical chunks for management.

Finally, the **transmissivity** of lakes and the consequent difficulty of excluding users from accessing many of the lake's resources has many management implications. Common pool resources (see Box 1.3), such as the fish in the lake, can be over-exploited since there is no incentive for individual users to limit their use of these resources. Rules are usually introduced, once the resource shows signs of over-harvesting, to ensure that these common pool resources are shared equitably. Rules may also need to be introduced to protect, public goods, the other category of non-excludable lake uses. The visual amenity of the lake and flood protection from levy banks are examples of such public goods. Unlike common pool resources, these rules are not needed to allocate the goods amongst competing users (by definition the use by one person does not affect another person's use). Instead the rules may be needed to protect the quality of the good. For example, prohibitions may need to be introduced on dumping rubbish to protect the visual amenity of the lake or rules may needed to ensure that all beneficiaries from flood protection contribute towards the costs.

The transmissivity of water also means that, for many problems, the lowest effective level of management (the principle of subsidiarity) is the lake and its catchment. Managing the water resource at this level can help internalize the externalities that arise from the transmissivity. Of course, having a management structure that is responsible for the whole of a lake basin is no guarantee that these externalities will be managed – that will depend on the sense of community, financial transfers, etc. This does not necessarily imply that a monolithic lake basin management authority is the best institution for management. Rather it argues for management coordination across the area of the basin and, often, coordination across the different sectors that use the basin's resources. Sometimes this can be most efficiently carried out by a single basin management authority; sometimes not.

**The Components of Lake Basin Management**

From the preceding discussion, it is apparent that there are a number of aspects to managing a lake's resources to ensure that they are accessed equitably and efficiently, given the inherent characteristics of lakes and their basins. These aspects, or components, can be categorized as:

- Institutions
- Incentives and Regulations
- People (Values and Participation)
- Technology
- Information
- Finance

**Institutions** carry forward the mandate for managing the lake and its catchment for the benefit of all lake resource users. They are sanctioned by society to give them the necessary authority and longevity to operate effectively. They can operate at local level (such as local councils), at regional level (such as a lake basin authority), at national level (such as sectoral government departments) or at international level (such as international commissions for transboundary lakes).

**Rules** governing peoples' use of lake resources and impacts on lakes can be encoded in formal laws, statutes and regulations and implemented by formal institutions. They can also be informal, often being developed and accepted amongst traditional groups of lake people. Rules are used to both ensure equitable allocation of lake resources and to ensure that these resources are not wasted.

The **involvement of people** is central to lake management. They decide the values to be obtained from the lake's resources; they provide knowledge and experience; they form informal organizations for management; they provide support for enforcing rules; and they can be a source of the finance needed to operationalize management. Institutions don't operate in a vacuum; they require leadership from committed and visionary individuals as is seen in some of the case studies.

**Technology** is not always essential for management; non-technological solutions can sometimes be sufficient. However, technical responses can dramatically increase access to a lake's resources and contribute to the resolution of some types of problems. For example, embankments can significantly add to a lake's ability to buffer floods (an indirect use value) while sewage treatment plants can be very effective at removing wastes and contaminants from concentrated sources of pollution.

**Information**, both traditional knowledge and scientifically acquired knowledge, promotes efficient management. That is, the more that reliable and demonstrable knowledge is used in management, the more likely it is that the goals of those groups using a lake's resources will be met at minimal cost. This report places considerable emphasis on scientific knowledge, primarily because it is obtained via a process that is open to scrutiny and leads to incremental improvements in understanding. This emphasis does not deny the value of traditional knowledge—in the introductory lake story, the experienced fishermen were well aware of the role that the intermittently flooded wetlands in played in fish breeding.

**Finance** is the Achilles heel of lake management in many developing countries. Policies can be well thought-out; institutions can be properly designed and established; rules can be embedded in laws; people can be involved; etc. But if there is no provision for long term funding of both structural and non-structural interventions then management is a hollow concept. This is the component which, in practice, is most difficult to establish successfully.

Putting these six components in some sort a management framework (a plan) may be easy on paper but is likely to be quite difficult in reality. For one thing, the critical deficiency in any one of the components could falter implementation of the plan. Additionally, there is a set of basic quality of the system of governance that will have to be satisfied for any such plan to be adequately pursuable. For example, (i) there must be a sound political system where those in authority are selected, monitored and replaced, (ii) the government must have the capacity to effectively manage its resources and implement sound policies, and (iii) the citizens and the state respect the institutions that govern economic and social interactions among them, etc. These are collectively qualified as **"good governance"** requirements and it encompasses more than just the procedural aspects of planning and management. The "good governance" also includes concepts of legitimacy, fairness, wisdom, acceptability, and accountability.

"Good governance", on the other hand, will not be achievable unless the elements of lake basin management are carried out fairly and efficiently. Fairly means that all groups and individuals receive equitable access to the lake's resources; have some level of certainty in planning for their future use of those resources; have a say in the decisions that affect them; and are compensated when they lose resources that they have a right to (see Box 2.2). It also requires that governments and institutions act in the interests of all citizens and not on behalf of powerful groups; consequently transparency of decision-making and access to legal redress are important components of good governance. Efficiency means that the components of management are implemented with minimal waste of resources. However, the long retention time of lakes requires that efficiency needs to be assessed in the long term; i.e. interventions that appear to be efficient in the short-term may not be efficient in the longer term.

These six components of lake management are discussed in detail in Section II of this report as part of good governance. These discussions draw lessons from the case studies and other experience about the application of these components in practice.

**Box 2.2. Equity**

*Equity considerations*, that is, who benefits and who loses (and how much) from any action, are important in managing a lake ecosystem. The distribution of costs and benefits is important for ethical reasons, as well as being an important factor in designing effective policies and management plans; i.e. there are two dimensions to equity—distributional concerns (the people dimension) and effective policy design. Formal government institutions are more likely to address the concerns of those people who are both “mainstream” and more powerful economically. Consequently, decision makers need to be particularly aware of the needs and role of poorer and more politically –marginal groups. These same groups may also belong to minority populations. Fishermen, who are often politically weak and marginalized, illustrate the second dimension. A sustainable fishing industry can promote an ecologically sustainable lake, for the benefit of other groups.

The ideas of “internalizing externalities” and “maximizing social welfare” carry the implicit assumption that economic transfers are actually made and that those who are disadvantaged by some action are compensated. Obviously this is not always the case. Therefore even when the “socially preferred” management option is identified and implemented, it is important to make sure that the required transfers and compensation actually take place. Equity concerns are among the most difficult issues any natural resource decision maker has to address, and lakes are no exception!

Equity is not the same as equality. Equality implies that ALL stakeholders are equal with respect to income or resources. This is almost never the case anywhere in the world. Equity, on the other hand, is a measure of “fairness” and implicitly implies that those who are poorer/worse off are not disproportionately affected by any change. The Lake Kariba brief describes the way in which the Tonga people were displaced and made worse off by the construction of a large reservoir, while the benefits were reaped by powerful sections of a colonial society. In fact, an *equity objective* for lake management may mean that management actions disproportionately benefit the poorest members of society (even if there is a “cost” in terms of conventional economic measures of benefits and costs).

## Section II. Meeting the Governance Challenge

This section, presenting the lessons learned from the 28 lakes regarding institutions (Chapter 3), incentives and regulations (Chapter 4), people (Chapter 5), technology (Chapter 6), information (Chapter 7), and financing (Chapter 8) is the core of the report. While each chapter in Section II can be read as a stand-alone description of one component of lake management, the case studies show that sustainable lake management requires a grasp of all the themes, taken together as a whole.

# Chapter 3. Effective Institutions: Responding to Change

**Key Lessons Learned about Institutions**

- Effective institutions in one sector can expand to tackle more complex issues.
- Scientific institutions are often a good starting point for transboundary lake dialogue.
- External accreditation can trigger effective management.
- Without political will, institutions are ineffective.
- Informal institutions can be more flexible in responding to issues.

## Institutions: Society's Response to Scarcity

In the absence of scarcity, there is little need for institutions. In the story at the start of the previous chapter population densities were initially low and development limited. There were enough of the lake's natural resources—water, fish, reeds, other products—for all to enjoy and consume as much as they want. As a result of both population growth and economic development, however, resources started to become scarce—that is, their uses become congested, and it becomes necessary to control and limit access to the "commons" and allocate the goods and services provided by the lake basin through rules of various sorts. Institutions are the originators, custodians and implementers of the agreed "rules of the game," or the "humanly devised constraints on human behavior".

As the level of scarcity and complexity grow, the nature of institutions also changes. Management, and institutions, typically evolve from the individual (or private management), to communal forms of management, to public or national management. For international lakes, transboundary management is difficult to achieve and typically occurs at a later stage of development. Basically, institutions are society's way of responding to the problem of "scarcity" by devising rules to allocate the goods and services provided by the lake and implementing those rules.

Institutions and institutional arrangements are essential to address the "common pool" aspect of lake management, to reduce the conflicts that otherwise inevitably arise from competition. Yet they are not costless. The lake briefs indicate that institutions and institutional arrangements are expensive to set up and maintain.

*What are effective institutions?*

In the context of lake basin management, effective institutions generate an improvement in the lake environment by distributing resources equitably and efficiently. Specifically, effective lake institutions, individually and as a group, share a number of characteristics. It is observed in the Lake Briefs that effective institutions…

- respond to new problems as they evidence themselves both in the ecosystem and in the "human system".
- tackle critical problems at the most appropriate scale. For example, hot spots can be identified within the lake basin and dealt with on a localized basis (e.g., Missisquoi Bay in Lake Champaign; Akanoi Bay in Lake Biwa; numerous islands in Lake Malawi). For issues confined to these locations, local institutions may be sufficient.
- remember, learn, and build and maintain both personal and institutional relationships ("social capital") with key stakeholders, including funders. This is greatly facilitated by the continuity of key staff. A key individual, catalytic and sometimes charismatic, can play a critical role in institution building, even if not permanently attached to a single organization.
- mobilize resources, direct government financing (or budgetary sources, if a government line agency or local government), and external funding.

- address collective choice problems (conflicts) that make it difficult for existing (usually sectoral) governance and user stakeholders to solve on their own business as usual basis. It does this by involving stakeholders to identify problems and suggest solutions. It also addresses the political problem of handling conflicts and tradeoffs among stakeholders, including new ones.
- secure the trust of the regulated and legitimacy among the public (Chilika Lake, India after 1997; Laguna de Bay, Philippines), and
- forge issue linkages, especially where source and affected party are different.

Effective institutions accumulate “institutional capital” as they evolve and learn. Institutional capital comes in various forms—social, human, informational, and physical. It allows effective institutions to change their agendas in response to changes in the natural and human environments; to address problems involving many different stakeholders (collective-choice problems); to be prepared for crises, in part because they are capable of learning from the experiences of others; to focus on critical problems; to enjoy a high level of legitimacy and trust among key stakeholders, built up over time through credible commitments; and to mobilize financial resources on a sustained basis, especially from a variety of different sources, including end users.

## A Typology of Institutional Forms for Lake Basin Management

Institutions can take various forms. The following examples are listed in order of increasing formal powers. However, this does not necessarily imply that more formal structures are better than informal organizations. Given the long time required to build effective institutions, building from below (a “bottom-up” approach) and on the basis of accumulated institutional capital may create the most effective and strongest institutions.

*Customary and self-regulated management*

**Customary and communal structures** for single sectors, such as fisheries, are effective in many situations with low population pressure and fairly abundant resources. In many cases, local sectoral organizations have expanded into multisectoral institutions without the “benefit” of regulatory oversight (Box 3.1).

**Box 3.1. An Evolving Institutional Base: The Lake Naivasha Example**

In 1929, the owners of the Lake Naivasha, Kenya foreshore organized themselves into the Lake Naivasha Riparian Owners Association (LNROA) in order to regulate the use of the lake bed periodically exposed in front of their properties as the lake level rose and fell naturally. These owners were, in general, wealthy, influential Europeans and European-Kenyans who wanted to protect this land because it provided lake access, a scenic foreground to their properties, and was useful for grazing activities. Other groups with an interest in the lake, such as fishermen, nomadic Maasai grazers, and residents of the local towns and villages were not part of the Association.

The LNROA was granted custodianship of this riparian land by the colonial government in 1933. The Association successfully regulated access to these riparian lands from that time through to the present day although, for most of that period, it was not an active organization. In the early 1990s it started to become more active because of the increasing pressures on the lake. It changed its name to the Lake Naivasha Riparian Association (LNRA) and expanded its membership base to include members that were not riparian property owners but who had an interest in the health of the lake.

During the 1980s and 1990s the population within the lake basin grew dramatically and a thriving cut-flower trade commenced on the shores of the lake. The larger flower growers organized themselves into a representative institution—the Lake Naivasha Growers Group—to respond to adverse publicity, including claims that their industry was polluting the lake. For a number of years, the LNGG and the LNRA were in conflict. However, by the late 1990s these conflicts had been mainly sorted out and the two institutions started working together for the management of the lake.

A management plan was drawn up for the lake in the late 1990s and the Lake Naivasha Management Implementation Committee (LNMIC) was formed to implement it. The LNRA plays a leading role on this cross-sectoral institution along with representatives of many other groups with an interest in the lake—fishermen, town people, and government agencies such as the Kenyan Wildlife Service. The LNGG are not formally members and nor are representatives of the settlers in the upper catchment and the traditional Maasai. These groups will likely be brought into the process, both due to the recognition by many riparian groups that the sediment load entering the lake from the upper catchment may become a problem to themselves, and because of new environmental and water laws in Kenya. The recent Kenya Water Act allows for the formation of representative Advisory Committees in each catchment that will have influence in the allocation of water and the regulation of pollution. When this happens, the LNMIC will likely evolve into the regional Advisory Committee and the evolution of the lake management institution will continue.

*Coordinating committee*

As population pressures and competition for resources grow, often a first step towards coordinated management is the creation of a **coordinating committee**. A committee or office, typically consisting of sectoral agencies (or, internationally, representatives from member governments), is formed to coordinate efforts, while implementation remains with existing sectoral and regional institutions. These committees are often weak since they do not have legislative backing, a separate budget, or independent staffing. As such, they are voluntary creatures of the sectoral ministries or, in international cases, of the member governments. Many international lake basin commissions fall into this category.

*Coordinating agency*

A **coordinating agency** has legal authority or some higher level authorization (such as cabinet approval), a separate budget and staff, and (sometimes) organizational independence from sectoral agencies. It does not have executive authority but exists to coordinate the actions of sectoral and regional institutions. For these reasons it is more powerful than a coordinating committee. Examples include the Lake Chilika Development Authority, the Cambodia National Mekong Committee, the Department of Lake Biwa and the Environment (Shiga Prefectural government), the interagency Lake Dianchi Protection Committee and Bureau, and the International Joint Commission of the Great Lakes. Most of the active lake basin management bodies in our briefs are coordinating agencies. The coordinating agency may be concerned with just the lake or it may also include the catchment. Its powers include persuasion, facilitation, and convening.

Coordinating agencies face several major challenges:

These agencies are often quite weak and have to contend with the complexity of preexisting, often imbedded, institutions and stakeholder groups. For example, the Chilika Development Authority maintains institutional linkages with seven state government organizations, four NGOs, three national ministries, two other national organizations, four international organizations, nine research institutions, and four different categories of community groups (see Figure # in Chilika brief). This is a difficult coordinating task and requires strong leadership coupled with firm political backing by politicians to succeed.

Successful coordination and the trust relationships required for coordination rely on the presence of key individuals, especially at the chief minister or governor level but also in agency management. The experience of the Lake Laguna Development Authority and others is that one of the greatest challenges facing a development authority is the frequency of changes in the government and appointed directors.

It is important that “coordination” not become a pretext for shedding responsibility. An effective agency must be an advocate for integrated lake management policy, working together with stakeholders to solve problems and, ideally, with a policy patron at a supra-sectoral level, such as the governorship. Preparing a lake basin management plan is an effective tool for policy coordination (see Chapter 9).

*Executive (regulatory) agency*

A regulatory agency can actually carry out actions, such as levying fees or creating enforcing regulations, under its own authority. Since the potential always exists for conflict with sectoral agencies, executive agencies should be authorized through legislation and retain powers such as permitting, policy setting, financing and implementation.

Since the existence of such an executive agency means that others have to give up power, they are often hard to establish. Prerequisites for creating an executive agency often include a) a long evolutionary history of trust building; b) a crisis; and c) no international borders. Probably the best instance of such an agency outside the governmental structure is the Lake Laguna Development Authority, which combines coordinating, development and regulatory functions (see Box 3.2). The water resources departments of Orissa and Madhya Pradesh (Lake Chilika and Bhoj Wetland, respectively) provide both coordinating and regulatory authorities, but are not lake-specific agencies. The actual executive powers vested in an executive agency can include the following functions: Regulatory, Development, Conservation, and/or Restoration.

**Box 3.2. Institutional reengineering of the Laguna Lake Development Authority**

Inherent in the existing LLDA Charter is the developmental function for water resources development purposes, but at present the LLDA is performing more of its regulatory function than its planning and development roles. This overarching mandate of LLDA has not been realized because of lack of capacity and appropriate mechanisms to enable the Authority to initiate and involve the private sector in capital intensive infrastructure development projects in the region. Further, the financial flexibility of LLDA and other government owned corporations, in terms of sourcing finances and utilization, has largely been constrained by the Philippine Government's multi-layered approval process for fund solicitation through the NEDA/Investment Coordinating Committee.

Performing the diverse functions as regulator and to a limited extent as a developer has overstretched the LLDA and resulted in its inability to fully accomplish its original mandate as a development agency. This is evident in its current business strategy and financial profile, thus the need to delineate and segregate its regulatory and planning-developmental functions. Likewise, the LLDA has realized that building institutional capacities for undertaking large-scale infrastructure projects in the region requires that the regulatory and policy-making function of LLDA is balanced with a strong, but segregated, development function. This was the starting point of the institutional re-engineering program. Previous studies identified potential investments of around US$381 million to maintain the environmental quality in the Laguna de Bay area through dredging, embankments, sanitary landfills, and sewage and treatment plants. LLDA urgently needs to develop the capability to leverage and facilitate private sector participation in necessary large-scale environmental and water-related infrastructure projects in the lake area.

Source: Laguna de Bay Brief

*The Role of Local governments*

Local governments play a critical role in lake basin management, since localized issues can often be handled best at local level. In addition, local authorities are often the most accountable to the public and may be the best placed to facilitate stakeholder dialogues at the operational level. They are the most capable of responding to local needs in addressing the economic, social, and environmental challenges of sustainable development. Their decisions on land use zoning, transportation, construction, public health, ecological zoning, solid waste management, and industrial incentives all affect water resources.

Few of the 28 lakes surveyed are managed entirely by a local government, however. The Bhoj Wetland and Lake Baringo are controlled by a municipal and a county authority respectively, while lakes Biwa, Chilika and Toba are under intermediate levels of government. The remainder are managed at the national or international levels. Local governments cannot manage all lake basins problems. Many problems, because of the transmissivity of lakes, affect a wider area than just one local government jurisdiction. In addition, local governments often lack jurisdictional authority and resources to address context-specific issues, including a limited ability to bring other levels of government to the table; (the financial and human resources to implement properly sustainability initiatives; and the necessary political will, due to the brevity of the electoral or administrative cycle.

In practice, the lake and its watershed often occupy a low position on the priority list of local governments, especially in developing countries. Indeed, local governments can be major sources of lake degradation if they are indifferent to urban sewage, diversion of funds, support of activities that generate pollution as well as revenue and employment. In many countries, local governments are highly politicized and just as hierarchical as distant agencies, making consensus-building very difficult on cross-sectoral issue (Box 3.3).

**Box 3.3. Involving local governments in an integrated policy at Laguna de Bay**

Lakeshore municipalities challenged the Laguna Lake Development Authority over the right to issue fishery permits, especially for the lucrative fish cages and fish pens. In 1995, the Supreme Court ruled in favor of the LLDA, noting that the lake "cannot be subjected to fragmented concepts of management policies where lakeshore local government units exercise exclusive dominion over specific portions of the lake water...The implementation of a cohesive and integrated lake water resource management policy...is necessary to conserve, protect and sustainably develop Laguna de Bay." This decision re-iterated LLDA's authority over permitting. It is also interesting to note that, since the permitting program began, the LLDA has maintained a revenue sharing policy of the fees with the local governments. This has undoubtedly contributed to the acceptance of the program at the local level

Source: Laguna de Bay Brief

## Evolution of integrated lake basin management

As lake uses increase in scope and magnitude, conflicts increase, and the benefits of some sort of integrated management of the lake becomes more evident. Stakeholder institutions evolve, often working out new ways of sharing the resource and avoiding present and potential conflict, especially internally but also with other sectors. For example, moratoriums on fishing have been imposed in Lakes Baringo and Naivasha to allow depleted breeding grounds to recover; some agricultural drainage in Lake Biwa is treated and recycled to avoid unwanted scrutiny of a highly protected sector; and the horticulturalists of Lake Naivasha have responded to pressures from EU consumers and the Lake Naivasha Riparian Association to adopt state-of-the-art techniques for pollution control.

Institutions tend to arise and evolve for developmental needs, but can transform themselves into effective preservers of the lake (Box 3.4). The Laguna Lake Development Authority began with a resource development focus, but the national environmental agenda quickly began to assert itself in its operations. Shiga Prefecture shifted the Lake Biwa Comprehensive Development Plan upon its first renewal in 1982 from its initially almost exclusive focus on developmental projects towards environmentally-friendly public works, such as a wide-area sewerage system and a large infrastructure for irrigation. The prefecture then went beyond the Plan to establish research and educational facilities such as the Lake Biwa Research Institute, the International Lake Environment Committee, the Lake Biwa Museum and Shiga Prefectural University.

**Box 3.4. Great Lakes: A large institutional infrastructure, evolving over a century**

The experience of the Great Lakes indicates that formal lake management institutions need to evolve to remain relevant. Beginning with the establishment of the International Joint Commission (IJC) to implement the International Boundary Waters Treaty of 1909 between the United States and the United Kingdom (for Canada), a considerable 'institutional infrastructure' for Great Lakes resource management has been created through laws, treaties, conventions, compacts and formal agreements. The principal stakeholders of these formal institutions are the governments involved, both federal and state or provincial.

The IJC was established as an independent body to advise and make recommendations on problems ("references") given to them by the governments and has been a pioneer in identifying emerging environmental problems, such as nonpoint source pollution and the effect of phosphorus on lake eutrophication. Initially, the IJC investigations only held public hearings on specific topics; otherwise, they were carried out in private because only the governments could give permission to release 'internal communications… by boards, committees'. With the 1972 Great Lakes Water Quality Agreement between the United States and Canada, the IJC opened up to more public involvement in its very effective PLUARG (Pollution from Land Use Activities Reference Group) activities. It also assumed responsibility for monitoring pollution along the lakes, identifying 43 hot spots (Areas of Concern, or AOCs). Each AOC requires a Remedial Action Plan (RAP), and remains listed until both countries agree on its removal. By and large, the IJC has been able to retain its independence, although critical monitoring functions were assumed by the member governments after 1989, with mixed results.

New stresses, both from changes in stakeholders' rights (Native Americans) and from problems arising from out of the lake basin (zebra mussels, airborne lead), pose severe challenges to which present institutional infrastructure must adapt.

*Trained and experienced staff* play a critical role. Putting resources into building the conservation agenda and capacity of existing sectoral institutions may strengthen their commitment and capacity for dealing with resource issues directly, or in cooperation with environmental bodies. This may require modifications in personnel procedures, however, in organizations where trained staff are regularly reassigned. This has been identified as a problem in Lake Malawi and Lake Nakuru, and is probably quite widespread. On the other hand, there are cases such as Lake Chilika where highly qualified people with excellent networking skills are brought in to improve environmental capacity and enlist the support of stakeholders at all levels.

Coordinating agencies rely on *sectoral institutions* to be effective. For example, Lake Constance relies on individual sectoral institutions that are sufficiently coordinated to integrate the management of lake conservation. The adaptability of existing institutions are essential to the successful management for Lake Constance. Also important have been the existence of infrastructure in place (especially sewerage) that allows upgrading at modest cost, a high level of social capital exhibited in the very strong research agenda of citizen groups and NGOs, a heritage of international cooperation, and the compulsion of EU directives.

*It is helpful if political and basin boundaries are the same*. Lake Biwa and its watershed are almost entirely coincident with the boundaries of Shiga Prefecture. Between 1972 and 1997, its development was governed under the Lake Biwa Comprehensive Development Plan, which distributed public works projects among existing agencies.

## The governance framework for lake basin management

*The enabling environment*

Whether formal or informal, water management institutions operate within a larger context, or governance framework. Effective lake basin management requires that this framework create an "enabling environment" that provides the conditions for institutions to be effective. A governance framework includes laws and regulations both as they are formulated and as they are implemented as well as a judiciary to fairly adjudicate disputes (see Box 3.5). It also includes certain cultural endowments, such as those that promote trust or impute non-market values to lakes. International lakes must deal with questions of national sovereignty that make coordinated management more difficult than for national lakes.

**Box 3.5. Public Interest Litigation in India**

A major development in stopping the continuing degradation of lakes in India has been the involvement of the judiciary, sometimes at the highest level, the Supreme Court. Indian law courts have been extremely proactive on the issue of environmental protection. Groups of affected people and third parties have been filing public interest litigations (PIL) in courts across the country seeking remedial actions, especially for highly polluted urban lakes.

The Supreme Court, in a PIL in the case of Badal Khol and Surajkund lakes in Haryana state, held that the precautionary principle is part of the law of the land, and limited construction activity in the near vicinity of the lakes. Although PILs have generally helped in restoration of lakes, there are opposite instances, as was the case of the Rabindra Sarovar lake in West Bengal, where the PIL sought to legalize encroachment onto the lake.

(From M.S. Reddy and N.V.V. Char, Management of Lakes in India)

*Transparency and accountability*

Especially in developing countries, a pervasive lack of accountability and transparency characterizes governance at all levels, even in democracies. Sophisticated laws, plans and policies are not implemented. Information, when it exists, is hoarded as an instrument of power. Under these circumstances, it is especially imperative to involve stakeholders (Chapter 5).

*Customary rights*

Sometimes the local government is able to assume the functions of lake management, especially where its boundaries coincide closely with a significant portion of the lake basin. Informal or “customary” institutions can manage user priorities or transfer rules, use rights for seasonal migrants, self-initiated lobby groups, and informal cooperatives. Outside investors using formal property claims sometimes appropriate resources used under customary rights, possibly contributing to the impoverishment of artisanal fishers and farmers. This type of conflict is very common in developing country cases, especially with the spread of fishpen culture in Asia. At Chilika Lake, arbitrary changes in traditional fishing rights to promote fishpen investments led to violent clashes with police that drew national attention to the lake.

In other cases, pressures are from migrating populations rather than heavily capitalized outsiders. Traditional use rights of seasonal migrants in Lake Tonle Sap are under challenge as customary migrants overstay their welcome and entirely new populations come into the area. Similar conflicts between ethnic communities are widespread in Africa.

Customary rules can transcend post-colonial national boundaries. In the Lake Chad area pre-colonial rules are still in place to some extent for establishing the order of use priorities in the face of dramatic changes in size and form of the lake. In this circumstance, the lingering application of colonial Roman Law in assigning free access to groundwater overlying landowners is retrogressive.

*The necessity of harmonization*

Differences in regulations and their enforcement can lead to perverse economic behaviors for transboundary lakes. One of the most pressing needs in many international lakes such as Lakes Victoria and Kariba is to harmonize national regulations in areas such as fishery and pollution control. Harmonization is not necessarily the same as uniformity. The intention is to ensure that there are not conflicts between the laws and regulations across national borders, rather than to ensure that the laws are identical.

At the same time, harmonization should be tailored to the specific lake as opposed to the needs of the riparian nations. Laws are too often formulated for the entire nation, and may not be appropriate for a transboundary lake. Nigeria is important to the Lake Chad basin, but the basin is not dominant in Nigerian policy thinking. It is necessary for basin states to enable within-basin stakeholders to harmonize rules among themselves across borders, but not necessarily with other regions in each country.

**Towards effective institutions**

Based on the experiences detailed in the lake briefs, a number of lessons have been learned about creating effective institutions. Realizing that institutions may be private, communal, national or international, however, these lessons have to be applied at the appropriate scale and manner for each particular lake.

The key lessons are contained in the following bullet points:

- <u>Effective management requires a core.</u> Institutional effectiveness is stronger when the lake is closer to an economic or political-administrative center of a nation. “Marginal” lakes receive marginal attention. International cooperation may be particularly difficult to achieve when a lake is marginal to one of the major basin countries, as Lake Victoria is to Burundi or Lake Chad to Nigeria.
- <u>Scientific institutions often make a good starting point for lake-wide dialogue.</u> Informal peer groups at the technical level can be a key factor in creating supportive networks, especially across national borders. Whether it is the Great Lakes or Lake Biwa, resident research institutes and centers for intellectual exchange provide not only knowledge creation and dissemination but also neutral fora where people can develop a common discourse.
- <u>Effective management builds on existing institutions.</u> Developing a lake-wide institution is best done by building on a powerful sectoral institution, often catalyzed by a crisis. Institutions usually exist already at the sectoral level. For example, fisheries management bodies already exist in many of the lakes studied in this report. Efforts to undertake cross-sectoral management of lakes should build on these institutions, as problems arise.
- <u>Effective management is not afraid to act.</u> It may be difficult to determine whether certain management actions will be successful or not. Nevertheless, the Lake Briefs show that management institutions can be very effective if they are seen to be taking action to remedy problems , even when there is little reliable knowledge available. This is what the Lake Laguna Development Authority calls a “ready, fire, aim” approach.
- <u>Effective integrated management focuses on specific problems.</u> The best lake management experiences often focus on a limited number of critical points, such as the removal of phosphorus from detergents in Lake Biwa, the biological treatment of water hyacinth in critical bays in Lake Victoria, the addition of tertiary sewage treatment in Lake Constance, or the identification of 43 hot spots (Areas of Concern, or AOCs) in the Great Lakes. Public support will follow from these initial successes.

# Chapter 4: Identifying Effective Policies: Incentives and Regulations

**Key Lessons Learned about Policy**

- It is not possible to implement major policy changes if people do not understand the long-term benefits.
- Point source control policies are often a first step because implementation is easier to do and results are easier to see than with broader, longer-term policy changes.
- Effective policy making usually requires a mix of different policies.
- Effective policies have to be tailored to the situation in each lake basin.
- Without proper monitoring and enforcement, policies become worthless.
- Designating a lake basin as a protected area does not necessarily stop exploitation.

Policy-making is an art, not a science, and changing specific policies for improved lake management is part of a multi-step process. After identifying the parameters of the lake's physical system (see Chapter 1), and the roles of the various stakeholders within the system (see Chapters 2 and 5), the decision maker considers what is happening at present, what alternatives are feasible, and the overall objectives of improved management. These are the "goals" of improved lake management and the objectives toward which new, specific policies are put in place.

Changing policies is an integral part of introducing effective solutions and making a difference in a lake basin. Policies can be considered at several different levels. The **broader policy framework** includes many dimensions—general goals for lake basin management, the supporting legal framework and institutional arrangements (both formal and informal), and the state of scientific knowledge. In addition, policies (or policy responses) are needed to address specific issues and change behavior. These policy tools often take the form of economic signals or incentives, as well as rules and regulations, and are designed to create specific outcomes. This latter set of policies are the focus of this chapter. People-centered policies, those that rely on public information and involvement, are equally important and are discussed in Chapter 5.

In some cases (the easy ones) the needed improvements are largely engineering investments, and the main problem is in securing financial resources (money!!). Engineering and infrastructure solutions are discussed in Chapter 6 and Financing is discussed in Chapter 8. However, in most cases, **improved management usually means improved management of people and their actions, and the introduction of policies to change their behavior.**

As discussed earlier, in almost all cases the users of lake resources (the stakeholders) are doing what they feel is best for them *given the prices, policies and institutions that they face*. Accordingly, any change in the patterns of resource use (whether it is a change in agricultural practices in the upper watershed or fishing in the lake, for example) will require someone doing something different, and *taking an action that they would not normally take*. In fact, since we assume that all individuals are already "doing the best that they can" any change in their behavior must be induced. Consequently, various policy tools are used to "change the rules of the game." This is the role of new policies or institutions—to make changes in the signals that lake resource users perceive and react to, and thereby improving the use of the lake and its resources.

The process of changing policies is never easy. As seen in most of the lake briefs, there are almost always winners and losers, and there are usually additional investment costs associated with what is being proposed. Different interest groups may require quite different policies, and in some cases where lake management is a regional or international responsibility, this further complicates the process of designing and implementing new policies. Hence effective policy change requires planning, political commitment, and the financial and economic resources to implement change.

### A Not-so-simple Example

The 28 case studies provide many useful examples of this challenge. In the case of Laguna de Bay, for example, the government's management approach has been flexible and has evolved over time as the management authorities have had to both respond to new challenges (e.g. expansion of fish pen operations and shoreline industrial development) as well as search for new sources of funding. See Box 4.1 for a discussion of this process, and how the Laguna Lake Development Authority has tried a variety of different policy approaches to address the lake's problems. As explained in Box 4.1, the LLDA has shown the wisdom of trying to make a difference and fine-tuning policies as experience was gained. This view is summarized in their informal motto of "Ready–Fire–Aim"!

**Box 4.1. Laguna de Bay and LLDA—an evolving policy response**

When the Laguna Lake Development Authority (LLDA) was set up in 1966 to help manage Laguna de Bay and its water quality problems, the approach used was a fairly traditional Command and Control (plus capital investments) approach. Initially funded by an annual allocation of one million pesos from the National Government, over time the LLDA has become much more self-financed through a combination of regulatory fees and fines, laboratory services, and resource user fees (aquaculture and water abstraction). As the LLDA gained experience, it broadened its mandate and set of activities to take a more proactive approach in managing the lake as an economic as well as an ecological asset.

A particular area of interest has been the development and management of the fish pen/ aquaculture industry, and the conflicts with traditional fishing populations and issues of changes in water quality. Programs were developed to both support fish pen development as well as alternative income generating programs for lakeshore communities. Conflicts among competing uses of the lake's resources grew: for example, the area covered by fish ponds increased from less than 40 hectares in the 1970s to more than 30,000 hectares in 1983, reducing the area available for open fishing and impeding lake navigation. Different government ministries sometimes worked at cross-purposes within the lake.

The LLDA has also evolved in its response and more recently has tried to blend economic instruments (that either use or create markets) with command and control policies. Implementation of the Environmental User Fee System (EUFS) began in 1997 and combined a fixed fee and a variable fee to attack the problem of water pollution from lakeshore industries and communities. The fixed fee component is based on volume of discharge and covers administrative costs. The variable fee is based on whether discharges are above or below the BOD standard of 50 mg/l. Implementation began slowly and focused on a small set of industrial polluters (who were, however, responsible for up to 90% of the total organic load being discharged into the lake). The EUFS was gradually expanded to cover other firms, residential areas and commercial establishments.

The EUFS use of fixed and variable fees helps to correct a problem commonly encountered with discharge standard based fees—the later encourage dilution of discharges (to meet the standard) while the fixed fees will tax the increase in quantity of wastewater released. The LLDA still has CAC functions like registering all units that discharge into the lake, and monitoring and enforcement are always issues.

In another innovative approach a fish pen fee (basically a licensing fee) was set whereby monies are collected from the fish pen operators and then shared between the lakeshore communities (more if they have fish pens in their area) and the LLDA for general operating expenses. The fee is currently about US$120 per hectare per year, and up to 35% of the money collected goes to lakeshore communities and the balance to LLDA.

The LLDA is an excellent example of a lake management authority that began life as a government mandated (and funded) regulatory agency and has evolved into a much more market-responsive agency willing to try different policy approaches to address evolving problems. In fact, the LLDA applies all four approaches in varying degrees.

LLDA's willingness to innovate is seen in the interactions with fish pen operators—clearly a high value operation (and consequently one that has a substantial ability to pay) but also an industry that contributes to environmental problems in the lake. Competition for lake resources between the fish pen operators and traditional lakeshore communities is an on-going concern and one that the LLDA has tried to address with a number of different policies including fish pen regulation and creation of new economic activities on the shore. The willing to try new approaches attitude of the LLDA is well summarized in their philosophy of "Ready—Fire—Aim". They are willing to start with actions and are happy to fine tune later. Put another way, in the world of policy formulation it is important that we "don't let the perfect [policy] be the enemy of the good."

**Identifying Potential Policy Responses**

As mentioned earlier, policies can be thought of at many different levels, including changing institutions or legal frameworks, or taking legislative action. As used here, however, ***policy response refers to a narrower set of discrete actions taken by governments or other management organizations in reaction to some problem and to produce some desired outcome, often by changing some price signal or setting certain standards or norms.*** These types of policies can also be thought of as a combination of economic signals and incentives (market-based policies) and rules and regulations (command-and-control policies).

In effect, this definition of policy making is an example of the "Monday morning rule"—whereby the decision maker, after attending a workshop and thinking about lake management challenges in the context of the analysis and approaches presented in this report, has to decide what can be done differently when he or she returns to the office on Monday morning. Therefore the focus is on **discrete, often modest changes that can begin to make a difference** (while not denying that broader, longer term social and institutional change are also an important part of the search for more sustainable lake management). Incremental changes are often the first step to effective lake management by making all stakeholders part of the management process and getting their "buy-in" into the process. Modest first steps towards control of industrial pollution in Lake Dianchi in China, for example, laid the foundation for more major interventions over time.

Although each lake or basin being analyzed will probably require a very specific set of policies to address its own concerns, there are some more general lessons that provide useful guidance, both on the **types of policies** most likely to be effective, and the **appropriate mix of policies** to be used.

Decision makers can draw upon an expanding literature on effective policies to manage environmental problems. Although many of the policies were developed for other ecosystems, the principles are very transferable to many of the problems encountered in lake basin management. In a broad review of environmental management polices, four broad categories of policies were identified (see **Five Years after Rio: innovations in environmental policy**, World Bank, 1997). These categories are the following:

- Policies that engage the public (public awareness, voluntary groups, the mass media, others)
- Command and control type policies (rules and regulations)
- Policies that use existing markets (and often use price signals)
- Policies that create markets (and often create price signals).

These categories cover the entire range of policy tools being used at present and represent quite different ways of attacking similar problems. The only other intervention commonly used in lake basin management is a technological response such as physical investment in capital works like advanced sewage treatment, dredging and the use of biological agents to control weed growth. These technical responses are an important part of the management package but are not "policies" in the sense used here—they are discussed in Chapter 6. Furthermore, the first category listed above—policies that engage the public—is really a different type of initiative and is appropriately discussed in the following chapter on the role of public participation in lake basin management. Each of these remaining three broad classes of policies is now discussed.

*Rules and Regulations—Command and Control Policies*

The first broad category of policy tools or instruments commonly employed by governments is the use of regulations and standards. These are often referred to as command and control (CAC) policies. Whether it is a restriction on the use of a certain type of fishing gear, or the setting of an allowable pollution load for industrial or residential effluent, command and control policies are popular with governments because they can specify the desired outcome. Environmental management in the West started with a CAC approach, and this helped to create the “policing” mentality about many resource management agencies. Users often felt that governments were there to oversee and police them, rather than work together for improved environmental and economic sustainability. There was an additional attractive feature about CAC type policies. Governments can state that they have strict standards in place and therefore feel like they are “doing something” about the problem—even is nothing is being enforced! The former Soviet Union was a classic example where everything was “controlled” by norms or standards, and almost none of the standards were actually enforced.

For some goals, in some social settings, command and control policies can be a very efficient and effective way to make a difference. For example, to reduce water pollutants in a lake specifying allowable boat engine types (two stroke or four stroke engines, for example) or fuels that may be used may be quite effective in reducing water pollutants. Similarly, banning certain pesticides can quickly help reduce water pollution from agricultural return flows. The lake Biwa example mentioned earlier used regulations to control phosphate pollution in the lake. Many developed countries relied heavily on CAC policies in the past, and they were effective in achieving environmental goals. Command and control policies work best when the number of people affected is not too large, and when there is a social acceptance of government-set standards. If “social capital” is weak and enforcement is lax, command and control policies are unlikely to be effective, A mixture of CAC policies is often used. To help manage fish stocks in a lake, specifying fishing boat size or imposing gear restrictions will have a direct impact on fish catch. Other CAC policies for fishery management include

- specifying “closed seasons” when certain species may not be caught,
- assigning allowable catch amounts per species or per period of time, or
- designating fishing zones for different categories of fishermen or different fisheries.

Note that command and control policies are NOT economic policies—they usually do not ask what are the benefits or costs of any policy (or, more importantly, what the net benefits are), they merely specify the desired outcome. As a result, CAC policies can be very inefficient ways to reach many goals. (In this case, “inefficient” means that the chosen policy may be effective in reaching a goal, but at a much higher cost that other policies.) The economic inefficiency occurs since CAC policies do not leave much room for negotiation or trades—everyone is expected to follow the same standard. Experience with air pollution reduction in the United States has shown that when polluters have the ability to "trade" pollution reductions, those firms that are more efficient in doing so can often "sell" extra reductions to older or less efficient firms. The net result of this market-based approach is that total pollution reduction targets are met but at a considerably lower cost than if each firm had to meet a given target (a traditional command and control approach). When the US wanted to reduce atmospheric sulfur emissions, for example, a tradable quotas approach was used and allowed the overall target to be met at half the cost originally estimated to achieve the same reduction. Of course, to implement such an approach requires setting an overall target for pollution reduction and allocating initial firm-level reduction goals before trading begins.

Finally, command and control policies are often costly to administer and implement. The more finely tuned the CAC policy, the larger the administrative burden in enforcing the policy. In addition, if the policies are aimed at large numbers of individuals (rather than just a handful of individuals) monitoring and enforcement may be impossible. A good example is the difference in enforcing fishery regulations for thousands of artisinal or near-shore fishermen or for a handful of larger operators. In this case neither group may be easy to manage with CAC policies—monitoring or policing a large number of relatively weak artisinal fishermen may be just as ineffective as trying to impose restrictions on a small number of often wealthy or influential large fishing operators. The challenges in Lake Victoria in managing the different groups of competing fishermen illustrate this point.

Another illustration of the challenge is to try and affect agricultural chemical use by farmers in the upper lake basin. A CAC approach would specify what chemicals are permitted or how they may be applied—and could be almost impossible to enforce and monitor. A "blunter" approach is to combine the use of some CAC policies (e.g. ban the import and sale of the most damaging chemicals) with certain market-based policies such as correctly pricing agricultural inputs (removing subsidies) so that there is an incentive to use the input carefully and not over-apply. This happened with fertilizer in Indonesia. In the past, heavily subsidized fertilizer was over-used in rice production, much of the fertilizer was wasted and entered water return flows, and this created serious downstream environmental impacts. The government then raised fertilizer prices (a market based policy) largely because the Treasury could no longer afford to pay the subsidy. The net result was a sharp decrease in fertilizer use (and the pollution of water that was an associated by-product of excessive fertilizer use in the past) but no decrease in rice production. Farmers just started to use fertilizer, now a more expensive and hence "valuable" input, more carefully!

In summary, command and control approaches are more likely to succeed when the following requirements are met:

- the number of individuals or units to be managed are small or there are easily monitored points e.g. landing beaches or sites for fish catch
- the institutional structure to monitor and enforce sanctions exists and is effective
- there is a reasonable level of "social capital," and individuals and society have respect for government and institutions
- there is a sense of "shared responsibility" for management of the lake basin and its resources

This is a rather demanding set of requirements and helps explain why in many countries command and control has been only minimally effective in promoting improved lake basin management (while still allowing governments to give the impression of having set many standards and having taken action).

In other cases, policies send signals or create incentives/ disincentives to change behavior. These policies are generally referred to as "market-based incentives" and either use existing markets or create new markets. Just as with command and control policies the market-based policies usually require monitoring and institutions to help enforce them.

*Policies that Use Existing Markets*

Markets and market prices are very powerful senders of signals—a higher price for a food or fish product will cause farmers or fishermen to increase production, a higher price for fuel or inputs will decrease incomes and may cause a shift in technology. Even subsistence farmers and fishermen are affected by market price signals, although the impact may be quite indirect and lagged in time. The policies that use prices to send signals are the most important category of what economists refer to as "market-based incentives" or MBIs.

Economists accordingly place a lot of emphasis on "getting the prices right" and the power of the market (and prices) to change behavior. There are several reasons for this:

- Market signals (prices) affect most people and normally do not require direct government intervention once the price has been set
- Market signals affect both those who are in the market and those who are only marginally involved
- People respond to market signals (prices)
- Market signals (prices) can change quite quickly and hence are a fairly responsive policy tool (think of the impacts in changes in the price of fuel or water)
- Market signals can be used to both reward good behavior (e.g. a subsidy for use of environmentally friendly equipment), or to punish undesirable behavior (e.g. a tax to discourage over use of a scarce resource or to discourage polluters)
- Changes in market prices is a classic way to “internalize environmental externalities” , and thus encourage more efficient resource use. A higher price for pesticides, for example, helps the price reflect the costs of pesticide pollution of water, and also encorgaes farmers to use less pesticide and use it more carefully.

Having said this, it is usually not a simple political process to introduce these changes. Since the well-being (welfare) of people is being affected, there will always be pressures to resist changes by those who will lose something due to changes in prices. This is natural—no one wants to pay more for anything (e.g. water for drinking or irrigation, fishing permits, waste water discharge permits) even if they agree that the current price is too low—and has some subsidy built into it. The people who receive free or subsidized services (or free access to certain lake resources) almost always feel that the lower price is the “correct” price and will fight efforts to raise the price. Whether they are successful or not in preventing efforts to increase prices (or restrict use) often depends on their political power. In addition, when those affected are low-income fishermen or farmers, there are important distributional issues about any new burden—can they afford the new costs (even if the costs are fully justified)? Are there other groups receiving subsidies who could (and should) pay more, and maybe provide a cross-subsidy to lower income resource users? For example, the Lake Naivasha Brief raises interesting questions about who benefits from the uses of the lake waters (flower growers, fishermen, traditional pastoralists), and who should shoulder what portion of the costs of improved management.

The one exception where some users *may* be willing to accept an increase in a charge or price for a previously free or under priced resource is where the user group sees that some action or investment is needed or else they will *all* lose in the future. This form of “enlightened self-interest” is unfortunately less common than one would like, but examples do exist. In Asia for example, both the fish pen operators in Laguna de Bay and the pulp industry in Lake Toba have accepted a new fee/charge in hopes of assuring the longer-term financial (and ecological) sustainability of the lake resource and their industry.

*Policies that Create Markets*

Sometimes *markets are poorly developed or lacking*—this is usually due to poorly defined property rights or where past use was limited and did not put pressure on the sustainability of the resource. In a fishery, for example, if the previous levels of catch were below the MSY—maximum sustainable yield—there was no need to regulate or control the catch—there were enough fish for all users. However, with population growth or introduction of new technologies (such as bigger boats or more effective fishing gear) this situation often changes. Users begin to compete with one another and the resource begins to degrade.

In these cases it may be possible to create a new market and then reap the benefits of market-based policy tools. For example, if the lake fishing industry is an open-access resource (e.g. anyone with a boat can catch fish) it may be possible to *assign property rights* (or catch quotas) to lakeshore communities. The fish have then become an economic commodity and the entitlement holders (those individuals or groups with the property rights or the catch quotas) now own an “economic asset” and have increased interest in and options for managing the fish resource. The newly enfranchised owners of the fish resource may chose to harvest their allotment, sell their quota to another group, or wait until later to harvest their share. This is not unlike what happens when grazing lands or forest lands are changed from communal open-access resources to resources that have identifiable property rights.

Note that communal resource management can work in some settings (usually where there are smaller, more homogenous groups), but the history of open access fisheries is full of examples where over fishing resulted in serious degradation of the fish resource. Some of the issues of communal management of resources are discussed in Chapters 2 and 5.

Another type of policy that creates a market is where there is *a new or expanding use*. In many case, for example, sport fishing in lakes has been traditionally unregulated and untaxed. The introduction of “user fees”—a license fee, a per catch charge, a daily admission fee—are all ways that a market can be created. Once the market is created the policy instruments or tools that are used are the same as those found under the third category (Policies that Use Existing Markets).

A final example of “market creation” is found in many international lakes or lakes that are designated as Ramsar sites. In these cases the lake basin and its resources have been recognized as having international benefits and international “stakeholders” in their management. This recognition is often accompanied by additional funding to help pay for management and the production of these trans-national benefits. The GEF has been actively funding management of international waters (including lakes) and many bilateral agencies and NGOs help pay for management in specific lakes that yield important biodiversity or other environmental benefits.

### The Policy Matrix

Policy-making is a creative process and successful policy-making is almost always a combination of several different policy instruments or tools. The institutional framework for implementing new policies is equally crucial. It is not possible (nor desirable) to be prescriptive with respect to which policy is best for each problem. Since policies are designed to affect people and their behavior, what works in one situation may not necessarily work in another. Successful policy implementation depends on many factors—socio-cultural factors, institutional dimensions, the extent of market development and public confidence in the “system” and various aspects of what economists call “social capital” (See Box 4.2).

**Box 4.2. Social Capital**

Social capital is the sum of the beneficial ways that different members of a society interact with one another. It is often the missing ingredient in creating a successful policy intervention. Societies with higher levels of social capital have greater possibilities of reaching co-operative solutions, and using self-discipline to enforce required changes. Social capital is not the same as economic wealth—some poor societies can have a large amount of social capital (especially if the population is fairly homogenous). One characteristic of societies with large amounts of social capital is a “shared vision”— the Costa Rican public’s view of the role and importance of the environment is one excellent example. The lack of social capital, in contrast, is often marked with distrust, cynicism, and failure to find co-operative solutions. Unfortunately, in many of the world’s lakes (especially those with very mixed, ethnically diverse populations and sharp competition for available resources) social capital is scarce and this makes implementation of new policies very challenging.

Table 4.1. The Policy Matrix—Selected Applications to Lake Basin Management

| | | Engaging the Public | | Command and Control | | | Creating Markets | | |
|---|---|---|---|---|---|---|---|---|---|
| By sector or theme | | Information Disclosure | Public Participation | Standards | Bans/Quotas | Zoning | Property Rights/ Decentralization | Tradable Permits/ Rights | International Offset Systems |
| Resource Management | Water resources | Lake-based NGO (Victoria) | Public awareness (Chilaka, Biwa) | | | | | | |
| Resource Management | Fisheries | | Fishing management (Laguna) | Licenses (George) Gill net size (Victoria) Gear standards (Peipsi) | Fishing moratorium (Baringo, Naivasha) | Fish pen zones (Laguna) | Fish pen licenses (Laguna) Fishing concession (Ohrid) | | |
| Resource Management | Land Management | Village level environmental conservation groups (Nakuru) | | | | Land use control (Naivasaha, Dianchi, Toba) | | | |
| Resource Management | Sustainable Agriculture | | Flower growers co-operative (Naivasha) | | | | | | |
| Resource Management | Biodiversity | | | Lake level control (Toba) | | | | | |
| Pollution Control | Water Pollution | | | Water quality standards (Dianchi) | | Detergent bans (Champlain, Biwa) | Land use planning (Dianchi) | | |
| Pollution Control | Solid Waste | | | Relocate landfill (Nakuru) | | | | | |
| Pollution Control | Hazardous Waste/Toxic Chemicals | | | | | Land use controls (Dianchi) | | | |

Table 4.1. (cont.) The Policy Matrix

| | | Using Markets | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Environmental Taxes on | | | User Fees for | | |
| By sector or theme | | Subsidy Reduction | Emissions | Inputs | Products | Natural resources | Services | Targeted Subsidies |
| Resource Management | Water resources | | | | | | Payments from downstream water users (Biwa) | Raise water level (Sevan, Aral Sea) Improve water quality (Aral Sea) |
| | Fisheries | | | | Fish levy (Victoria) Fish pen fee (Laguna, Ohrid) Fish catch (Ohrid) | Fishing licenses (Champlain) | | |
| | Land Management | | | | | Environ-mental mgt fee (Toba) | | Reforestation (Dianchi) |
| | Sustainable Agriculture | | | | | | | Watershed areas (Naivasha?) |
| | Biodiversity | | | | | | | |
| Pollution Control | Water Pollution | Fertilizers subsidy reduction (Peipsi,) | Industrial pollutants taxes (Laguna, Dianchi) | | | | | Sewage/ wastewater treatment (Great Lakes, Dianchi) |
| | Solid Waste | | | | | | | |
| | Hazardous Waste/Toxic Chemicals | | | | | | | |

Policies have to be tested and proved in the field and it is difficult to predict in advance whether or not a policy will be completely successful. The case studies provide many examples where well-intentioned policies were ineffective, or where policies successfully used in one setting failed in another.

One aid to policy making is the use of a Policy Matrix—a simple device that lists the main potential policies on the columns (grouped by the five major policy types introduced earlier – engaging the public, rules and regulations, using markets, creating markets, and engineering solution)) and the major management issues on the rows. The different cells of the matrix are then filled in with examples drawn from the case studies and the literature. See Table 4.1 for an example of a Policy Matrix and selected examples of its application to lake resources management. The Policy Matrix draws from examples in this chapter as well as the chapter on People (Chapter 5).

For example, the common problem of over fishing can be addressed by any number of different policies. Although what is likely to work in any particular lake will depend on the situation in that lake, a set of potential policies that could be considered to control over fishing include the following:

- Auctioning of pre-determined catch quotas (using a market), or
- Assignment of new catch quotas that can then be bought and sold (creating a market), or
- Restrictions on the types of fishing gear allowed, fishing effort, or allowable catch (command and control approaches), or
- Public information campaigns to encourage fishermen to limit or restrict their catch (public information/ involvement).

Obviously the selection of an appropriate policy, or **mix of policies**, is likely to very site-specific. See Box 4.3 for an example from Lake Dianchi or using a mix of policies to address water pollution. Even when command and control approaches are chosen to address a problem, public information and consultation may be essential in gaining acceptance of (and compliance with) the new policies. Since policies basically are designed to change human behavior, we must never lose sight of the importance of properly consulting on and explaining the new policies if they are to be successfully introduced. Those societies that have gained recognition as being “environmentally friendly”—Costa Rica is one example—have been able to do this largely through public education and participation, and obtaining political support at the highest levels of government. Otherwise improved environmental management will always be everyone’s second (or third) priority.

**Box 4.3. Lake Dianchi, China—A mix of policies to improve lake water quality**

Water pollution was a major problem in Lake Dianchi in China. Although Kunming, the capital, obtained its primary water supply from the Song Hua Ba reservoir, Dianchi was an important water source for Kunming in dry years as well as serving industry and agriculture. Pollution came from sewage, industrial effluents, irrigation return flow and storm run-off. The municipal government responded with a combination of policies—strengthen administration and enforcement of laws and regulations, and new investments totaling more than 2.1 billion yuan (about $250 million). The investments were supported in part by a World Bank loan. Large engineering investments were made in sewers and water treatment facilities, and industrial polluters began to meet discharge standards.

Still, numerous old industries remained important sources of pollution. A pollution levy system had previously been introduced into China and was being applied in the basin along with the discharge standards under which industries were charged a penalty if their discharges exceeded the discharge standards. The charges provided an incentive for industries to take steps to control their pollution. They were assisted in making pollution reducing investments by government loans and grants, funded in part by the revenues collected from the pollution levies, as well as from additional government funds for environmental protection. This “carrot and stick” approach, combining discharge standards, pollution charges, and loans for pollution-reducing investments, has been used in many locations to help encourage industries to reduce their pollution.

In Dianchi progress has been reported in reducing pollution in the lake. Compared with 1995, by the year 2000 industrial wastewater discharged was reduced by 60%, COD was reduced by 80%, and soot, dust and $SO_2$ were all significantly reduced. These benefits, largely due to capital investments and management improvements, have been supported by an active program of citizen’s involvement and public dissemination of water quality information. In order to help repay loans for the capital improvements and their operation and maintenance, the city also began to charge user fees via water charges, and fees for wastewater treatment and domestic solid waste disposal. The management challenge remains since Kunming is growing rapidly and is the economic hub of the province. Still the example of management of Lake Dianchi illustrates the application of a number of different policy tools to work together towards the longer-term goal of improved lake water quality.

## Lessons of Past Experience: Increasing the chances for successful policy implementation

Given the “Chinese menu” approach to policy making (selecting one policy from this category and another from another category)—and the many possible ways to achieve any given objective—what suggestions can be made for effective policy design? Based on considerable worldwide experience with implementing environmental-management policies, five broad lessons have been learned about what is likely to make a successful policy package. Again, one cannot be prescriptive but successful interventions in many environmental management areas indicate that successful (e.g. effective) programs often share these characteristics:

**Build “political will”**. Without the support of the general public and the political establishment it is usually impossible to implement effective management. Whether this is done by grass-root level efforts, or a carefully developed public information campaigns, the creation of interest in and commitment to improved lake basin management is an essential component of improved management. Often referred to as “political will”, this merely means that governments and management authorities are committed to take actions and enforce changed policies.

Governments rarely lead with respect to improved environmental management—they usually follow demands from the public. Once the general public is committed to change, it is a powerful incentive for governments and management authorities to take actions and enforce changed policies. Accordingly, the role of an informed and involved public is essential in creating the “enabling framework” for improved lake basin management. Active citizen involvement has helped create political will to take action in lakes as diverse as Biwa, Sevan, Constance or the Great Lakes.

**Achieve financial sustainability**. Successful programs usually generate some or all of the revenues needed for their management. Fortunately a number of potential policies have the attractive feature of helping reach an environmental or economic objective while also generating resources (e.g. money!) that can be used to pay for management. Examples include the use of “user fees” or other use-based charges. For example, expanding lake–based recreation and the implementation of a user fee can help put management on a self-financing basis. Some of these approaches are discussed in Chapter 8 on financing.

As mentioned earlier, there are serious sustainability questions about management programs that are entirely dependent on either outside funds or the use of subsidies. If local financial support (e.g. income) is not developed, when the external source of funding ends, so may the management program. There are too many examples of lake management initiatives or research programs that lasted only as long as the external funding. External resources should therefore play more of a **catalytic role rather than an implementing role**. A number of the case studies illustrate this point.

**Ensure administrative sustainability**. Linked to the financial issue is the administrative and institutional requirement needed to implement any new set of policies. Effective policies have to fit within the institutional capabilities that exist, or the new policies have to provide sufficient resources to develop and strengthen institutions. Command and control polices (e.g. regulations) may be particularly demanding with respect to institutions – both for monitoring and imposing any needed sanctions. Again, experience around the world illustrates the difficulty in building institutions that are effective and sustainable—and this is increasingly difficult when the scale of the institutional responsibility increase. Localized institutions may be easier to set up and maintain than regional, or international institutions.

**Build effective constituencies for change**. In addition to the broader issue of building “political will” for change, managing lake basin resources usually means managing various groups of people, often with quite different interests. As pointed out by Carpenter and Cottingham “the fundamental problem of lake restoration is an economic mismatch: those who cause the problem do not benefit sufficiently from the remediation.” Therefore, building a sense of “community” and ownership among the various “stakeholders” is essential if new policies are to be implemented. A strict enforcement-only approach (basically a command and control approach) is unlikely to be successful, especially in the longer term. Lake management, since it often involves large numbers of users, many of whom are poor or “marginalized” members of society, is especially challenging. This point is well illustrated by many of the case studies.

**Actively work towards policy integration**. Policy integration means that different policies in different sectors of the economy need to work together to obtain the desired objectives. While this is a simple statement to make, actually practicing it requires that analysts, planner and decision makers explicitly consider the external impacts of their more narrow sectoral policies. For example, attempts to improve lake water quality are hurt when agricultural development policies designed to increase grain production provide subsidized fertilizer or agricultural chemicals in the upper watershed, thereby promoting increased chemical use and increased grain production (a good thing) but resulting in increased chemical inflows into the lake and reduced water quality (a bad thing).

The focus on the role of science and technology in this report (see Chapter 6 and 7) helps inform this debate. Policy integration is never easy since it requires different parts of government or the management structure to change what they would normally do. Although the higher objective is “improved lake management”, the direct implication at the sectoral level may be to decrease output (c.f. the agriculture example given above).

In addition, if policy integration within a country is difficult, the problems are compounded when the lake is an international lake and lake management must incorporate more than one country and many different government entities. The Great

Lakes Commission of the United States and Canada illustrates the slow, but quite successful, evolution of an international management regime. The numerous difficulties in implementing improved management in Lake Victoria, in contrast, illustrate the remaining challenges.

**Policies, Policy Tools and Governance**

This chapter has focused on policy tools (*how* one gets something done) that are used after one has decided on more general policies (*what* one wants to accomplish). Linking policies and policy tools is the whole issue of governance and institutions (*who* will get something done). As discussed in Chapter 3 on institutions and governance, creating effective governance institutions is one of the major challenges of development. And lake basin management, given the diverse set of stakeholders in most lake basins with often conflicting interests, is one of the more difficult governance challenges.

Chapter 5 discussed the role of participation and people in improved lake basin management. As the chapter stated forcefully, involving people is not an option in lake management, it is essential. However, all of the issues discussed up to now, including the role of people, are necessary but not sufficient conditions for improved lake basin management if taken one by one. Chapter 3 on institutions and governance shows how these different concerns can be linked and made to work together.

# Chapter 5: Involving People: Values, Education and Participation

**Key Lessons Learned about People**

This chapter needs a complete re-write. Material from Chapter 4 on involving people appears at the end and needs to be integrated or put back into Chapter 4.The following lessons may emerge after re-write…

- Good policy must reflect the desires of the people. (People supply endpoint)
- Policies developed without participation of stakeholders cannot be effectively implemented.
- One key way of preventing lake value degradation is to internalize social norms into people's behavior through education.
- Awareness raising can go a long way in tackling lake problems.
- Relevant stakeholders include those with a right, those at risk and those with responsibility. (Or, not everyone is a relevant stakeholder.)
- Reliance on civil society to reflect the will of society as a whole shortcuts the democratic process and gives faction dangerous power.

Managing lakes means managing people. In fact, one of the most difficult elements of effective lake management is the shift from considering "people" as a homogeneous and passive citizenry that "receives governance," to one recognizing "people" as active participants in the process of lake management. The lake briefs contain many examples of engineering solutions that were only partially effective – and for which it was necessary to involve people to achieve the management goals. A basic conclusion, therefore, is that behavioral change at the individual, household and community levels is essential, and that "involving people" is an essential, not optional, part of effective lake management.

Involving people for effective lake management is not a new concept. The World Lake Vision stated that:

> "Citizens and other stakeholders should be encouraged to participate meaningfully in identifying and resolving critical lake problems."

Involving people (so-called public participation) provides individuals and groups with a forum for informing decision-makers about their views. It focuses primarily on involving, informing and consulting the public in planning, management and other decision-making activities. In fact, of all the policy tools available to facilitate effective lake management (see Chapter 4), decision-makers most often underestimate the potential of those policy tools that involve the public. This is in part because the public participation process is more bottom-up and consultative, while the traditional decision-making and policy-making framework is top-down and dictated, usually by governmental entities. The challenge, therefore, is to make the involvement of people "meaningful," and to also develop mechanisms for resolving conflicts when consultation alone is not sufficient. The rhetoric is clear: Effective lake basin management ideally should involve all citizens and stakeholders in the process. As noted in Chapter 7, one of the requirements for meaningful public participation is to provide the information and data needed to make the public aware of the magnitude of given lake problems, and the public's role in both causing and solving them, as well as the ultimate environmental and socioeconomic consequences if the problems are ignored. Fortunately, the various lake briefs, as well as the results of three regional workshops, support this principle and provide insight as to how to begin to put it into practice.

The lake briefs show that local communities and non-governmental organizations (NGOs) are among the stakeholders that can significantly affect the outcome of management efforts in lake basins. They demonstrate that active community participation also can be vital to reducing poverty and achieving social equity and sustainable development in lake basin management.

**Who are the “People”?**

Different stakeholders are involved in different phases of the lake management process, and this stakeholder participation takes place at different levels of governance—community, local, national or international, or a mix of these. Various methods, ranging from information sharing to empowerment, can be used to match the different circumstances, capacities and needs of lake stakeholders. It is logical, therefore, to ask who are the “people” (the public) to be involved in lake management? A broad definition is that the public comprises the people within a country or locality, or a community within a specified region. It typically comprises people of diverse, sometimes conflicting, interests and attitudes, as well as groups of people with a common interest. Relevant groups include drainage basin ‘citizens’, businessmen and industrialists, farmers and agriculturalists, environmentalists, non-governmental organizations, international organizations and professional societies, funding agencies and even governmental entities in some cases. For the purposes of this report, the public is taken to mean all those people and groups with an interest in the supply, use, management and/or conservation of lakes, whatever their individual views, complementary or antagonistic.

To this end, principal lake stakeholders include the following:

*Farmers and Agriculturalists*

In many parts of the world, productive farming requires irrigation, and farmers were among the largest water users in 7 of the 28 lake basins. Lake Baikal is the most striking example in this study of the significant human health and ecosystem effects of excessive water abstractions on the lake and its basin. Because agriculture uses substantial amounts of fertilizers and pesticides, which can seriously degrade lake water quality, water awareness programs typically target farmers to improve agricultural management practices.

*Business and Industry*

Every society faces trade-offs between the production of things people need or want, and the waste generated as a result of the production. The resulting water quality degradation has both human and ecosystem health implications. Further, parastatal hydroelectric power companies constructed the two modern dams in this study (Tucurui, Kariba). Dams also had a major effect on Lakes Ohrid and Toba, where major rivers were re-directed to flow into the lake basin.

Domestic and international tourists also are drawn to lakes for their scenic beauty and recreation (swimming, fishing, etc.). Thus, tourism is, or is hoped to become, a major industry for more than half the lakes in this study. A combination of good water quality and cultural heritage sites are essential for successful tourism, and many of the lakes in this study are striving to re-orient their tourism based on scenery, protected areas, and cultural heritage. Tourism development strategies are evident in varying degrees for Lakes Baikal, Biwa, Champlain, Cocibolca, Constance, Dianchi, Issy-Kul, Ohrid, Sevan, Titicaca, Toba, and the North American Great Lakes.

*Youth*

Environmental education can be a very effective tool for public involvement, particularly when directed to children. It also must be approached, however, as a continuous, lifelong process, ideally beginning at the elementary school level. Further, the best results are usually gained when relevant educational activities are conducted in direct contact with nature. However, only a few lake briefs specifically mentioned lake programs targeted to children, a major example being Lake Biwa. More than 300,000 5$^{th}$ grade students have participated in a two-day work-study program since 1983 on a “floating school” ship. For

Lake Peipsi, more than 5,000 children a year have participated in an international creative works contest, "World of Water Through the Eyes of Children," since 1996.

*Indigenous People*

As used here, the term 'indigenous people' refers to traditional occupants of portions of a lake basin that may be distinguished from other groups in national society by their language, culture or economic activities. From a national perspective, they are typically considered minorities, although they may form the dominant population in a given lake basin. The traditional knowledge and belief-systems of indigenous peoples, however, are based on sustainability and living in harmony with their environment, and can be invaluable in promoting good lake management.

Neglecting indigenous peoples had negative impacts for several lakes in this study. A disregard of the indigenous fishing community in the Lake Chilika basin, for example, it was a source of conflict between the "gheri" fishermen and the increasingly marginalized indigenous fishermen, the latter typically employing sustainable fishing practices. The Tonga people in the Lake Kariba basin were forcibly displaced to build the Kariba Dam, without consideration of its prolonged negative impacts on the Tonga community. Positive experiences also are available in the lake briefs. In the case of Lake Titicaca, for example, the Binational Authority, in coordination with the lake's indigenous communities, greatly facilitated monitoring and lake regulatory activities.

*Women*

Among the four Dublin Principles for water management, the third principal specifically refers to the issue of women's participation: *"Women play a central role in the provision, management and safeguarding of water."* Few lake briefs, however, acknowledge women's participation in implementing water programs and projects. One is the Participatory Rapid Appraisal (PRA), a successful technique for Lake Toba in which women were invited to participate in community meetings. Women also organized the previously-noted "Soap Movement" to eliminate the use of phosphorus-containing detergents in the Lake Biwa basin (see Box 5.1).

*Non-Governmental Organizations (NGOs)*

The term 'NGO' generally denotes formal groups of organized individuals for a variety of reasons. With memberships ranging from local to global, NGOs can advocate a particular cause or carry out programs . As used here, the term NGO refers to non-governmental organizations that are intermediaries in the process of facilitating policies and projects at the local community level. NGOs can play an important role in developing the capacity of local communities for self-mobilization and collective action, including helping marginalized community groups lacking the capacity to appropriately articulate their demands.

*Local Governments*

Although not a 'public' stakeholder in the traditional sense, local governments can play a central role in improved lake basin management. Constituted as municipal, district and regional or state governments, local governments are the bodies 'closest to the ground,' with the responsibility of feedback, initiation of ameliorating activities and execution of policies, and usually have the major day-to-day responsibility for development. By the nature of their commitment, they are often best placed for facilitating this dialogue at the cutting-edge execution level.

There is widespread agreement that what is required for effective management is *'to make **distributed governance** effective.'* Distributed governance describes a system whereby the State no longer acts alone. Rather, many different parties—government, civil society, private sector, individuals—have roles and responsibilities. As the level of government closest to the people, local governments are key actors in the field of freshwater management. Their position as a service provider, coupled with their ability to create behavioral change in their communities, afford them the opportunity to influence public responses to water use and mismanagement.

The first type of 'local authority' comprises lakes (and their basins) managed by a local government, or a number of local governments acting together, which is only possible when the lake lies within the boundaries of a single country. The Bhoj Wetlands, for example fall under the jurisdiction of the Bhopal Municipal Corporation (BMC). The state government executes the lake plan using its departments as well as the BMC. Lake Baringo is controlled by the Baringo County Council, with the lake being managed via a committee with governments, community and NGO representatives.

A second class is represented by Lake Naivasha, wherein the initiative for lake management came from local stakeholders, primarily through LNRA, an association of property holders that expanded its membership to become more representative. It developed a lake management plan approved by the national government, also forming the LNMIC as a wide body with additional representation from the district and national level. LNMIC has no legal powers or formal budget, however, and the lake management plan is implemented through consensus building.

Lake Biwa (managed directly by the Shiga Prefecture) and Chilika (under the direct control of the state government, with full regulatory and executive powers) are a third type, managed by single regional governments with jurisdiction over the lake. The powers of such governments are more effective than municipal or district bodies, and do not depend on authority delegated by national governments.

Some lakes fall within the boundaries of a single country, but are managed directly by the national government (e.g., Laguna de Bay, Lakes Nakuru, Tonle Sap, Tucurui, Issyk-Kul and Sevan). Only preliminary lake management studies have been carried out for the latter four cases. The Laguna de Bay case, however, is particularly instructive, since the LLDA enjoys wide regulatory powers and has been successful in identifying several management initiatives.

The largest type in this study comprise lakes shared between a number of different countries, ranging from two (Aral Sea) to five (Lake Chad). A lake authority or project has usually been set up by an interstate treaty/agreement to manage the lake, with powers being delegated to the authority. These situations range from model arrangements (e.g., Lake Champlain, with broad participation from all stakeholders) to more informal structures (e.g., Lake Constance, where the stakeholders participate through indirect means). For Lakes Dianchi and Nyasa/Malawi), no such authority has yet been established, with lake conservation efforts remaining uncoordinated.

Resources, professional support and capacity building of local bodies are needed to facilitate achievement of their desired functions. To this end, national governments must be more receptive to facilitating the access of local governments to financial and information resources, and to providing an enabling environment in which priority issues, defined at the local level, can be addressed. Thus, a strong and equal partnership is needed between all spheres of government—local, national and international.

**Public Participation and Empowerment**

Public participation in environmental management is a complex issue involving many aspects. The term 'public participation' is used in differing ways in different cases, sometimes being interchanged with other terms (e.g., stakeholder or citizen participation). According to the World Bank (2000) there are four exclusive levels (or types) of participation. In ascending order, from least influence to most influence, they include: (1) information sharing (one-way communication); (2) consultation (two-way communication); (3) collaboration (shared control over decisions and resources); and (4) empowerment (transfer of control over decisions and resources). These levels are not indicators of scale, but rather distinctly different ***types*** of participation. It is not necessarily assumed, however, that all participation is good, or that a higher level or more participation is automatically better. Its ultimate value depends on the particular lake management situation. Some rationale for public participation and involvement in lake management are summarized in Box 5.2

The experience from most developing countries suggests that international actors constitute an important stakeholder group. Through multilateral or bilateral programs and international NGOs, international donors can play a unique, critical role in translating global institutional agendas and local grassroots agendas into a common policy for managing lakes for their sustainable use. Further, international stakeholders often facilitate the critical technical and financial assistance for developing and establishing participatory lake basin management in developing countries.

*Community-level Participation*

At the community level, stakeholders can be individuals and/or community-based organizations (sometimes referred to as primary stakeholders). In this report, they refer to local communities involved in lake basin management, referred to as community-level participation. The term ‘community’ is used to designate both communities-of-place and communities-of-interest. Communities-of-place include members of the public who may be affected by, or interested in, lake management decisions and actions by virtue of their residency at or near the locations of management interventions. Communities-of-interest include groups with a focused interest in management of resources unrelated to their residences. Some communities can be both of place and interest (e.g., villages highly dependent on fishery, forestry or agriculture).

**Lessons Learned Regarding Public Participation**

Communication, education and public awareness are major elements for trying to change human behavior. In the public participation process, communication is a two-way exchange of information, ideally leading to mutual and enhanced understanding, and facilitating cooperation between different groups in lake basins. Education refers to the process of informing, motivating and empowering people to be effective stakeholders. Awareness involves bringing lake issues to the attention of individuals and key groups with the power to influence outcomes. Awareness tends to be an agenda setting and advocacy exercise meant to help people understand why lake management is an important issue, the management targets, and what is being done (or can be done) to achieve them.

Based on the lake briefs, a number of best practices for public participation, and tools for information dissemination are summarized below. Additional information is provided in Boxes 5.3 and 5.4.

- **Active participation of the local community is vital to managing lakes and their resources for sustainable use**. Achieving meaningful community-level participation can be difficult, and depends on the degree of the community awareness of the important technical and social issues. Thus, local community involvement in lake management efforts should be accompanied by public awareness and information campaigns. In the Lake Baringo case, for example, the awareness-building program was linked to establishment of four wildlife sanctuaries managed by local communities.

- **Effective participation of local communities depends on social organization that establishes manageable groups within a community**. Communities may lack knowledge on how to build community institutions that represent a community's diverse interest groups or the capacity to act collectively. Thus, local community involvement needs to be supported by various measures to develop the capability for collective actions. NGOs can play an important role in this task, particularly in helping marginalized community groups.

- **NGOs can play an important role in the implementation of projects and activities directed to integrated lake basin management.**

  Based on the experiences in this lake initiative, an important set of policy instruments is the set of policies or actions that involve the public in some way, ranging from relatively "soft" approaches (public information and publicity campaigns), to more targeted techniques (public participation exercises, public consultation), to more extreme approaches (public oversight committees with assigned powers). Nevertheless, although public participation offers great potential, it is no panacea. It is an essential, but not always sufficient condition, for developing and implementing improved lake basin management regimes.

  In almost all cases, however, the potential for using public participation and awareness to improvement lake basin management are substantial. As noted in the lake briefs, these approaches tend to be more successful in lakes where the population is better educated, better informed and wealthier. By definition, they also are usually willing to forego some present private benefit for a greater public gain. In poorer societies, however, this may be a less feasible approach, since people would likely be unwilling to give up any present income possibilities without some alternative being available.

- **Appropriate indicators of success are needed to assess the effectiveness of lake management interventions**
  Environmental and socioeconomic indicators provide a means of identifying lake problems, their root causes and potential impacts, and particularly for assessing the degree to which a lake management intervention has been successful (or not). The SOLEC experience (State of the Lake Ecosystem Conference) in the North American Great Lakes provides valuable insight into the difficulties of developing and using indicators that are insightful in regarding to identifying the magnitude of the management problems being faced in the lakes and their basins, as well as in evaluating the success (or not) of addressing these problems (see Box 4.1). Although much work remains to be done on this topic collectively by the scientific and management community, there is no doubt that a set of meaningful, measurable and understandable indicators represents an important means of identifying problems, assessing management options, and ensuring the awareness of the public and lake decision-makers of their necessity. Such indicators also can be valuable in changing the community attitudes toward the need for lake management interventions, including the possible impacts of what might happen if nothing is done.

**Box 5.1. "Soap Movement" in Lake Biwa Watershed**

A well-known example of public involvement is the case of the so-called Soap Movement in the Lake Biwa drainage basin. The initial problem was the occurrence of red tides, and their impacts on the lake's water quality, and a growing public awareness of the links between water quality, red tides and the use of phosphorus-containing synthetic detergents. Started initially by a woman's consumer group, the detergent manufacturers actively resisted change, and fought the Soap Movement. This manufacturer's resistance resulted in an increased level of awareness about the problem throughout the Shiga Prefecture, and actually helped ensure the very opposite result from what the manufacturers wanted (e.g., banning of phosphate-containing detergents). In this case, the impetus for change clearly came from the people, and the government responded to this movement with enactment of the Eutrophication Control Ordinance of 1979. The Lake Biwa example illustrates the potential synergies between public involvement (crucial, but not sufficient by itself) and government action (in this case, a regulatory policy) that resulted in an effective response to Lake Biwa's water quality problem related to phosphate-containing detergents.

**Box 5.2. Some Important Rationale for Public Involvement and Participation**

- In democratic societies, government policy agendas (including natural resources) are fundamentally defined by the public;
- Policies and decisions that include significant inputs from public participation and consultation tend more often to be 'publicly owned' than those that without such inputs;
- Public participation allows governments and decision-makers to 'tap' into local and indigenous knowledge;
- Stakeholders affected by management decisions will not feel that their views were not considered (even if not completely used);
- Large parts of lake and reservoir basins are owned by the public (individuals rather than the state) in many countries;
- Management decisions often can be reached more expeditiously, following public participation (i.e., fewer time-consuming objections);
- It is 'good business' to give the customer (i.e., the public) what it wants;
- Best practice environmental management recognizes the good sense of proactive community involvement and consultation.

(*Source: Trudel et al., 2002*)

**Box 5.3. Best Practices for Public Participation**

- Written MOUs to denote partnerships, cooperative agreements, etc.; "soft law" can be as important as laws and regulations;
- Legal requirements for open information and accountability;
- Permits for foreign investments need to include community consultation and an environment impact assessment (e.g., fish farms for Lakes Cocibolca and Toba);
- Engaging community groups, both formal and informal, is an effective way to involve people; formal groups have a greater likelihood of sustaining results and activities;
- Support for local watershed groups, etc., through small grants and other forms of technical assistance. The best practice is to provide both project funding, and financial support for basic operating costs of groups working to achieve basin management goals;
- Education and Science centers are important (e.g., Lakes Chilika, Champlain, Laguna de Bay);
- Information, education and awareness are a starting point for effective involvement;
- Gender perspectives should be considered, including important role of women, gender training (Lake Nakuru), sensitization to gender perspectives, etc;
- Recognizing and building upon the connection between people and their cultural heritage, as well as formal designations (e.g., World Heritage Sites, Biosphere Reserves, Ramsar sites);
- Mapping the watershed and presenting it to stakeholders is fundamental to establishing a basin-wide perspective;
- Participatory Rural appraisal (PRA) technique has been effectively adapted and applied in several developing country situations in Africa and Asia;
- Involving people is essential for basin management practices related to land use for controlling soil erosion and urban runoff through the conservation and management and management of agricultural and forest lakes (e.g., Lake Nakuru basin);
- Institutions, whether formal or informal, need to be created to facilitate and coordinate public involvement;
- Community-based (bottom-up) approaches to lake basin management help encourage participation of citizens and stakeholders, and can lead to better management results. However, the community-based approach must be implemented within the context of existing governance structures and in coordination with relevant lake basin institutions
- Involvement of citizens and stakeholders should be done as early as possible in the lake planning and management process;
- A democratic governance framework, although not essential, can facilitate the process. Even in highly-developed democracies, however, it remains a challenge to get citizen involvement.

**Box 5.4. Information Dissemination Tools**

Innovative tools for dissemination information include:

**Resource, education or exhibition centers—**Places where information generated through research and monitoring programs can be collected, collated and distributed through media such as print, Internet, television and other audio-visual means. These centers also provide a focal point for organizing campaigns, public forums and socio-cultural activities. Such centers have proven successful for Lakes Champlain, Chilika, Biwa, Nakuru (youth hostel) and Sevan, and the Bhoj Wetlands. In the Lake Ohrid basin, "Green Centers" were established in Macedonia and Albania to serve as clearinghouses to connect NGOs to each other and to provide the critical information they need to mobilize public interest and action.

**Participatory Rural Appraisal** (PRA) programs—An avenue for disseminating information, particularly to local communities. They have been utilized, for example, in the Lake Baringo basin to dissemination information on the resource values of the lake system.

**Models or pilot programs—**Useful for demonstrating the possibilities and advantages of conservation actions (e.g., Lake Naivasha).

Chapter 4 material by JAD.

One important set of policy instruments or tools is the set of policies or actions that involve the public in some way. These include such relatively “soft” approaches as public information and publicity campaigns, to more targeted techniques like public participation exercises and public consultation, and, at the extreme, public oversight committees with assigned powers. Public participation offers great potential but is no panacea—it often is an essential but not sufficient condition for formatting and implementing improved management regimes.

In almost all cases, however, the potential for using public participation (and awareness) to improve lake management are substantial (see Chapter 5 for more on the potential for involving people). Not surprisingly, people-centered approaches often tend to be more successful in lakes where the population is better educated, better informed, and wealthier and by definition willing to forgo some present private benefit for a greater public gain. Is this borne out by Briefs?? In poorer societies, this may be less feasible since people are unwilling to give up any present income without some alternative being offered. As seen in many locations, public consultation and participation *per se* are no guarantee of improved or successful management—different groups can still have conflicting objectives and may agree to consult on, but not abide by, the new proposals. Consultation is a necessary, but by no means sufficient, condition for effective lake basin management.

Of all of the policy tools available, decision makers most often underestimate the potential of those policy tools that involve the public. This is in part because the very process is more bottom-up and consultative while the traditional decision-making and policy-making framework is top-down and dictated. Nevertheless, a number of useful examples of public involvement in improved lake management are seen in the lake case studies. Slower and not “openable”

One well-known example is the case of the Soap Movement in Lake Biwa. The initial problem was the occurrence of red tides and a growing public awareness of the links between water quality, red tides, and the use of phosphate-containing synthetic detergents. Started initially by a woman’s consumer group, the soap manufacturers actively resisted change and fought the Soap Movement. This resulted in an increased level of awareness about the problem throughout Shiga prefecture, and actually helped ensure the very opposite result (e.g. banning of phosphate-based detergents) from what the manufactures wanted. In this case the impetus for change clearly came from the people, and government followed with the enacting of the Eutrophication Control Ordinance of 1979. The Lake Biwa example nicely illustrates the synergies between public involvement (crucial but not sufficient by itself) and government action (in this case a regulatory command and control (CAC) policy) that resulted in an effective response to the water quality problem. This instrument should be left to earlier chapter or else these chapters need to be merged.

# Chapter 6. Technological Responses: Possibilities and Limitations

**Key Lessons Learned about Technological Responses**

- Technological interventions by themselves are not sufficient: root causes must be addressed.
- When diverting wastewater, don't forget about the "new" downstream.
- It is cheaper to prevent toxic contamination that to dredge a lake.
- Extensive research is needed to ensure that the introduction of a biological agent to a lake will not have unexpected effects.
- If root causes of macrophytes growth (high nutrient levels) are not addressed, successful removal of one species can just make way for another species to invade.
- Water diversion schemes, while they may have a positive effect on the receiving basin, can be disastrous for the exporting basin.
- If the root cause of a problem has been controlled, then dredging can have a positive, long-term effect.

Changing people's behavior is not easy. Whether it is done by making rules or creating incentives (Chapter 4) or by internalizing new values through education and raising awareness (Chapter 5), it is a challenge. Decision makers know this. And that is why one of the first responses to a problem at many of the lakes in this study is a technological response—a "quick fix"—one that tries to alleviate a problem, often not by addressing the root causes, but by engineering a solution.

Sometimes these technological responses can have profoundly positive effects on lakes. Below, we will look at cases where measures like sewage treatment, dredging, and the biological agents have increased lake values. One of the key lessons of this report, however, is that technological responses on their own are not sufficient and is the main reason why we see a range of responses described in Chapters 4, 5 and 6.

The purpose of this chapter is to discuss the conditions under which technological responses can be useful and to extract some lessons from the lake briefs. This chapter examines "technical" conservation/remediation interventions that help protect a lake's values and does not discuss development interventions such as fish pens and hydropower dams. The technological responses described here can be broadly divided into two groups: watershed-based measures (which include point and nonpoint measures) and in-lake measures (which include biological, chemical and physical measures). Table 6.1 provides a summary of the various techniques described in the lake briefs as well as an overview of this chapter.

However, the extraction of lessons about technological interventions from the lake briefs is limited for two main reasons. First, the lakes selected for this project tend to be quite large, so many of the techniques used at smaller lakes (e.g. water-level drawdown, deep water discharge, artificial circulation, sediment oxidation) are not described. The Bhoj Wetland case (the smallest lake in the sample) is an exception which illustrates some of these potential techniques such as artificial aeration. A reader interested in a more comprehensive survey of technological responses may wish to consult reports such as Holdren et al. (2001) and National Research Council (1992).

## Table 6.1. Summary of Technological Responses at the 28 Study Lakes

<table>
<tr><th colspan="2" rowspan="4">Problem</th><th colspan="6">Drainage Basin-level Measures</th></tr>
<tr><th colspan="4">Point source control</th><th colspan="2">Nonpoint source control</th></tr>
<tr><th rowspan="2">Wastewater Diversion</th><th colspan="3">Wastewater Treatment</th><th rowspan="2">Constructed Wetlands</th><th rowspan="2">Reforestation</th></tr>
<tr><th>Conventional</th><th>Advanced</th><th>Industrial</th></tr>
<tr><td colspan="2">Biodiversity Loss</td><td></td><td></td><td></td><td></td><td rowspan="4">Extensive, including<br>Aral Sea<br>Lake Chad<br>Lake Champlain<br>Lake Naivasha<br>Lake Ohrid</td><td rowspan="4">Lake Baikal<br>Lake Baringo<br>Bhoj Wetland<br>Lake Chad<br>Lake Chilika<br>Laguna de Bay<br>Lake Nakuru<br>Lake Ohrid<br>Lake Tanganyika<br>Lake Toba</td></tr>
<tr><td rowspan="3">Eutrophication</td><td>Algal Blooms</td><td>Lake Dianchi,<br>Lake Tahoe,<br>Lake Washington</td><td></td><td rowspan="3">Lake Biwa,<br>Lake Champlain,<br>Lake Constance,<br>Lake Dianchi,<br>North American Great Lakes</td><td rowspan="3">Lake Biwa,<br>Lake Champlain,<br>Lake Constance,<br>Lake Dianchi,<br>Laguna de Bay,<br>North American Great Lakes</td></tr>
<tr><td>Low Dissolved Oxygen</td><td>Bhoj Wetland,<br>Lake Dianchi</td><td>Extensive (see Box 1 for list)</td></tr>
<tr><td>Excessive Macrophyte Growth</td><td></td><td></td></tr>
<tr><td colspan="2">Exotic Species</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Pathogens</td><td>Lake Michigan,<br>Bhoj Wetland</td><td>Extensive (see Box 1 for list)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Siltation</td><td>Various Indian Rivers</td><td></td><td></td><td></td><td>See above</td><td>See above</td></tr>
<tr><td colspan="2">Toxic Contamination</td><td></td><td></td><td></td><td>Lake Baikal,<br>Lake Biwa,<br>Lake Champlain,<br>Lake Constance,<br>Lake Dianchi,<br>North American Great Lakes</td><td></td><td></td></tr>
<tr><td colspan="2">Water Level Decrease</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6.1. (cont.) Summary of Technological Responses at the 28 Study Lakes

<table>
<tr><th colspan="2" rowspan="3">Problem</th><th colspan="7">In-Lake Measures</th></tr>
<tr><th colspan="2">Biological</th><th>Chemical</th><th colspan="4">Physical</th></tr>
<tr><th>Predators</th><th>Biomanipulation</th><th>Biocides</th><th>Aeration</th><th>Dilution/ Diversion</th><th>Dredging</th><th>Harvesting</th></tr>
<tr><td colspan="2">Biodiversity Loss</td><td></td><td></td><td></td><td></td><td>Aral Sea</td><td></td><td></td></tr>
<tr><td rowspan="3">Eutrophication</td><td>Algal Blooms</td><td></td><td>???</td><td>Ex of algicide?</td><td></td><td rowspan="3">Lake Dianchi</td><td rowspan="3">Bhoj Wetland, Lake Biwa, Lake Dianchi (Chilika Lagoon for indirect marcophyte control)</td><td></td></tr>
<tr><td>Low Dissolved Oxygen</td><td></td><td></td><td></td><td>Bhoj Wetland</td><td></td></tr>
<tr><td>Excessive Macrophyte Growth</td><td rowspan="2">Lake Kariba, Lake Naivasha, Lake Victoria</td><td></td><td rowspan="2">Lake Kariba</td><td></td><td rowspan="2">Bhoj Wetland, Lake Biwa, Chilika Lagoon, Lake Toba, Lake Victoria</td></tr>
<tr><td colspan="2">Exotic Species</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Pathogens</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Lake Chad, Lake Victoria (macrophytes removal to control vector breeding grounds)</td></tr>
<tr><td colspan="2">Siltation</td><td></td><td></td><td></td><td></td><td></td><td>Bhoj Wetland, Chilika Lagoon</td><td></td></tr>
<tr><td colspan="2">Toxic Contamination</td><td></td><td></td><td></td><td></td><td></td><td>Lake Champlain, Lake Dianchi, North American Great Lakes</td><td>Bhoj Wetland, Lake Victoria</td></tr>
<tr><td colspan="2">Water Level Decrease</td><td></td><td></td><td></td><td></td><td>Lake Dianchi (Proposals at Aral Sea and Issyk-kul)</td><td></td><td></td></tr>
</table>

## Watershed-based Measures

Point-source Control

*Wastewater Diversion*

One simple way of avoiding the negative effects of wastewater on a lake is to divert it outside of the basin so that it never reaches the lake. Over 100 years ago—to combat typhoid and cholera outbreaks—the wastewater of Chicago was diverted from Lake Michigan by an engineering project that reversed the flow of the Chicago River from its original direction to Lake Michigan to the Illinois River/Mississippi River system. This effectively removed the huge city of Chicago, located on the shores of Lake Michigan, from the drainage basin of the North American Great Lakes. However, while it took care of the pathogen problem in Lake Michigan, the water quality of the Illinois River and Mississippi River suffered as a result. Similar diversions of sewage have been carried out in the Bhoj Wetland case to control nutrient inflow as well as to minimize microbial contamination of this drinking water source. Diversion of sewage may become an option at Lake Dianchi, but only after completion of another diversion project—one that brings water from outside the Dianchi basin into the basin for use in Kunming city. The reason is that without the in-coming diversion, the water balance in the basin depends heavily on the irrigation return flows and re-use of domestic sewage, so exporting sewage was, until recently, not an option because of the need to keep scarce (yet polluted) water resources in the basin.

In addition to the Lake Michigan and Bhoj Wetland, there are two classic cases of sewage diversion in the literature. In the 1960s sewage was diverted from Lake Washington (near Seattle in the NW United States) to the Puget Sound, which as part of the ocean, was thought to have higher assimilative capacity. As a result of the diversion, the lake went from a eutrophic to an oligotrophic state due to lower nutrient loading, making Lake Washington a well-known lake that had been "saved". A similar scheme was carried out at Lake Tahoe (on the California-Nevada border in the Western United States). Even though the sewage flowing into Lake Tahoe had been treated at an advanced level, the remaining nutrients were still high enough to pose a problem for this ultra-oligotrophic lake. The sewage was diverted out of the basin into a constructed impoundment.

The key lesson learned from these examples is that wastewater diversion can have a positive effect on a lake from which the sewage is being diverted, but it is important to consider potential negative effects on the area receiving the new pollution load. That may indeed be preferable in cases when a valuable lake resource is being saved is greater than the costs being incurred elsewhere, including the losses suffered by people not well represented in the decision-making process.

*Conventional Wastewater Treatment (Primary and Secondary Treatment)*

Directly treating wastewater before it gets to a lake is another major response to lake problems, and one that actually addresses the root causes. This sub-section, and the two that follow, look at three major types of wastewater treatment found in the cases: conventional wastewater treatment (for pathogen and organic removal), advanced wastewater treatment (for nutrient removal) and industrial wastewater treatment (for toxic removal).

Conventional wastewater treatment is traditionally divided into primary and secondary treatment. Primary treatment involves mainly physical means of treating wastewater, such as sedimentation tanks, whereas secondary treatment usually employs microorganisms to degrade organic material in the sewage, by processes such as activated sludge or trickling filters. Conventional treatment is usually carried out at centralized locations that are connected to sewerage pipes that bring in the sewage from surrounding domestic sources, although on-site treatment is common in areas with low population density. Conventional treatment removes many pathogens and much organic material thereby alleviating problems related to pathogenic contamination and low dissolved oxygen levels due to high organic loading. However, as discussed in Chapter 2, in many cases, the main motivation for constructing a conventional wastewater treatment system is the amenity and direct health benefits of sanitation it provides to users—regardless of the positive effects it may have on a lake. Box 6.1 summarizes the use of conventional and advanced wastewater treatment in the 28 cases.

**Box 6.1. Conventional and Advanced Wastewater Treatment at the 28 Study Lakes**

Ide (2004) analyzed the extent of sewage treatment at the 28 lakes based on per capita gross national income (GNI) and population density. The results are summarized in the table below. The extent and degree of wastewater treatment is indicated by the **bold** words in each cell (e.g., **Low to High**). The classes of treatment are indicated as **low** = primary, **medium** = secondary, and **high** = tertiary. For lake basins with low population density and low GNI per capita (cell I-1), almost no sewage treatment is carried out. As both income and density increase (I-2, II-1, II-2), conventional treatment systems expand, usually with bilateral funding. For high GNI per capita countries (III-1, III-2), even in sparsely populated areas (III-1) conventional and advanced treatment are carried out, usually with central or local government funding. A full discussion can be found in Ide (2004) on the CD-ROM.

| Population Density / GNI per capita | 1) < 100 person/km$^2$ | 2) >= 100 person/km$^2$ |
|---|---|---|
| I) Low-Income Economies<br>< US$736 | I-1) Malawi, George, Tonle Sap, Issyk-Kul, Chad, Kariba, Tanganyika, Baringo, Chilika<br>**Rare or Low**; Even not in plan | I-2) Victoria, Naivasha, Nakuru, Bhoj Wetland, Toba<br>**Low to Medium** (in urban area)<br>Funded by bilateral assistance |
| II) Middle-Income Economies<br>US$736 – US$9,075 | II-1) Aral Sea, Baikal, Titicaca, Ohrid, Xingkai/Khanka, Tucurui, Peipsi/Chudskoe, Cocibolca<br>**Low to Medium**<br>Partly funded by bilateral assistance | II-2) Dianchi, Laguna de Bay<br>**Low to High**<br>Funded by bilateral or the central government's assistance |
| III) High-Income Economies<br>> US$9,075 | III-1) Champlain, Great Lakes<br>**High**<br>Funded by the central and local governments | III-2) Constance, Biwa<br>**High**<br>Funded by the central and local governments |

Source: Ide (2004).

*Advanced Wastewater Treatment (Tertiary Treatment)*

Advanced wastewater treatment, as discussed here, is simply enhanced nutrient (N, P) removal at conventional wastewater treatment plants. The purpose is to cut down on the load of nutrients to a lake to prevent or control eutrophication. While conventional treatment removes a small percentage of nutrients in sewage, advance treatment such as chemical precipitation and nitrification/denitrification can achieve up to 95% removal of nutrients. Advanced treatment requires both conventional treatment to be in place and additional funds for construction and operation; therefore, it is usually carried out only in high-income economies like those in cells III-1 and III-2 of Box 6.1. In our 28 cases, only Lakes Biwa, Champlain, Constance, Dianchi and the North American Great Lakes have extensive advanced treatment facilities in place. However, in those cases, advanced treatment has profoundly reduced the load of phosphorus to the lakes, a root cause of eutrophication.

**Box 6.2. Timing of Water Supply, Conventional and Advanced Wastewater Treatment Development**

The cases of Lake Constance, Lake Biwa and Lake Nakuru provide contrasting examples of the timing and methods of how infrastructure like water supply, conventional wastewater treatment and advanced wastewater treatment are developed.

For Lake Constance, people in the lake basin have had water supply service for more than one hundred years. Installation of a sewerage system came much later than the completion of the water supply system. In 1972 only 25% of all inhabitants in the catchment area were connected to sewage plants with biological (conventional-secondary) treatment. However, the percentage has increased rapidly since reaching 90% in 1985 and over 95% in 2001. At the same time, the percentage of biologically-treated sewage that is also treated with phosphorus removal systems (advanced) increased from 24% in 1972, to 88% in 1985, and to 97% in 2001.

The population coverage of water supply at Lake Biwa basin was about 30% in the 1950s, but in step with high economic growth in Japan, the percentage increased rapidly and reached 80% in the 1960s. However, sewage treatment systems covered only 4% until the 1980s. Drastic expansion of the sewage system in Shiga started in the early 1980s, and current coverage is now around 70%. Interestingly, because the construction of sewerage and sewage treatment was relatively “late”, both conventional and advanced treatment systems were constructed together from the beginning. Today, the percentage of advanced treatment in Shiga is the highest in Japan.

In sharp contrast to the above two lakes, a full scale water supply system was first installed in the catchment area of Lake Nakuru in the early 1990s. As a result, the old sewage treatment plant (conventional) became unable to treat the volume of newly generated wastewater, and much wastewater began to come into the lake without treatment. To solve this problem, a large-scale improvement project of sewage system started at Lake Nakuru several years later. However, no advanced treatment has been installed yet. Additionally, connection to the upgraded plant has not been completed and it is running well under capacity. This illustrates the necessity of a multisectoral plan that considers the development of water supply system together with sewage system.

In short, water supply, sewage, and advanced treatment systems were adopted in stages at Lake Constance as well as other lakes in most developed countries. However, both sewage and advanced treatment systems were introduced simultaneously at Lake Biwa after the completion of water supply system. Even though Lake Nakuru had the above-mentioned problem and does not have advanced treatment yet, it achieved the development of water supply and sewage system almost at the same time. These facts imply that, if financial arrangements are available, there is a possibility to develop those three systems simultaneously although stepwise implementation of environmental infrastructure is more realistic and common. The development of environmental infrastructure in a multisectoral manner would be more desirable to achieve long-term goals for lake management.

Source: Ide (2004).

### *Industrial Wastewater Treatment*

While industrial wastewater can be a source of organic matter and nutrients to a lake, one of the main reasons for industrial wastewater treatment is to prevent toxic contamination. The extent of industrial wastewater treatment is similar to advanced wastewater treatment (discussed in Box 6.1) with some exceptions. Extensive treatment with strict effluent standards is in place at Lakes Biwa, Champlain, Constance, Dianchi and the North American Great Lakes. This treatment removes toxics as well as organic matter and nutrients before it can reach the lakes.

At Lake Baikal, the only significant source of industrial wastewater to the lake—a pulp mill—is installing a closed wastewater treatment system to control release of organo-cholide compounds to the lake. Plans to control toxic effluents have been proposed for Lakes Naivasha and Nakuru but are yet to be carried out. There is a special program in place at Laguna de Bay that charges industries for the amount of organic matter (BOD) they discharge to the lake. The brief argues that this has lead to a sharp drop in organic loading to the lake (see also Chapter 8 for discussion).

In some cases, such as the Russian side of Lake Xingkai/Khanka or Lake Sevan, economic downturns can lead to a drop in industrial wastewater loads—an example where factors exogenous to the lake basin itself van have a great influence on the lake.

The main lesson regarding industrial wastewater treatment comes from the cases where it was *not* carried out. In general, when there was a large release of toxic in a lake basin, the three characteristics of lakes make clean-up a huge undertaking. Long retention time means that toxic chemicals in a lake are not flushed and stay in the system for a long time. Complex dynamics means that the chemicals often biomagnify, creating both ecological damage and risk to humans. Transmissivity means that the problem cannot usually be contained to a small area but tends to spread. As discussed latter in this chapter, various remediation methods exist, but all are more expense that proper treatment in the first place.

Nonpoint Source Control

Point source control is one of the first technological responses to lake problems, but even in cases where it has been considered successful, nonpoint sources of pollutants often remain uncontrolled and contribute to persistent problems. The Lake Biwa, Champlain, Constance and North American Great Lakes Briefs all cite nonpoint sources as the main challenges facing those lakes. The difficulty in controlling nonpoint sources, which include agriculture and urban runoff, is that sources cannot be readily identified (complicating regulation and enforcement) and usually are related to precipitation events and therefore quite variable. The problem of nonpoint source pollution is compounded in many lake basins by the destruction of littoral wetlands, areas that typically moderate nonpoint inputs to a lake by serving as a sort of “filter”.

*Constructed Wetlands*

Almost all the 28 lake briefs indicate some degree of human encroachment on littoral wetlands. This usually results from development of lakeshore areas (urban sprawl at Lake Champlain, construction of roads at Lake Biwa) or reclamation of wetlands for farming or grazing. One simple way of reducing nonpoint source loads to a lake is to rehabilitate these wetlands. An additional benefit is that rehabilitation helps conserve and restore biodiversity. Some of the more detailed efforts include:

- The Lake Ohrid Brief describes how the 2003 “Transbouandary Watershed Action Plan” signed by riparian countries provides for habitat protection and restoration through wetlands inventory and the establishment of a no-net-loss policy.
- The Lake Chad Brief provides a good example of rehabilitation of the Logone wetland in Cameroon in 1993. The embankments of the barrage along the river were modified over eight years. Stakeholders and local community members were involved in the planning and design of the project.
- The Lake Champlain Brief details how the Lake Champlain Basin Program sponsored a wetland acquisition strategy that laid the groundwork for a four-phase, multiyear program to permanently protect almost 9,000 acres of wetlands in the Champlain Valley. By 2001, $1.4 million in federal funds had been provided to the project, which had conserved 4,000 acres of wetlands and surrounding areas in the Basin.
- The Lake Naivasha Brief shows how several of the larger farms in the basin have looked at ways of improving their impact on the environment by using integrated pest management to cut down on pesticides and using constructed wetlands to treat their wastewater.
- The Aral Sea Brief illustrates international efforts by the GEF and World Bank to restore wetlands on the lower Amu Darya delta.

The main lesson learned, especially for lake basins where wetlands are still in their natural condition, is that wetland protection should be a top priority. If wetlands are lost, the cases show that there will be an imperative in the future to replace them; therefore, it is much more cost effective to avoid destruction in the first place. The activities of the

Ramsar Convention, the major international effort to promote wetland conservation and restoration, are detailed in Box 6.3.

*Reforestation*

Like the destruction of wetlands, loss of forest cover in a lake basin also invariably has negative effects on a lake, usually by increasing land erosion and sediment transport. Reforestation schemes (replacing destroyed forests) are discusses in the Baikal, Chad, Laguna de Bay, Nakuru, Ohrid, Tanganyika and Toba Briefs. Afforestation schemes (to plant forest where it did not exist before) are described in the Baringo, Bhoj Wetland and Chilika Briefs. Once again, the key lesson learned is that it is better to preserve the original resource than to restore it, as will inevitably be necessary.

**Box 6.3. Wetland Conservation: The Ramsar Convention and Lakes**

One of the most important international initiatives to protect and restore wetlands is the Convention on Wetlands (Ramsar, Iran, 1971), known as the Ramsar Convention for short. The approximately half of lakes in this survey have Ramsar sites, which include, in some cases, both littoral areas and the lakes themselves.

The Ramsar Convention defines "wetlands" in its Article 1.1 as "...wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" and Article 2.1 provides that wetlands "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands".

For lake systems, a detailed Ramsar Classification System for Wetland Types the classification has the following categories:
O—Permanent freshwater lakes (over 8 ha); includes large oxbow lakes.
P—Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes.
Q—Permanent saline/brackish/alkaline lakes.
R—Seasonal/intermittent saline/brackish/alkaline lakes and flats

Note that for the Convention lakes can be fresh, brackish saline or alkaline. Lakes in general are not well represented as wetlands of International Importance, although some regions have good representation. More importantly, the fact that the Convention urges contracting parties to manage effectively and sustainably all wetlands, including lakes, within a contracting parties national boundaries, means the Convention process and advice covers all lakes and the dependant biodiversity, even if some of this is migratory.

Of the Ramsar sites (wetlands of international importance) the areal extent of the 4 categories, in each of the Ramsar regions, is shown in the Table below:

| | O | P | Q | R | all 4 types |
|---|---|---|---|---|---|
| **Africa** | 14,535,913 | 16,253,389 | 1,593,452 | 2,294,209 | 24,313,987 |
| **Asia** | 2,904,800 | 1,589,078 | 4,100,218 | 2,442,435 | 6,118,175 |
| **Europe** | 15,372,268 | 5,807,754 | 3,818,388 | 2,172,043 | 16,861,747 |
| **North America** | 14,289,625 | 1,360,416 | 913,297 | 1,201,914 | 14,920,266 |
| **Oceania** | 704,720 | 3,609,323 | 477,211 | 1,789,330 | 4,982,808 |
| **Neotropics** | 18,751,932 | 11,116,523 | 4,391,158 | 8,242,720 | 25,440,355 |
| **World Total** | 66,559,258 | 39,736,483 | 15,293,724 | 18,142,651 | 92,637,338 |

The Ramsar Small grants fund, a rather small fund, has nonetheless funded lake projects to a value of around CHF 950,000, helping deal with management issues for lakes with a total areal extent of 4,278,364 Ha. The Lakes were in all regions of the world, including the following countries: Bulgaria, Former Yugoslavia, Armenia, Georgia, Russian federation (3), Algeria, Uganda, Burkina Faso, Comoros, Togo (2), China (3), Mongolia, Philippines, Argentina, Paraguay, Peru, Ecuador (2), and Bolivia.

The Convention will continue to promote wise management of lake systems, as part of its global approach to wetlands and water. Approaches that emphasize the need for integrated management approach, and build on the river basin initiative being developed between Ramsar, CBD and UNDP-GEF will continue to be advanced by the Ramsar secretariat. Lake issues will be included in the range of issues and advices to be considered by the next COP meeting, set for November 2005 in Kampala, Uganda.

Source: Peter Bridgewater, Secretary General, RAMSAR Convention.

## In-Lake Measures

<u>Biological Measures</u>

*Predators*

Biological measures can be used to control either introduced nuisance species, such as water hyacinth, or problematic outbreaks of endogenous species, such as excessive blooms of cyanobacteria. A major reason why introduced species are often so successful in new environments is because they are no longer faced with their natural enemies. Thus, when Water Hyacinth is introduced (unintentionally) to a lake where these pathogens and predators are absent, and where other conditions are favorable (temperature, nutrients), then the growth can be explosive. These enemies of the invasive species' can be introduced in order to control their rampant growth.

For example, at Lake Victoria two species of weevils (*Neochetina eichhornia* and *Neochetina bruchi*) have been used successfully to combat serious infestation of Water Hyacinth. Extensive research was conducted prior to the release of the weevils to show the weevils would be Water Hyacinth-specific and would not result in another uncontrollable distortion of the ecosystem (as occurred after the introduction of the Nile Perch in the 1950s). The weevils have been successful in controlling the Water Hyacinth infestation in this lake, although the reduction in the weed was probably assisted by a period of extreme weather. The traditional fishing communities have been successfully engaged in raising and releasing the weevils for water hyacinth control, so the program can be expected to sustain itself.

In Lake Kariba, grasshoppers (*Paulinia acuminata*) were used to control excessive growth of the invasive Kariba Weed (*Salvinia molesta*). The effect of these predators, along with generally dropping nutrient levels, has been credited with the weed's decline.

The Lake Naivasha case notes that Kariba Weed has been on the lake since 1962 and by the early 1970s it had become a major ecological problem as it covered a large portion of the lake. After chemical control (see below) failed, a biological control agent *Cyrtobagus salviniae*, a host-specific insect, was introduced and by the early 1990's had effectively reduced the Kariba Weed cover to insignificant levels. Unfortunately, after the Kariba Weed was controlled, Water Hyacinth was able to spread rapidly, probably due to lack of competition with Kariba Weed. Water Hyacinth is now being controlled by the Neochetina weevils described above. The key lesson learned is that without attacking the root causes (high nutrient levels), control of one aquatic weed may just make room for another.

Fish can also be introduced to control aquatic weeds. For example, at Bhoj Wetland, herbivore Grass Carp (*Ctenopharyngodon idella*) along with Indian Major carp were introduced in the lakes to control submerged weeds such as Hydrilla, Najas and Vallisnaria. In order to avoid any problems cause by breeding of the Grass Carp, triploid species that do not reproduced were used. This introduction has resulted in the reduction of density of aquatic weeds up to 50% and increase in fish production by 130%. Thus there has been improvement of lake water quality as well as economic conditions of fishermen.

*Biomanipulation*

Biomanipulation is the deliberate introduction of species that will affect the lake's food chain in a beneficial way. The technique has been most widely used to control outbreaks of nuisance algae. In the classic approach, top-level predatory fish are introduced to a lake in order to reduce the populations of insectivorous fish. This, in turn, reduces the pressure on invertebrates which feed on the algae. Invertebrate populations increase and algal numbers decrease. While the technique has been successful in trials, it has not proven sustainable in the long-term. There are too many alternative food pathways and too many other influences on algae for the technique to be reliable. In addition, it requires a detailed knowledge of the aquatic ecology of the lake and the long-term presence of ecological monitoring. For these reasons, its use has been confined to lakes in the developed world and even there it is not in widespread use.

Chemical Measures

*Biocides*

Another possible technical response is to apply a chemical to a lake to control an algal bloom or to kill an invasive species. While bio-degradable chemicals can often be used to contain unwanted side-effects of a chemical, the cost is usually prohibitive is the infestation is extensive. For example, herbicides have been used at Lake Kariba to control both Water Hyacinth and Kariba Weed but given the scale of the infestation, it was shown that chemical measures would be uneconomical. In addition, there is usually a strong public reaction against these methods, even when biodegradable chemicals are used. For this reason, this approach is not very common.

Physical Measures

*Aeration*

The decay of organic matter in a lake, either because of high organic loading from the watershed or from the decay of algal blooms, can lead to low dissolved oxygen (DO) in a lake. Low DO can lead to fish kills and the denial of benthic waters to commercially and ecologically important species. One short-term way of dealing with the problem is to inject more dissolved oxygen into the low DO area, usually the bottom of the lake. This is only viable in the smallest lakes. For example, aeration has only been used at the smallest lake in our study, the Bhoj Wetland, where a total of 15 aeration units have been installed to oxygenate the bottom water. This has not only caused improvement in water quality but has become a tourist attraction. Naturally, this effort does not attack the root cause of low DO levels which is high organic loading and eutrophication of the lake.

*Freshwater Diversion into a Basin*

In cases where water in a lake basin is in short supply or when a lake has been heavily polluted, another physical countermeasure is to bring more water in from outside the basin. Adding more water to a lake and/or its basin can alleviate a water shortage or it can serve to dilute already polluted water, thereby lowering the concentration of pollutants in the lake. While bringing in more water does not address the root causes of any problems (inefficient water use, overuse, or pollution), it is nevertheless used in some cases.

For example, to alleviate a chronic water shortage in the Lake Dianchi basin caused by rapid population growth in a water scarce area, a water transfer scheme from the Zhangjiuhe River (a tributary of the Jinsha River which is located downstream of the Dianchi Basin) is under construction (expected completion date of 2005/6). The project will bring in about 245 million $m^3$ of water into Kunming for the purpose of the city's water supply. Additionally, the Aral Sea brief notes that "during the latter part of the Soviet period, water managers in Moscow and in Central Asia proposed diversion of massive flow, up to 60 $km^3$, from Siberian rivers to the region as the panacea for perceived water shortage problems. Although real and serious potential ecological threats (of regional, not global magnitude as claimed by some opponents) were given as the chief reason for canceling the project, economic considerations were the fundamental factors in this decision." The Issyk-kul brief also mentions similar yet-to-be-implemented schemes to transfer water into the basin in order to maintain development of irrigation (in the Issyk-kul basin), and also to maintain the current water balance and water level of the lake.

A unique "diversion" scheme is currently taking place at the Aral Sea (apart from the proposal discussed above). Desiccation of the Aral Sea, due to diversions of inflowing rivers, has lead to the split-up of the lake into three parts (as of 2004). A small dam has been built between the Small Aral in the north and the Large Aral in the south. The dam is used to retain water in the smaller yet deeper northern part; without the dam, water would continue being lost from the Small Aral to the Large Aral, where it tends to be rapidly lost due to high evaporation. It is expected that the Large Aral will completely dry up in the mid-term, but with this "diversion", the Small Aral will stabilize and a portion of the biodiversity of the original Aral Sea will be maintained.

A key lesson from these diversion schemes is that, while they may have a positive effect on the basin that receives that water, there is undoubtedly a negative effect in the basin that loses the water. As discussed in Chapter 2, there have been numerous diversions *from* lake basins (e.g. Aral, Baringo, Chad, Nakuru and Sevan), all with large, often unexpected, negative effects. Proposed schemes of water transfer from Lakes Naivasha and the North American Great Lakes have not been carried out, in part due to the knowledge of these negative experiences and economic reasons.

The use of transferred water to "dilute" a polluted lake is more common at small lakes than at the type of lakes in our survey. However, one of the purposes of the Lake Dianchi diversion discussed above is to change the flushing rate of the lake in order to decrease the hypereutrophic conditions that currently prevail. The Lake Ohrid case discusses how a large river (Sateska) was diverted from its natural course, which originally flowed to a point outside of the Lake Ohrid basin, to a new course within the basin that was designed to drain a marshland for farming and to increase the hydropower potential of the lake. The purpose was not to "dilute" the water of Lake Ohrid, which at the time was oligotrophic, but the effect of the diversion was to increase the size of the Lake Ohrid subwatershed by about 174%. The problem was that this new inflow brought with it a large load of sediment and organic matter that has had a negative effect on the lake.

Nevertheless, it is obvious that the proverb "dilution is not the solution to pollution" is perfectly correct. Given the transmissivity of lakes, even if a greater water volume is somehow attained, it is only a matter of time before the pollution spreads. In fact, the Lake Ohrid case shows that "dilution" can actually be a cause of "pollution". A key lesson from these diversion schemes is that, while they can have a positive effect on the basin that receives that water, there is usually a negative effect in the basin that loses the water and sometimes even in the lake receiving the additional water. Very thorough studies need to be carried out in advance to understand these likely consequences. Again it is a matter of balancing these benefits against the costs and taking into account the equity issues in any such water transfers.

*Dredging*

The removal of sediment from lake bottoms by hydraulic dredging is a common activity to removed excess silt, nutrients, and toxic compounds. For example, changes in basin land use led to large increases in sediment loading to both the Bhoj Wetland and Chilika Lagoon. For the Bhoj Wetland, the deposition of silt had created a land mass formation at confluence points which resulted in decrease in storage capacity and surface area, as well as the obstruction of the lake's outlet. Silt was removed from the upper and lower lakes by both hydraulic and dry excavation means, increasing the capacity of the lake by 4%. The excavated materials were used to convert previously barren lands into productive lands for agriculture. At the Chilika Lagoon, siltation of the outlet of the lake resulted in a decrease in salinity which caused both a decline in the native fisheries as well as an increase in invasive macrophytes growth. A new channel to the ocean was dredged and the salinity returned to normal conditions, leading to a dramatic recovery of the fishing and prawn industries. There was also a decrease of the area covered by invasive species and substantial increase in the weed free zone consequent upon desiltation operation.

Dredging of sediment is also sometimes used to remove internal sources of nutrients (usually phosphorus) in shallow, eutrophic lakes or toxic contaminants. For example, the Lake Biwa, Bhoj Wetland and Lake Dianchi cases all describe how dredging was carried out to remove phosphorus-laden sediment. In another example, 140,000 tons of PCB contaminated sludge were removed from the sediment of Cumberland Bay in Lake Champlain at a cost of US$35 million. Similar programs have been used to remove toxic contaminants from the North American Great Lakes and heavy metals from Lake Dianchi. However, the sediments of a lake are part of a complex ecosystem harboring benthic organisms that act as food for higher trophic levels and provide services such as removal of nitrogen. Removing sediment invariably destroys these functions.

The key lesson from these dredging activities is that, if the root cause of the problem (excess siltation, nutrient loading or toxic contamination) has been controlled, then dredging can have a positive effect on a lake. However, dredging, by itself, without load control is not cost effective and only a temporary measure and may destroy important ecosystem functions.

*Harvesting*

In many cases, excessive macrophyte growth impedes boat traffic, blocks irrigation channels, interferes with hydropower generation and water treatment plants as well as degrading recreation values. Infested areas can also foster the spread of vector-borne diseases. Harvesting these macrophytes can be a relatively quick and direct way to remove the nuisance weeds as well as the nutrients and any toxic chemicals they may have accumulated.

The Bhoj Wetland, Lake Biwa, Chilika Lagoon, Lake Toba and Lake Victoria briefs all discuss how harvesting has been carried out for a variety of reasons. Of special interest are the harvesting programs at Lakes Toba and Victoria which have relied heavily on community involvement. The harvested weeds can sometimes be turned into an economic good by local communities. In the case of Lake Victoria, the weeds were used for handicrafts. However, harvesting is usually a temporary measure that does not address the root causes leading to excessive macrophytes growth.

# Chapter 7. Informing the Process: The Role of Science and Monitoring

**Key Lessons Learned about Information**

- Information is costly and never complete so lack of complete information is not a reason for delaying action (note LLDA's "Ready, fire, aim!")
- Local knowledge is often overlooked but can be invaluable; make efforts to tap this source.
- Sharing and utilizing the collective knowledge base for lake management requires ensuring that all relevant stakeholders are involved at the beginning in identifying lake problems and helping to formulating realistic solutions for them.
- Information not properly "translated" into the language of decision makers and stakeholders is wasted.
- Resident scientific institutions are better than teams of scientist brought in for short-term studies. The nature of lakes (long water residence times and complex dynamics) makes long-term commitment particularly valuable.
- The entire lake basin, not just the lake itself, must be a part of any monitoring program.
- Keep things simple: Simple models can often provide management information equal to that obtained from complex models.

## Information Needs for Lake Basin Management

Information is necessary for good decision-making, but is costly and never perfect. This is the dilemma facing all decision makers—how to balance the need for further study with the need for action. In the absence of any good information, a decision maker could simply flip a coin and hope for the best: this is obviously not desirable. Nor is it desirable for the decision-making process to be paralyzed because 100% certainty has not been obtained about the current state of a lake basin or about the effects a range of policies may have on it. This chapter draws lessons from the 28 cases on the search for an appropriate balance.

Information comes in a variety of forms. Many readers will immediately think of "scientific information", such as the values of measured parameters like dissolved oxygen, nutrient concentrations and biomass counts that come from scientific studies and monitoring programs. The use of this "hard" information is indeed important and forms the bulk of this chapter. When devising and implementing policies, however, it is also very important to know socio-economic information about the watershed; to know about cultural values and people's view of the resource; to know about the institutional and policy frameworks that exist—to know what is possible and what is not (see Box 7.4).

Another valuable source of lake information resides in the memories and experiences of indigenous people living along a lakeshore or in lake basin communities. Often this local knowledge can augment scientific information. In the absence of long-term monitoring programs, it may be the only source of information about a given lake. Thus, in the absence of scientific data, the Ugandan government has been able to use local knowledge to identify and protect important fish breeding areas on the eastern shore of Lake Albert on the border between Uganda and The Democratic Republic of the Congo.

No matter what form information takes, the long retention time, complex dynamics, and transmissivity of lakes, mean that good information is particularly valuable in the decision-making process because the cost of a mistake (or missed opportunity) can be very high. Reflecting the experience presented in the 28 cases, this chapter first discusses the uses (and "non-uses") of science, then covers monitoring as a special topic before considering lessons learned on how information is shared and how information gathering is carried out

## Use of Scientific Information

The lake briefs contain many examples of how the use of science and other types of information has led to better decision-making. The cases show that science is used in three main ways: (1) to show the limits of resource, (2) to enlighten hard-to-see connections and (3) to provide novel/innovative solutions.

*Showing limits to a resource*

Fishing is one of the main resource uses in many of the lakes in this survey; overfishing is one of the main problems. Overfishing threatens lake ecosystems and livelihoods built upon them, especially in developing countries. One of the key contributions of scientific studies has been information leading to moratoria on fishing (e.g. Lakes Baringo and Naivasha) or restrictions on allowable technologies (e.g. Lakes George, Ohrid, and Victoria). As a result of the policies based on this information, these fisheries have either recovered, or are in better shape than they would have been without the policy change.

Another common problem facing many lakes is eutrophication, caused by excessive nutrient load (usually phosphorus; occasionally nitrogen) generated from human activities in a lake's drainage basin (and sometimes beyond). As illustrated in Figure 1.1, a lake can absorb a certain quantity of nutrient load without showing dramatic changes. However, there also is often a point at which the loading becomes excessive, leading to a major (usually undesirable) shift or imbalance in the lake ecosystem. The extent of the nutrient load, along with information on how much is "tolerable" is a key contribution of science. The briefs on Lakes Champlain, Constance and the North American Great Lakes show how far science can actually go in aiding the decision-making process. For example, based on a comprehensive modeling exercise, the United States and Canada acted jointly to reduce the phosphorus load to the Great Lakes, mainly by enhancing phosphorus removal at wastewater treatment plants and by banning P-containing detergents in the drainage basin. It is interesting to note that, even though this policy was successful in controlling much of the point-source load to the lakes, recent study has shown that nonpoint sources also must be controlled to fully meet the targets. The Lake Baikal brief also demonstrates how scientific study can reveal that, contrary to popular opinion, nonpoint sources can be a major threat to a lake.

*Enlightening hard to see connections*

Lakes are complex. It is not enough for humans to rely on gut feelings arising from everyday experience, because human judgment is not necessarily suited to understanding complex ecosystems. A key role of science, therefore, is to shed light on hard-to-see, indirect connections that are common in lake management. Some examples include the following:

- For Lake Naivasha, there was a controversy about the causes of the declining water level. A simple model was developed, making use of long-term monitoring data, to show that abstractions for horticulture and not other causes, such as climate variability, were almost certainly responsible for the decline in lake level. As a result, there was widespread acceptance of this cause and an understanding that different interest groups needed to work together to use the lake's resources equitably. (See Box 7.1 for a fuller discussion.)
- For Laguna de Bay, scientific investigations showed the negative effects of a hydraulic control structure (designed to stop salt water intrusion from the ocean) on the lake fisheries. Eventually, it was decided to halt operation of the structure, allowing natural salt water intrusion occur again, resulting in a decrease in turbidity and improved conditions for fisheries.
- For Lake Biwa, it was shown that decreasing snowfall amounts over the last few decades along with a weakening of the spring overturn (both possibly related to climate change) led to a decrease in the transfer of large amounts of dissolved oxygen (from snowmelt and from the atmosphere) to the hypolimnion every spring, resulting in possibly anoxic conditions at certain times, with the potential

for large-scale phosphorus release from sediments and a rapid worsening of the eutrophic conditions.

- For the North American Great Lakes, research has shown the connection between fossil fuel burning at distant power plants and mercury deposition to the lakes. These sources are mostly outside of the watershed but part of the "airshed" and, therefore not one of the first pollutant sources normally considered by decision makers.
- For Lake Victoria, recent studies (Hecky 2004 on CD-ROM) suggest the role of atmospheric deposition of phosphorus to the lake has been greatly underestimated. If confirmed, this unexpected pathway could have major implications for managing the lake.

**Box 7.1. The Value of Long Term Monitoring and Simple Modeling at Lake Naivasha**

For over 100 years, Lake Naivasha in Kenya had attracted the attention of hydrologists, partly because of the extreme decade-to-decade changes in its surface area, and partly because it remained fresh even though there is no surface outlet. The first phenomenon was eventually explained as being the result of the shallow bathymetry of the lake coupled with climate variability, while the second was found to result from groundwater outflows that carried away dissolved salts.

The lake's water balance became more than a scientific curiosity when, in 1982, a vegetable grower successfully switched to raising flowers for the cut flower trade. This success rapidly led to much of the land around the lake being converted from grazing and cropping to intensive horticulture. By the early 1990s over 100 $km^2$ had been converted to grow flowers for the European cut flower trade. With this growth came an influx of workers. Water was abstracted from the lake, the local aquifers, and the inflowing rivers for the horticultural industry and for domestic use by the rapidly increasing population.

The Lake Naivasha Riparian Association (LNRA), representing landowners and others around the shores of the lake, feared that the lake's water was being over-used by this new development. They also were concerned about pollution of the lake and aquifers from agro-chemicals used by the horticulture industry. However, many horticulturalists did not believe that they were over-using the water resource and pointed out that the lake was higher than it had been in the 1950s prior to the development of their industry. They, in turn, formed the Lake Naivasha Growers Group (LNGG) to counter these and other claims about their industry.

In 1996 the LNRA asked the Ministry of Water Development to study the water balance and the water related environmental impacts. This study was carried out in close collaboration with ITC in the Netherlands. This study was able to settle the issue of lake water use by developing a simple, spreadsheet based water balance model of the lake and its catchment. The model required data on the inflows from the two major rivers; direct rainfall onto, and evaporation from, the lake's surface; and observed lake level and bathymetry. These data were available from a variety of sources—government and private sector—for a period from 1932 to the present day (some of the data, such as the local rainfall, were available from 1901).

If a groundwater outflow of 4.6 million $m^3$ per month was allowed for, then the model was able to reproduce the observed lake level from 1932 to 1982 with remarkable accuracy (Figure Box 7.1). 95% of all observed monthly lake levels differed from the modeled levels by 0.52m or less over this period. This accuracy makes the growing discrepancy between the observed and the modeled lake levels after 1982 all the more striking. By 1997 the observed level was 3-4 m below that predicted by the model if there had been no abstractions.

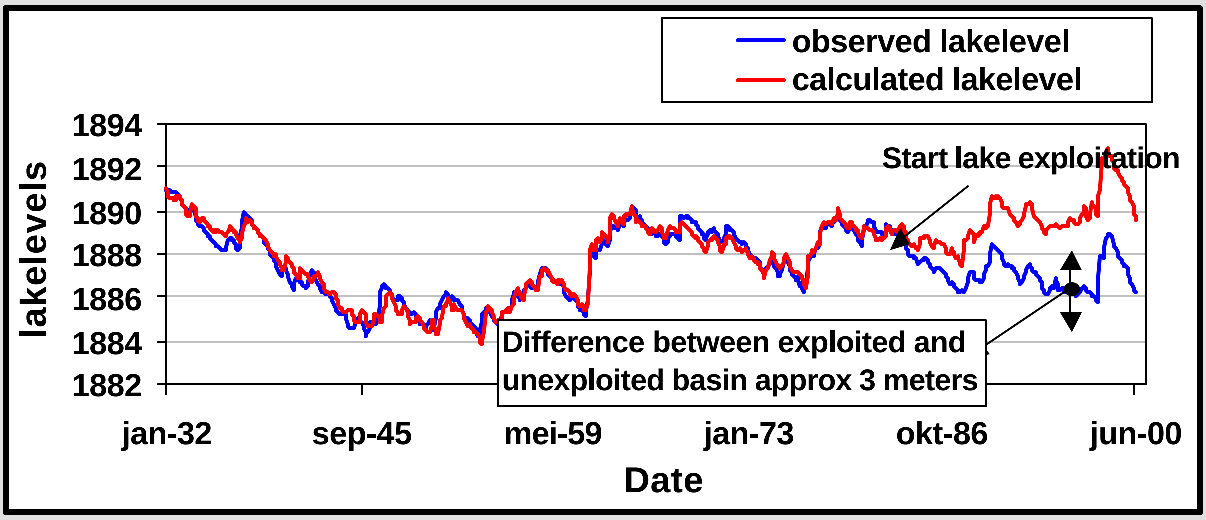


Figure Box 7.1. To be reformatted (color removed, dates put into English) with data provided from original author.

This argument was strengthened by the coincidence between the onset of this decline in water level and the commencement of horticulture in the area in 1982, and the close match between the annual water deficit by 1997 (60 x $10^6$ $m^3$) and the estimated water use based on the area of horticulture and the crops grown.

These results are now broadly accepted by all within and outside the horticulture industry around Lake Naivasha as showing that the rapid development of the industry and the increase in domestic demand has had a significant impact on the lake level. The LNRA and the LNGG now work more closely together to promote a stronger conservation ethic amongst horticulturalists and to protect the lake's values. Apart from the results of the water balance study the LNGG understand the importance of their activities on the lake.

This conclusive result could not have been achieved without access to long–term reliable monitoring data. It was the closeness of fit between the modeled and the observed lake levels prior to 1982, as much as the steady divergence thereafter that added to the power of the results.

A second notable feature was the simplicity of the modeling. The spreadsheet-based water balance was simple enough to be transferred and used by the LNRA without requiring specialist modeling expertise.

Source: R. Becht and D.M. Harper 2002. Towards an understanding of human impact upon the hydrology of Lake Naivasha, Kenya. Hydrobiologia 488 1-11.

*Providing Innovative/Novel Approaches (to solve conflicts)*

Finally, science can be used to develop innovative and novel approaches to address a range of lake problems. Some of the major examples from the cases include:

- For the Chilika Lagoon, modeling studies showed how dredging a channel between the lake and the ocean could improve salinity conditions and fishery production in the lake. The channel was dredged, leading to a dramatic recovery in the fishery and prawning catches. Apart from restoring livelihoods fisherfolk, this action also alleviating a major source of conflict among the local communities.
- At Lake Kariba, ecological studies showed how introduction of a fish (*Limnothrissa miodon*) into an ecological niche opened up by the formation of this reservoir provided a commercially valuable fishery.
- For Lake Chad, test releases from the Tiga and Challawa dams showed that such releases could perfectly simulate wet season conditions. This demonstrated that the dam outlets and the Hadejai barrage were adequate for generating artificial flooding in most wetlands in the river system, a previous source of conflict in the drainage basin.
- For the Bhoj Wetland, high levels of heavy metals were shown to result from immersion of idols during religious festivities, an unlikely but significant source. Research was used to quantify the problem and show how a solution (moving the ceremony to another site) was possible.
- For the Aral Sea, scientific studies indicated that construction of a dam between the Small Aral and Large Aral seas could maintain the current (greatly reduced) size of the Small Aral given the reduced inflows, and with it, some of the lake's biodiversity and livelihoods for local people.

*A Note on Modeling*

The term "modeling" probably conjures up images of computers and mathematics for many readers. But models are not necessarily complex, mathematical or even run on a computer. Actually, they can be quite simple: anything that is a generalization of reality that used to gain deeper insight can be is a model. This section on "Use of Science" can, in fact, be thought of as a model: we proposed that science is used for three main purposes in lake basin management; we use case studies to test the "model"; we hope the "model" will be used by readers to better understand the use of science at their own lakes.

The point is: a wide range of models has been used the lakes in this survey; some are as simple as a thought in a decision maker's head like "Nutrients cause eutrophication; our lake is eutrophic; let's cut down on nutrient loading"; some are as complex as three-dimensional, time-varying, ecological-physical models. A complex hydro-dynamic model of circulation patterns was used to assess the likely benefits from different lake openings in Chilika Lake before the new opening was dredged to the ocean. On the other hand, a model was constructed of Lake Victoria but it has not proven useful to understanding the processes in the lake or been influential with decision makers because of its complexity and data demands. In the case of the North American Great Lakes, the issue of model complexity also was illustrated. Five different eutrophication models, ranging from simple phosphorus loading graphs to multi-dimensional, time-varying models, were used to determine the phosphorus target loads for the North American Great Lakes (GLWQA, 1978). Despite the range of complexity in the models used, however, they tended to converge on the same target numbers, implying that the simple models were sufficient. Lake Naivasha (Box 7.1) provides another example where a simple, spreadsheet models proved to be influential in management.

Overall, the cases indicate that it is important that lake modeling efforts be tailored to the lake being modeled, including ensuring that the model is no more complex than is needed to meet the modeling objective. It is essential that the model design is driven by the managers and other stakeholders and not by the model developers. Initial brainstorming sessions between lake stakeholders and model developers can substantially facilitate this goal. Further, a model for a given lake should not be developed without the participation of local experts and officials in its development, as well as those ultimately responsible for its long-term use and refinement. In the absence of specific data and information for a lake being modeled, initiation of specific monitoring also may be required to obtain such data. A conceptual model developed at an early stage of a lake management project can help identify data needs and required sampling and monitoring efforts, thereby saving both human and financial resources.

It is noticeable how often simple models have proven successful. The lesson is not that simple models are best—it is doubtful if the Chilika Lake requirements could have been met with a simple model—but that the complexity of the model needs to be matched to the capacities of the users, the data available and the demands of the task. If the model development is driven by technological possibilities and not by the needs of the decision makers, then it is very likely that the model will not be used.

### "Non-use" of Science

The lake briefs also show how a lack of scientific information can constrain the decision making process. There are a number of cases where science could have been used effectively, but was not. For example, the lake briefs cited the need for scientific studies to show:

- The effects of climate change versus local water withdrawals on lake levels in Lakes Chad and Baringo;
- The limits to grazing in Lake Baringo;
- The limits of irrigation on Lake Chad and the Aral Sea;
- The effects of aquaculture on Lake Toba;
- The effect of future upstream dams on Tonle Sap; and,
- The effects of siltation/nutrient loading, before it becomes a major problem, at Lakes Malawi and Tanganyika.

The briefs also show how scientific knowledge may have influenced policies before they were implemented. Examples include:

- Health problems resulting from the unexpected release of airborne particles from the exposed lake bed of the desiccated Aral Sea;
- Ecological studies might have shown the detrimental effects from lowering the level of Lake Sevan for hydropower and irrigation; and,
- The effects of soil erosion and nutrients from human wastes on the eutrophic status of Winam Gulf in lake Victoria may have been better appreciated by decision makers if scientific studies had been carried out some years ago.

While the briefs do not speculate on why scientific studies were not carried out in these and similar cases, it is possible to use experience from scientific input to management in other fields to suggest the causes. First, decision makers often see scientific inputs as time-consuming, expensive and inconclusive when they need to make decisions quickly. It can be as difficult to persuade scientists that an imprecise but timely answer is required as it is to persuade decision makers that a delay of a year while waiting for factual information can be highly cost-effective in the long-term. Secondly, scientists are often poor communicators with both decision makers and stakeholder groups. They can have difficulty in expressing their findings in ways that have meaning to non-scientists. Thirdly, it can be very difficult to get scientists from disciplines as diverse as sociology and hydrology to work together. This integrative approach to scientific studies is particularly necessary in understanding lake basins where so many processes (terrestrial and aquatic; biophysical and socio-economic; physical and ecological) interact. Finally, it is worth stating that these typical difficulties affect scientific studies in the developed word as much as they affect the developing world.

**Value of Monitoring**

Without carrying out special scientific studies or developing models, simple monitoring of a lake and its basin can provide valuable insights into a lake's baseline condition, its change over time including the effects of a given policy.

*To assess baseline conditions*

One key purpose of monitoring is to understand the baseline or "normal" conditions of a lake in order to inform policy. Such monitoring programs have been in place at all of the study lakes located in developed countries and in some of the developing countries such as at Laguna de Bay in the Philippines. Two other examples from developing countries illustrate the value of baseline monitoring:

- The Lake Nakuru brief notes that the monitoring data demonstrate the high degree of natural variation that can occur in the lake's water levels due to high levels of evaporation and water abstractions, as well as influences from more global phenomena, such as global climate change. All are causing dramatic changes in the lake's limnological characteristics. By having information on this natural variation, decision makers are better positioned to recognize and evaluate the impacts on the lake from human activities in its drainage basin.
- Monitoring data collected over the past several years at Lake Ohrid suggest that both the phytoplankton and zooplankton communities in the lake are changing, consistent with the increasing eutrophication of the lake. This baseline monitoring makes it unequivocally clear to the basin communities that there is a need to control nutrient loads to the lake.

While long-term monitoring is most desirable for providing a baseline, even short-term, historical studies can also prove valuable. For example, Talling's work on Lake Victoria in 1961 provides an invaluable baseline on the condition of the lake 40 years ago and was has been used in recent times to show that the lake has changed dramatically from a diatom-dominated to a cyanobacterially-dominated lake. In another example, various studies on the endemic species of Lake Dianchi in the 1950s, have proven useful in understanding past conditions in that lake and on the need for biodiversity conservation.

*To assess effects of a policy*

Decision makers need monitoring of a lake's condition after the implementation of a policy change, to properly evaluate the effectiveness of the policy. As discussed in Appendix A, when evaluating policies, it is important to use a with/without project (policy) analysis. The Lake Dianchi brief shows how, even though the pollution load to the lake has increased in recent years, polices have led to a divergence between the load generated at source, and the load entering the lake. Without good information on loading, the current policies would probably be declared a failure, when in fact they have had a positive effect. The Lake Titicaca brief argued that monitoring made it possible to establish clear priorities during the execution of the Master Plan for Flood Prevention and Resource Management in the basin. On the other hand, the Lake Chad brief noted that, because of the absence of international monitoring bodies, past agreements on the conservation and development of basin resources could not be enforced, resulting in detrimental impacts on the lake ecosystem.

*What to monitor*

Experience in monitoring lakes around the world has demonstrated that some parameters that are relatively simple-to-measure can provide a great deal of insight into the condition of a lake and its resources. A list of fundamental in-lake parameters is provided in Box 7.2. Although many additional in-lake and laboratory measurements can be very helpful (e.g., types and numbers of different algal species; composition of rooted plants), the list in Box 7.2 can provide a reasonably accurate picture of the major problems facing a lake. However, it will not necessarily indicate the sources of these problems. Because the lake drainage basin is the place where human activities occur, and the root causes of most lake problems, information on drainage basin characteristics may also be needed to help identify sources of lake problems.

**Box 7.2. Easily obtained parameters for evaluating lake conditions**

- Water flushing rate: The faster the flushing rate, the faster a pollutant will be flushed from a lake (assuming the pollutant input has been reduced or eliminated). This is a function of both lake volume (how much water the lake contains) and the water inflows and outflows (the rate at which water enters and leaves a lake, including that lost to evaporation);
- Water transparency: The clearer and more transparent the water, usually the better the water quality;
- PH: This is a measure of the acidity of water. Fish cannot survive above a certain level of acidity;
- Specific conductance: A measure of the quantity of dissolved minerals (e.g., calcium, magnesium, sodium, potassium) in the water, typically the higher the specific conductance, the higher the mineral concentration;
- Dissolved oxygen concentration: The lower the oxygen concentration in the water, the greater the likelihood the oxygen-consuming organisms (especially fish) will be affected. Further, a low oxygen concentration can accelerate the release of nutrients from sediments at the bottom of lakes;
- Biological oxygen demand (BOD) and chemical oxygen demand (COD): These tests provide information on the possibility of pollution from organic substances. A special concern exists in regard to synthetic organic materials (DDT, PCBs, dioxin), which are carcinogenic and can bioaccumulate in the tissues of aquatic and terrestrial organisms, including humans.
- Nutrients: Phosphorus (and nitrogen in some cases) is considered to the nutrient controlling or limiting the maximum biomass of algae and aquatic plants. The higher the concentrations of the biologically-available forms of these nutrients, the greater the potential for nuisance algal blooms and other eutrophication symptoms in a lake;
- Temperature: This parameter has important implications for the physical structure of the water column, as well as maintenance of aquatic life (especially fish). Temperature also controls the rate at which various biophysical and chemical reactions occur;
- Chlorophyll concentration: As a measure of algal biomass (quantity), the larger the chlorophyll concentration, the greater the possibility that the lake will experience nuisance algal blooms and other eutrophication symptoms.
- Heavy metal concentration: Certain heavy metals, particularly those that can bioaccumulate in

the tissues of aquatic and terrestrial organisms, including humans (e.g., lead, mercury), are toxic. The higher the concentration, the greater the potential for negative impacts.

*A Note on Serendipity*

Long-term monitoring, even when carried out without an immediate purpose, can have serendipitous effects. For example, the Lake Biwa brief highlights how long-term records of parameters as diverse as snowmelt, temperature, and dissolved oxygen in the hypolimnion all subsequently came together to give indications about the potential effects of global warming on the lake. The North American Great Lakes brief also notes that both formal and informal data sets "become invaluable in monitoring and interpreting ecosystem changes often unrelated to the purpose for which the data were originally collected."

## Sharing Information

The Lake Nakuru illustrates an important point; the need ensure that research and monitoring findings are available in simplified language that decision makers and resource users can understand. The key lesson learned is that the value of science and monitoring as information for policy makers evaporates if the results and their meaning are not properly transmitted. Some ways in which information can be successfully shared include the following.

*Use of Indicators*

While some of the parameters presented in Box 7.2 are easily understood by the public and decision makers, many are not. Transparency is a fairly easy concept (the less "stuff" in the water, the clearer it is; therefore, the deeper one can see into the water); In contrast, the Chemical Oxygen Demand is not. In fact, even professionals can make mistakes about the type of COD measured (e.g., was the oxidizing agent manganese or chromium?). To make the sharing of information as easy as possible, many of the lakes in this study have developed "indicators" of various types of describe lakes or basin conditions.

For example, the development of easily understood indicators has been the subject of major biennial conferences in the North American Great Lakes basin (described in Box 7.3). For Laguna de Bay, the Laguna Lake Development Authority has shown considerable progress in presenting water quality data in a simple schematic diagram called the Water Mondriaan. Inspired by the work of Piet Mondriaan, a famous Dutch painter, it presents technical information in the form of simple lines and colors in an easily understood format for the public and decision-makers. For its International Waters Projects (including # of our study lakes), the GEF has developed a suite of indicators (process indicators, stress reduction indicators, environmental status indicators) which are flexibly applied and can allow for easy evaluation of project progress (Duda 2002).

**Box 7.3. Evolving Indicators: The State of the Lakes Ecosystem Conference (SOLEC)**

The purpose of the U.S.-Canada Great Lakes Water Quality Agreement (GLWQA) is "to restore and maintain the physical, chemical and biological integrity of the Great Lakes Basin." To evaluate the effectiveness in meeting this goal, the Environmental Protection Agency and Environment Canada biennially host a "State of the Lakes Ecosystem Conference (SOLEC), to report on the state of the Great Lakes ecosystem and the major factors impacting it, **including environmental and socioeconomic indicators for assessing these factors**. SOLEC also provides a forum for information exchange and discussion among people in all levels of government, corporate and not-for-profit sectors that make decisions affecting the Great Lakes. To date, five SOLEC conferences have been held.

- SOLEC 1994—The first conference addressed the entire lake system, emphasizing aquatic community health, human health, aquatic habitat, toxic contaminants and nutrients, and the changing Great Lakes economy;
- SOLEC 1996—This conference focused on areas where biological productivity was greatest and humans had maximum impacts, including nearshore waters, coastal wetlands, lakeshore lands,

impacts of changing land use, and information availability and management. Also recognized was the need for a comprehensive set of indicators to allow the governments to report on progress made under the GLWQA in a predictable, compatible and standard format;

- SOLEC 1998—This conference focused more formally on the indicator development process, with development of a suite of easily-understood indicators that objectively represented the condition of the Great Lakes ecosystem components, as called for in the GLWQA;
- SOLEC 2000—This conference reported on the state of the Great Lakes on the basis of 80 science-based indicators developed since SOLEC 1998. It also introduced a new group of "Societal Indicators," which seek to measure both human activities impacting the environment, and the societal action(s) taken in response to these environmental pressures;
- SOLEC 2002—This conference continued to update and assess the state of the Great Lakes, focusing on 43 indicator assessments used to provide the most comprehensive analysis to date of the Great Lakes Basin Ecosystem. It also presented a candidate set of "Biological Integrity" indicators, as well as proposed indicators for agriculture, groundwater, forestry and society responses, which, as a part of the "Societal indicator" suite, measure positive human responses to ecosystem pressures.

Work continues on the Great Lakes indicator suite, including efforts to streamline the reporting requirements of the GLWQA, and to report progress under it within the context of management challenges and actions. Further information on the SOLEC indicators can be found on the website: http://www.epa.gov/glnpo/solec/

*Museums and Information Centers*

Lake-based museums or centers are another useful way to ensure that scientific and other types of information are widely disseminated. One example is the realization of a Lake Science Center established at Barkul in the Chilika Lake basin for hydrobiological and other studies during 1999-2002. The Lake Champlain brief highlighted the value of developing a lakefront laboratory and science museum (Leahy Center) as a means of fostering effective lake management within the drainage basin. The Lake Biwa Museum is a long-standing and very successful example of a lake science center devoted to disseminating of information and data about the lake and its problems. Based in part on these successes, establishment of a Lake Resource Centre (LRC) at the Bhoj Wetland has been recommended.

*Involving People*

Finally, many of the case studies show the benefits of directly using people to gather and provide information on lakes. Examples include the following:

- An interesting example of information gathering by citizens is the "Firefly Monitoring" in the Lake Biwa drainage basin. Akanoi Bay, which feeds into the South Basin of Lake Biwa, used to be famous for fireflies. Changes in landscape (mainly the channeling of rivers and loss of natural habitats), however, have led to a decline in the number of fireflies. A local NGO implemented various restoration projects, with one key indicator of success being an increase in the number of fireflies—a simple, but effective, indicator of restoration progress.
- In Lake Victoria, water hyacinth expansion and control are carried out and monitored by local fishing communities, who are the ones best placed to carry out such work.
- The Lake Tanganyika Brief notes the importance of involving the local communities in data collection. It is noteworthy that the Brief also questions the extent of this involvement, since the collection of water samples or reading of water/rain gauges may not be appropriate for communities that are not trained to undertake such tasks.
- The Lay Monitoring Program in lake Champaign has conducted lakewide monitoring of eutrophication parameters using citizen volunteers every year since 1979. The information collected by these citizen monitors has been used to develop state water quality standards.

## Organizing / Carrying out Science and Monitoring

In an ideal world, with no shortage of funding or and trained staff, each lake basin would have a resident institute—recognized for its capabilities and impartiality—carrying out both required and elective research and monitoring and coordinating information gathering between various sectors. This actually is close to reality for some of the survey lakes. Where funds are scarce, however, we see fragmentation and a reliance on international funding—not necessarily problems, but also not ideal.

*Resident Institutes*

Lake Champlain (along with Lake Biwa and the North American Great Lakes) provides an example of just how important and effective a role science and monitoring can play. The Lake Champlain Basin Program has always sought to base planning and policy decisions on sound scientific information. The brief contends that, without this strong foundation in sound science, a watershed management program will not necessarily produce the desired outcomes. Nearly two dozen representatives from the technical community throughout the lake basin have been brought together in a Technical Advisory Committee (TAC) to examine the scientific issues of every major policy question, and provide policy and budget guidance to the Steering Committee each year. The TAC also reviews research and implementation projects to ensure both scientific merit and successful conclusion. Moreover, it is chaired by a non-governmental scientist who also holds a seat on the Lake Champlain Steering Committee. When scientific information is not adequate to guide a management decision, the LCBP allocates funds to support focused and timely research or monitoring to address the knowledge gap. This effort, however, does not come cheap. Monitoring environmental conditions in the lake basin typically requires up to $300,000, a sum of money usually not available for most lakes.

*Internationally funded programs*

For lakes in developing countries without the ability to maintain resident programs international studies and funding can play an important role. For example, lakes like Malawi, Victoria and Tonle Sap have received much attention from foreign scientists and the information gathered has been used in decision making.

Several of the cases indicate the need for local training and ongoing support to ensure the sustainability of such internationally-funded programs. In Lake Tanganyika for example, except for the CLIMLAKE project, all the training conducted only lead to certificates, rather than higher degrees. In such situations, the riparian states are forced to rely heavily on expatriates to undertake tasks which would otherwise have been undertaken by local experts. The Laguna Lake Development Authority (LLDA) provides a contrary example, in which local ability was well supported and developed.

*Fragmentation*

The Lake Toba brief illustrated the shortcomings when the agencies conducting various research projects did not readily communicate with one another. Instead they kept much of their results and data to themselves for reasons of prestige and dominance. As a result there is no sound, comprehensive research project covering the major aspects and concerns of the lake.

The same problem arises between countries. In the Lake Xingkai/Khanka Brief it was stated that, although China and Russia developed their own monitoring and information management systems for the lake, a lack of adequate technical and institutional capacity to collect, analyze and store relevant data has prevented harmonized and cost-effective management for the transboundary environmental issues. A UNEP Diagnostic Analysis brought teams of Chinese and Russian scientists together to produce a definitive document. The GEF's Transboundary Diagnostic Analysis (TDA) process has helped countries exchange information and work together in several of the study lakes (e.g. Lake Titicaca and the Caspian Sea).

**How much information is enough?**

Like money, no amount of information ever seems to be enough: almost every brief cites the need for more information, for more research, for more monitoring. Even in cases where a tremendous amount of money has been spent on information the call is unambiguous. The Lake Champlain brief states that additional research and monitoring efforts are needed to better understand the sources and effects of toxic pollutants in the Basin, whilst the Lake Biwa brief states that the funds wasted for the lack of a scientific approach in managing the lake far outweighed the required investment—another clear call for more scientific information.

One lesson learned from this chapter is that the lack of information should not impede action. The Laguna Lake Development Authority (LLDA) has adopted the slogan "Ready, fire, aim!" for good reason. The LLDA has not been paralyzed by incomplete information; instead they have learned while acting and, as a result, have been successful in their management efforts.

Finally, acquiring a sufficient level of information does not necessarily have to be prohibitively expensive: the Lake Nakuru brief cites the development of a cost-effective package of practices for environmental monitoring, noting that it is not likely to cost more than 1% of the annual revenue generated at the Lake Nakuru National Park in which the lake is located. A checklist of the essential information and data for lake management is given in Box 7.4

**Box 7.4. The Information Bare Essentials: A Checklist for Decision Makers**

- Scientific/Technical Prospects and Options—What is the current condition of a lake (i.e., current water quantity and quality, and changes in them over time)? What is the status of its biological communities? What are the root causes, within and outside the lake drainage basin, for the observed problems? What are the lake management options and what are their possible outcomes? How can progress in lake recovery be evaluated? What is the expected degree of, and recovery time frame for, specific lake problems?
- Sociological Perspectives—What is the cultural history of lake use in its drainage basin? What customs, social mores or religious beliefs influence the use of lakes and their resources? To what extent can the public and other lake stakeholders be mobilized to help identify and implement effective lake management efforts?
- Economic Characteristics—What are the economic characteristics of the drainage basin stakeholders, including the relevant governmental management bodies? Are sufficient financial resources available for sustainable management interventions? Is poverty alleviation linked to sustainable lake use? What economic incentives, penalties or subsidies exist to facilitate lake management interventions and what are their past experiences?
- Institutional and Legislative Frameworks— What is the existing legislative framework in the drainage basin? Do adequate institutions and laws exist to regulate, protect or guide the sustainable use of a lake and its resources, or are new or modified ones needed? Do different lake management institutions have overlapping or conflicting mandates? Are existing laws and regulations enforced in a consistent, equitable manner? What other legislative incentives exist and what are their experiences?
- Political and Governance Structures—What are the political realities regarding the sustainable use of lakes and their resources within the lake drainage basin? Is the political structure amenable to public inputs? Are current politicians and government officials providing the necessary leadership to facilitate needed lake management interventions? Is the lake governance process transparent, equitable and accessible to the public and other lake stakeholders?

# Chapter 8. Mobilizing Sustainable Funding

**Key Lessons Learned about Financing**

- Although international finance is attractive (it often comes as grants that do not have to be re-paid) international finance is also short-term and often targeted to specific issues. Consequently decision makers need to develop both local and national level sources of funding.
- Financing for capital infrastructure investments usually comes from the national level or from international resources; local level funding is an important source of money to help meet routine recurrent expenditures.
- Financing for routine monitoring and lake scientific labs is particularly problematic; this is one are where external financing may play an important catalytic role but should not be relied upon for long term funding.
- It is easier to levy local fees when the money stays in part in local coffers (to pay for current needs) and locals have a say over its use.
- To ensure global benefits from lake projects, particularly in the case of international lakes, a programmatic approach is better than a project-by-project approach. In order to sustainably provide global benefits, global action and close co-ordination among national management agencies is required. This is one case where external funding may be necessary to implement the new management regime.

Improved lake basin governance costs money—money for new or existing institutions and staff, money for investments in discrete projects, money to compensate "losers" when new policies are introduced. Sustainable lake basin governance means sustainable financing—and financing that is sufficient in quantity and guaranteed over time. Neither condition is likely to be met in many of the world's lake basins.

In an ideal (and completely unrealistic) world all stakeholders using or affected by a lake and its basin would contribute to the costs of actions and policies needed to maintain ecological integrity and economic sustainability. However, in most lake basins the numbers of people involved are large and the ability of many to pay is very limited. In addition, there is often no effective institutional mechanism to collect money from individuals and make the required investments or payments. And the administrative and financial costs of collecting fees or charges can be substantial.

Lake basin decision makers face two major types of costs: **capital investments—**usually large and "lumpy" investments in infrastructure like sewage treatment or lake hydraulic works—and day-to-day **management costs**—largely salaries and modest capital costs and usually referred to as "recurrent costs". In most developing countries neither cost is met from local resources. This chapter examines what a decision maker can do to at least increase funding for regular, on-going expenses. Capital investments will probably have to continue to be paid by others—national governments or foreign donors.

**The Decision Maker's Complaint**

Securing sufficient financial resources is a constant concern. A few excerpts from the Lake briefs make interesting reading:

- "the Government has been suffering from acute shortages of resources and this has weakened the capacity of remaining extension staff to carry out its activities" Lake Nakura Brief
- "it is unclear how successful projects developed under the GEF project will continue to receive funding now that the (GEF) project is over" Lake Baikal Brief
- "lack of financial support in general and poor working conditions in particular make it hard for the preserve to function in any normal way" Lake Issyk-kul Brief
- "the assessment rates overall sustainability as unlikely. Staff incentives were reduced with a return to Government salaries. Malawi cannot provide

sufficient budget to sustain the lake research program…” Lake Malawi/ Nyasa Brief

Around the world, in rich and poor countries alike, decision makers complain that resources are not enough to do all that needs to be done. While this complaint may be true for almost *any* natural resource, improved lake governance, and the financing that supports it, is often attainable if one is *careful in resource use*, *creative in identifying new sources of funding,* and *inclusive in involving stakeholders*. For example, judicious investment in knowledge gathering (monitoring and scientific studies) can help target management interventions so that funds are used efficiently; and, high rates of fee collection can be achieved if users of the lake's resources are given a genuine say in the management of the lake basin.

In addition, since money is transferable between uses (or, as economists say, fungible), the challenge for decision makers is usually to increase the *aggregate* amount of money available, regardless of the source. While it is often true that international donor funds are often tied to specific activities or investments, these same donor funds are usually additional money and they free-up other money that is not “tied” and can then be redirected to other uses. Consequently decision makers often focus as much on increasing total funding (that is, increasing the size of the “financial pie”) as they do on the allocation of those funds (who or what receives the “slices” of the same pie).

As mentioned in Chapter 4 on policy, **political will** is an essential ingredient in increasing support for and funding for improved lake management. Any funding scheme has to be implemented on order to collect revenues, and this requires political will. The second essential ingredient is **public acceptance and understanding** of the new system—and this implies education and awareness building.

This chapter considers three distinct sources of potential funding for improved lake basin governance, and presents examples and the opportunities and cautions about each source of funding. Most of this funding will be for recurrent costs, also referred to as O, M and R—operations, maintenance and replacement—and not for initial capital costs. These three main sources of funding include the following:

- Local sources (including user fees and other locally generated revenues),
- National level financial resources, and
- International funding including both bi-lateral and multi-lateral funds (including the GEF).

Selected examples from the 28 case studies are given to illustrate each type of funding.

## Locally Generated Funds

A somewhat new source of funding for improved lake basin governance is *locally generated revenues*, either payment for services (e.g. **user fees** like drinking water charges or recreational charges) or fines for pollution (e.g. **pollution charges** like wastewater discharge fees). These funds are collected from various groups and include those who are direct users (and beneficiaries) of the lake resource such as fishermen, those who benefit from the lake as a source of ecosystem services (e.g. various people who benefit from flood mitigation, improved water supply, or enhances amenity values), or those groups whose activities pollute or harm the lake (e.g. industries or municipal wastewater disposal systems).

In this case the definition of “locally generated funds” is broad enough to include revenues from those downstream users who are directly linked via the ecosystem. This means that a downstream beneficiary may be an important source of funding for decision makers. This is especially true if the downstream uses are high valued uses such as drinking water or hydropower generation (and these same users also have a high ability-to-pay, that is, they are well-off). For example, Lake Biwa is fortunate to have large and wealthy downstream stakeholders. Lake Biwa has been very successful in attracting money from Osaka and Kobe for investment and management costs to help protect the Lake's resources and ensure continuing water supply (both quantity and quality) to these large urban areas. In fact, total public investment in the Lake Biwa region for lake management totals hundreds of millions of dollars.

*Private funding* is a subset of locally generated funding and is usually only important when the number of stakeholders is very small and the community is both relatively rich and socially cohesive. One can think of small lakes with a small number of owners/lake users who band together to make needed investments and enforce certain management policies. This has been observed around some small lakes in the US where the primary use is recreational, and in fact most "externalities" have been "internalized" (see Appendix A). This is only rarely seen in practice (usually where the lake is small and the number of stakeholders is also small) and almost never observed in larger lakes or where large numbers of stakeholders are involved. Private funding via donations can be important additional source of money (sometimes targeted to specific management objectives such as biodiversity or cultural conservation).

Although not discussed in the Lake Sevan Brief, a recent study (Wang 2003) has examined the willingness-to-pay (WTP) of Armenians, both inside Armenia but more importantly, the larger and wealthier community of Armenians living abroad. The initial results for residents of Yerevan, the capital, indicate a total WTP of around $18 per person. This is based on a monthly payment of $0.50 per month for a 3 year period) to stabilize the lake level and prevent any further lowering of the lake level. Although seemingly not a large sum per person, this is a substantial WTP given the very low income levels in Armenia. Additional research is looking at expatriate Armenian WTP measures and these numbers are expected to be much higher. The challenge, of course, will be to design an effective policy tool to collect some of the WTP, both within Armenia and abroad.

*User Fees*

Locally generated (and locally retained) financial resources often take the form of some sort of "*user fee*"—perhaps from fishermen or recreational user, or from those who consume a lake resource such as drinking water. A *user fee* is a charge that is paid by someone who *derives a benefit* from the direct, or indirect, use of the lake and therefore has both an interest it the conservation and management of the lake's environment, and an implicit responsibility to help pay for that conservation and management. Education and public awareness are central components of any new user fee system. In Box 8.1, for example user fees from fish pen operators in Laguna de Bay in the Philippines have become an important source of funds for the local lake development and management authority. This example also illustrates the importance of agreeing on a distribution of the funds with responsible institutions, such as local government, and those paying the fees.

**Box 8.1. User Fees in Laguna de Bay, the Philippines**

The Laguna de Bay managers have used several different types of user fees to help both generate revenues and provide an incentive for polluters to reduce pollution.

Introduced in 1997, the Environmental User Fee System (EUFS) is designed to help reduce pollution loading in the lake system and is composed of a fixed fee and a variable fee. The fixed fee covers the administrative costs of implementing the system and the variable component is based on the BOD concentration of the effluents. The current threshold level for BOD is 50 mg/L. The combination of a fixed fee (a Command and Control measure) and the variable fee (an economic-based instrument) has been effective in both meeting administrative costs and encouraging firms to reduce their pollutant levels. The EUFS has been implemented in stages with the larger firms affected first.

Revenues from a separate user fee on fish pen operators are shared between the local government units and the Laguna de Bay Lake development Authority (LLDA). The fee, currently about US$120 per ha of fishpen, generates revenues for improved lake basin management and makes the lakeshore communities active stakeholders in lake basin management.

These two fees have been effective in achieving two important goals – developing a source of local funding for the LLDA and lake shore communities, and providing an incentive for industrial polluters to reduce their emissions to the lake.

Tourism, both national and international, is another excellent example where user fees (admission fees, daily use charges) can be developed and begin to produce revenue for improved lake management. This is a well-established practice and has been implemented in a number of lakes where tourism is an important use—for example, in Lake Nakuru, visitors to the national park to see the flamingos all pay a user fee. This practice could be expanded to other lakes, especially where there is a clearly defined lake-based recreational activity (c.f. Lake Baringo). An important ingredient for success, however, is the local retention of at least part of the fees collected, couples with public education and communication on the link between resource management and economic activities.

Setting user fees requires considerable judgement. In almost all cases the user fee is less that the true value of the resource being used. This is commonly observed in water supply systems where user fees often just cover operations and maintenance (O & M) costs but do not pay any of the initial capital costs. In irrigation systems user fees often do not even cover O & M costs. This is neither surprising nor a major problem. People do not like to pay for the services of any ecosystem (there is a feeling that natural resources are a gift from nature and should be free!). In addition, setting ANY user fee begins to establish the principle that these resources have value (and alternative uses or opportunity costs). Thus implementing even a partial user fee system starts to send the correct market signal and can begin to generate some revenues for improved management.

Successful introduction of user fees also requires that the population being taxed understand why the fee is being levied and also the population see some result in terms of improved management. If these requirements are not met collection of the fees becomes even more difficult and an adversarial relationship between the users and the decision makers may develop.

*Pollution Charges*

Fees can also be levied on those whose actions potentially *damage the lake* and its sustainability. *Pollution charges* or *levies* are therefore a potential source of funding and serve a double purpose—if there is pollution this charge helps generate revenue to address the pollution issues or compensate those who are hurt by the pollution. In addition, pollution charges also serve as an incentive for polluters to decrease their pollution and therefore avoid paying the pollution charges. In theory pollution charges could be paid directly by the polluter to those whose welfare is hurt by the pollution. This is administratively very hard to do so usually these charges are collected by some central institution and then payments are allocated to various groups—both those whose welfare is hurt as well as other stakeholders in the basin. In some cases the charges go to the central treasury and the decision makers must fight to get some share back to pay local compensation. (This is also often the case with user fees.) In Lake Dianchi in China, pollution fees are used (in addition to more commonly observed water supply charges), to raise revenues. Box 8.2 discusses the situation in Lake Dianchi.

**Box 8.2. User fees in Lake Dianchi, China**

Lake Dianchi near Kunming, China is the center of a major urban, industrial and tourism region. Pollution from industry, agriculture and urban sewage was a major problem. The lake authorities have made major investments in sewage and wastewater control. In the year 2000 they spent over RMB 340 Million (about US$ 41.5 million). To address the ongoing problem of industrial pollution, the lake authorities have combined a pollution levy system with a loan/ grant program for installation of pollution control equipment.

Starting 15 years ago old industries were charged a pollution levy if their discharges exceeded the stated discharge standard. In addition, the 1988 Dianchi Protection Ordinance prohibits the introduction of any new polluting industries in the Lake Dianchi catchments.

Existing industries, when taking actions to control pollution, were provided with loans from the government for the required investments. These loans were funded by a combination of the environmental pollution levy receipts plus special funds allocated for Lake Basin environmental improvements. As an added incentive, if it was shown that after the pollution controlling investments were made that the industry could then meet the pollution discharge standards, the loan was converted to a grant and no repayment was required. By combining government investments, pollution levies, and a loan/ grant program for pollution controlling investments, the lake management authorities have begun to tackle the major problem of pollution of this important lake.

Whether it is a user fee or a pollution charge, the idea is to establish a connection between those who benefit from using the lake resources (or negatively affect its quality), and the costs required to maintain the same resource. These fees and charges help to generate revenue for improved management. A user fee or a pollution charge also reinforces the idea that a lake and its resources have value and therefore have to be used wisely. As was discussed in Chapter 2, free resources and free goods tend to be overexploited and poorly managed. Resource degradation is common. Think of the condition of many open access resources including oceans and seas, lakes and public parks. When money changes hands (and a market is functioning) it sends the correct signal: a lake and its resources are valuable and scarce, and one has to use the lake resources wisely. Fees and charges help to re-enforce this message (it costs you money to use it) and also help provide funds for needed conservation and protection (to ensure availability of the resource over time).

*An independent source of funding?*

In addition to creating a cause-effect link between the resource and those who use the resource, user fees and pollution charges also have the very attractive feature of *helping to create local sources of financing, both in terms of collection and control*. This is important to any decision maker since these funds are not entirely dependent on requests to the regional or national treasury. And, as was stated at the beginning of this chapter, nationally-allocated funds are never sufficient in amount nor guaranteed over time.

However, one major potential problem with locally generated financing remains. In many countries the legal framework states that all money collected from user fees have to go to the National Treasury, and money is the re-distributed and allocated based on certain principles. While this approach is the correct one from a pure public finance perspective (taxes and revenues that are collected should be "pooled" and used in their "best and highest valued" uses) the fact is that very little money normally flows back to the lake for improved lake management.

The lack of uncertainty of having access to collected money creates an obvious problem with incentives to collect these fees—local managers are unlikely to collect money rigorously if little or none of the money is then available for local purposes. One potential solution to this problem is to devise a revenue sharing scheme whereby any revenue collected is divided between the generating unit (e.g. the lake management authority) and the local or national government. In the case of Laguna de Bay, fees from fish pen operators are in fact split between the lake authority (LLDA) and local governments. Although national government (and Ministries of Finance or the Treasury in particular) do not like "*revenue-sharing*" proposals, an argument could be made that this approach actually INCREASES resources available at both levels—local and national, since splitting SOME revenue may generate more resources to both sides that not splitting NO revenues! (Put another way—50% of "something" is more than 100% of "nothing"!!!)

An interesting example of precisely this sort of approach is found in Mexico where user fees for national marine parks in the Yucatan Peninsula are now split between the park managers and the local communities, rather than going directly to Mexico City (and never being sent back for local use). To implement this idea, however, took several years of work and the passage of a law in the Mexican Congress expressly allowing this form of local revenue retention and revenue sharing.

*The Principle of Cross-subsidization*

One well-accepted financing principle is that of cross-subsidization. That is, certain activities (or uses of a lake, for example) can generate a lot of money while other activities generate very little or no money. The principle of cross-subsidization states that "excess" money can be collected from one use to help pay other expenses. Whether or not this should only be done within a sector (e.g. lake fisheries, tourism) or within the lake basin, is a political, not an economic question. Cross-subsidization is justified by the transmissivity of the lake ecosystem and the differing abilities of different parts of that ecosystem to generate revenues to meet the management needs that affect all users.

Sectoral ministries (e.g. the ministry of fisheries or agriculture) typically only look at their narrow sectoral boundaries. Administrative boundaries are just as much a barrier and only in a few cases are the lake basin and the administrative boundary the same (such as is the case for Lake Biwa). This leads to one of the key lessons from studies of integrated watershed management—plan in an integrated framework and implement along sectoral lines. Lake Basin authorities, especially if they have independent sources of funding, can help promote this process by allocating money across different sectoral needs, but sectoral authorities (like a lake fishing commission) is almost never able to break out of the sectoral approach.

*Should people pay for "gifts of nature/basic human rights"?*

Another issue is whether or not it is appropriate to charge a user fee for a "gift of God" or a basic human need/ right like drinking water. Regardless of ones views on the inherent "right" of people to water, user charges can be justified by the argument that what is being paid for is the *service provided* (e.g. the costs of supplying water), not the resource itself (the water).

Merely saying that "water should be free to all" (or parks or open spaces should also be free) does nothing to help ensure its timely provision. Some countries have enshrined certain "human necessities" in their Constitution, but this is a political issue separate from managing and maintaining the resource.

*The special case of the "poorest of the poor"*

It has to be recognized that in some situations part of the stakeholder population is truly so impoverished that they cannot pay anything to help better manage the resource that they depend on. However, rather than starting with this as the assumption for all populations, the special case argument needs to be examined carefully in each case and justified. Often it can be shown that the poor pay more because of the non-delivery of services than would be the case with basic public provision of certain services (such as potable drinking water). In addition, the important point about locally-generated funding is to establish a cause-effect link between the resource and those who benefit from its use. This helps create general public awareness and expectations about appropriate and effective management. Both help create political will to do better resource management.

In conclusion, it is not possible to say what percent of current lake management funding should be locally generated (and retained). While locally generated funds are probably still only a small share of lake management funding in most places, it is the part of the funding package that has the most potential for future growth. In addition, it is the only source of funding over which decision makers and local authorities have control. As the appreciation of the wide range of lake-associated benefits grows (e.g. see earlier discussions in Chapter 2), new ways to generate funds locally will develop (Chapter 4 discussed a number of different policy instruments or tools that can be applied).

**National Funding**

Most lake management programs rely, entirely or in part, on financing from the national (or provincial/state) government, either through sectoral ministry funding or via special appropriations for integrated lake management committees. The Lake Briefs provide details on lake management institutions for lakes as diverse as Victoria, Constance, the Great Lakes, Biwa and Toba. Several of these are international lakes, while Biwa and Toba are national lakes. Still, the intentions are similar—to bring together various interested stakeholders in a meaningful way to improve lake management.

National level funding (and here this refers to any funding above the local level and implies that funding comes from general tax revenues that are collected and then re-allocated) can be a major source of money but is often insufficient in amount and may not be sustainable over time. This is particularly true if the lake in question is remote or populated with a minority population group.

One area where national funding mat be both appropriate and essential is capital infrastructure investments. These large, "lumpy" investments—for such things as wastewater treatment or major water supply projects—are rarely funded at the local level. Local resources are often not sufficient or the benefits may be quite wide-ranging and long-term so national level funding is appropriate. See the Lake Dianchi and Lake Toba briefs for examples of national funded infrastructure investments.

Combining locally generated resources with national funding may be an attractive alternative to relying solely on national funds. National funds are usually more "fungible"—they can be used for any of a variety of purposes, while locally-generated funds may have a narrow sectoral focus. For example, local user fees from fishermen will augment available resources but will probably only be spent on fish management—not on other lake management problems, some of which may actually create more benefits per dollar spent.

The institutional (and political) issue of separating *sources of finance*, from the *uses of those resources*, remains. Although lake basin management authorities (or international lake commissions) have the responsibility to look broadly and identify the most appropriate investments or actions that are needed wherever they occur in the basin, it is not always easy to do so. There will always be pressures from the sectoral ministries, or the more vocal groups, to focus narrowly. Worldwide, resource allocation decisions are decided as much by political power and political will, as by dispassionate analysis.

**External Funding**

Faced with this funding challenge—to rely on locally generated funds (but a source that may be quite small in total amount), or to rely on national funds and the fierce funding competition between the various sectors, ministries and regions of the country—many decision makers look abroad to external funding.

External aid is seen as a way around two important financing problems: first, increasing the amount of money/resources available, and second, breaking the link between the sectoral ministry/source of funds and their use and allowing a wider variety of management issues to be tackled. External funding can be either from bilateral (country to country assistance) or multilateral sources (regional blocks like the European Community or United Nations agencies).

About half or more of lakes in the set of 28 lake briefs have some sort of external support. External funding is often used for infrastructure investments (e.g. sewage and wastewater treatment, water control structures) but also often helps pay research and management costs. The external funding ranges from a marginal share of the total to the bulk of management funding. For these jointly funded activities to be fully effective, there needs to be a clear agreement between the parties about how their respective commitments will be integrated and a mechanism to make sure that each party abides by its commitment. For example, the Japanese government funded the expansion of the Nakuru (Kenya) town water supply and upgraded the town's sewerage treatment plants to treat any consequent increase in effluent being discharged to Lake Nakuru. However, the benefits from these investments are not being fully realized because of limited commitment by the Kenyan government to its obligations to water and wastewater management.

External support can take the form of **loans** that have to be repaid (e.g. loans, both "hard" and "soft", from the World Bank to a country for lake management as is being proposed for the Aral Sea). "Hard" loans carry market-determined interest rates; "soft" loans carry below-market, highly subsidized interest rates. More desirable from the perspective of decision makers are **grants**—money that does not have to be repaid. Most bilateral assistance (such as from the European Community and individual countries) and GEF funding are in the form of grants. Some lake projects combine grants with loans. The first phase of the Lake Victoria Environmental Management Program, for example, has two major sources of external funding, a GEF grant of about $33 million, and a "soft" IDA loan of about $43 million.

*The Special Case of the Global Environmental Facility (GEF)*

While most bilateral or multilateral funding is provided to promote various social/ecological objectives (e.g. poverty alleviation, ecosystem protection, regional development), the Global Environment Facility (GEF) is the only funding that is based solely on the fact that lakes have global environmental benefits (for either biodiversity or the management of international waters) and that their proper management implies management costs that exceed what a country would be willing/able to undertake based on estimates of national benefits and costs. *Hence GEF funding is designed to cover the "incremental costs" of an activity*—those costs that produce international environmental benefits, as opposed to national-level benefits. The latter, national benefits, are supposed to be paid for by the countries themselves and are not normally eligible for GEF funding.

This rationale for GEF funding becomes more complicated in the case of international lakes, since even though the ecosystem may be whole and linked, the management actions, and the incidence of benefits and costs, may vary greatly between riparian countries. If there is a “shared vision” for lake management, and the countries share many other characteristics, the chances for success improve considerably. In the case of Lake Peipsi, the governments of Russia and Estonia have signed three agreements (fisheries, environment and water use) and have set up a Transboundary Water Commission to improve the management of the lake. While these actions may fall short of a formal joint vision for the lake, they represent sectoral agreements and ensure that there are on-going discussions over a wide range of issues so that each country is well aware of the intentions of the other and any problems that may arise. In other cases the riparian countries are still working towards common goals for shared lakes. For example, the development and protection of Lake Victoria has been hampered for many years by the absence of an overarching agreement between the three riparian countries (Tanzania, Kenya, Uganda). However, under the auspices of the East African Community, the three countries are now drafting a Protocol for Sustainable Development of the Lake Victoria Basin and plan to establish a Lake Victoria Basin Commission as part of that Protocol. If successful, this initiative will lay the foundation for a joint approach to managing the lake and much of its catchment (the two upstream countries of Rwanda and Burundi are not yet part of the EAC).

In still some other cases, the world community seems much more concerned with what happens than the riparian states. Lake Malawi provides a case in point. This lake, recognized to be the most bio-diverse in the world, is central to the economy of Malawi but of less importance to the other two riparian countries—Tanzania and Mozambique. Malawi operates a fishing industry and an aquarium fish trade, the latter of which exploits some of the highly localized and rare fiah species. The latter two countries are developing agriculture and tourism within the lake’s catchment with the potential for adding sediment and nutrients to this important international waterbody. There is considerable international concern about the threat to the lake’s biodiversity and a number of bi-lateral and multi-lateral projects have been funded to help preserve the biodiversity and promote environmentally responsible fisheries. However, without an agreement (or even a mechanism for discussions) between the three countries these international efforts are unlikely to be beneficial in the long term.

External funding (bi-lateral, multi-lateral, GEF) has benefits and costs. It allows decision makers to do more by expanding the financial “pie” and therefore helps pay for various new policies and investments, but may come with certain conditions or biases. In addition, external funding is usually not sustainable over time. The average GEF project is a one-off investment over 3 to 5 years.

*External funding—necessary? sufficient?*

Some successful cases of lake management have no or very limited external funding (e.g. Lake Dianchi in China) and, conversely, some lakes with large amounts of external funding have had very little success in implementing effective management plans.

Funding, either domestic or external, must be seen as a “necessary but not sufficient condition” for effective lake management. And development experience in general has shown that long-term financing commitments have to come from domestic sources. Consequently there are important issues about how external funding can be best used and how to ensure a smooth transition to national or local sources of funding.

*The Sustainability of External Funding, or, is there life after external funding??*

One of the strong lessons from the review of the 28 lake briefs is that it is very important that external funds *play a catalytic, rather than an implementing role* in lake management. There are too many examples of foreign donors financing program or project implementation, with the activities ending as soon as the funding from external sources ends. Effective financing requires that foreign resources help create the conditions whereby local or national resources can continue with management after the external funding ends. One problem noted in several Lake briefs, is the tendency for the external funds to be used to pay for international consultants and not being used to build capacity in the developing countries. Another related problem is that when externally funded salaries are considerably higher than government salaries, it can be very difficult to retain staff once the external funding ends and salaries revert to the old schedule (e.g. Lake Malawi).

It has been argued that GEF-type payments for global environmental benefits should be on-going since the benefits are on-going. This argument for "international funding for international lakes" implies a longer-term commitment to international lakes of global importance. Although this is clearly desirable to do and conceptually correct, in practice it is not very feasible. The history of international funding is not very promising for this type of initiative. "Donor fatigue" is observed in all sectors, and what is attractive for international funding today may receive only limited support in a few years time. Sometimes external funding is used to help set up trust funds or other mechanisms to help ensure continued funding. Bi-lateral and multi-lateral donors, however, have not been willing to commit to open-ended funding commitments.

One potential promising future source of longer term funding is **international payment for environmental services.** If global markets develop for certain environmental services (such as we see in the earliest stages for carbon sequestration, perhaps for biodiversity protection in the future) these global markets may form a way in the future to ensure continuing external funding for lake management. This has not happened yet, however, and therefore is not yet an appropriate way to plan for longer-term financial support.

The idea of user fees that was introduced earlier, therefore, offers one avenue for developing new sources of funding. The entire rationale of this report is that healthy lakes provide a wide variety of services and physical products and that decision makers need to do a better job of demonstrating these benefits to the broader community, and eventually to start collecting some payments for these environmental services, payments that can be used to help pay for required management actions. Lake Toba in Indonesia presented one example whereby the lake management authority has been working with various stakeholders to increase its funding base (and its base of political support) for improved lake management. In particular, a major industry, PT Toba Pulp, a pulp producer, is working with the local community to behave in a more "environmentally friendly" manner. In addition, the company will set aside 1% of its net revenue for the use of the local government for improved environmental management in the lake basin. Once implemented, this "user fee" should generate over $500,000 per year for the local resource management authorities.

**Practical Steps towards Securing Additional Funding**

Decision makers seek practical ways to increase the financial resources available to them. Ideal sources of funding are those that are sustainable, easy (and cheap) to collect, and help re-enforce lake management objectives. Since collecting revenue is itself not a costless activity (and it seems counterproductive to spend more to collect the fee than the fee itself generates) astute decision makers look for ways whereby the users/beneficiaries can help share the responsibility for fee collection. This has the greatest possibility when the fee is user-based and the service (fishing, recreation, camping…) is provided by a private business.

Of course the ideal financing combination will be unique to each lake, but the following situations are examples where opportunities exist to secure additional funding from local, national or international sources:

- Lakes with international environmental benefits that make them eligible for GEF funding (c.f. many of the GEF-linked lakes): *funding source—external funds*
- Lakes with major industrial users who can help pay for water management or pollution reduction costs (c.f. Dianchi or Toba): *funding source—pollution charges*
- Lakes with important downstream users who can help pay to ensure their secure water supply and water quality (c.f. Biwa): *funding source—user fees*
- Lakes with well-off lake community user groups who are able and willing to help pay for sustainable resource management (c.f. fishermen in Laguna de Bay; flower growers in Naivasha): *funding source—user fees*
- Lakes with important recreational uses that can be tapped via user fees (c.f. Dianchi, Constance, Great Lakes): *funding sources—user fees, property taxes*
- Lakes with international waters where one partner is more willing (and able) to help pay for improved management (c.f. Peipsi): *funding sources—GEF and other bilateral and international transfers*
- International (external) willingness-to-pay for bequest and/or existence values: *funding sources—NGOs, bilateral and international transfer such as from the GEF*

Starting the process of collecting fees where none were collected before is not easy. People would rather have a service provided for free than pay for it. Experience around the world, however, strongly suggests that much more can be done to increase local (and national) revenue collection, and that when the lake users see that they are also receiving improved services and management as a result, there is wide-spread acceptance of these charges. Given that both national level and external funding is available for many lakes, many decision makers have the luxury of starting small with initial revenue enhancement activities and thereby beginning to build public acceptance (if not active support!) for increasing local revenues. Obviously this is a governance issue that requires a partnership between the various lake stakeholders and active public participation. It is worth the effort, however, in order to build a sustainable financial base, and establish a clear link between the users of the lake basin and its resources and a responsibility to help pay for some of the management costs.

## Section III. Synthesis

The report concludes with this section. Chapter 9 on integration of plans brings all the themes of Section II together and discusses how lake basin management is carried out in practice. Chapter 10 recaps the report and puts forth some guidelines for anyone interested in taking action to improve the conditions of a lake and the people and nature which both depend on it.

# Chapter 9. Plans to Action: Integration of Planning Dimensions

This chapter introduces how we can go about integrating the basic components of lake basin management and their associated concerns described in Part II into the process of developing lake basin management plans. First, it discusses lake basin management plans in terms of their scope and the associated mode of implementation. Specifically, they are categorized into visions, long-term comprehensive plans, short-term action plans and specific interventions plans. A simple conceptual framework is then introduced to facilitate assessment of the current state of the lake basin and its management as compared to the management needs in future, drawing attention to two overarching requirements, i.e.;

- development of a social consensus
- requirement for knowledge about lake basin biophysical and socio-economic processes.

The importance of these two requirements permeates many of the Briefs.

Finally, we discuss how widely differing planning dimensions of lake basin management projects may be meaningfully integrated. Here, emphasis will be placed on the importance of allowing the integration process to take place gradually while keeping in sight the long-range and broad issues typically found in the management of such complex systems as lake basins.

## Lake Basin Planning

A plan consists of a set of goals and objectives agreed by all stakeholders together with the actions to be taken to reach those goals and objectives. Plans can be developed at a number of levels of generality. Each of them contains the well-recognized stages of planning:

- establishment of an agreed goal,
- development of alternative strategies for reaching the goal,
- selection of the preferred strategy based on assessment of feasibility
- implementation of that strategy with mobilization of necessary resources,
- refinement of the strategy through monitoring and evaluation.

Generically, these stages exist regardless of scale and scope of the plan.

The most broad-scoped and generalize form of lake basin plan is a **"vision"**, a declaration with some long-term aspirations to work toward but with little or no binding mandates or resource commitment. The recently completed Vision and Strategy Framework for Management of Lake Victoria Basin is an example. It lays the foundation for the riparian countries to manage the lake jointly, with aspiration to achieve some high level agreed goals. A vision framework such as World Lake Vision (http://www.ilec.or.jp/eg/wlv/WLV_Final.PDF and Box 9.1) can be both inspirational and instrumental in promoting the development of more specific implementation-oriented forms of lake basin management plans as exemplified by Lake George Basin Management Plan (Paper presented at the GEF LBMI African Workshop, Integrated Management of Lake George, Uganda: The Lake George Basin Integrated Management Organisation, LAGBIMO).

**Box 9.1. World Lake Vision**

The World Lake Vision is a call to action made by some 40 local, national as well as international organizations concerned with sustainable use of lakes and their values. It focuses on their uniqueness, their range of uses, and their fundamental importance to the human condition and the natural order now and in the future. The World Lake Vision provides guiding principles or menu of strategies and opportunities, as fundamental components of an integrative framework for identifying significant lake problems and developing practical solutions. The seven principles detailed in World Lake Vision document provide a blue print for achieving the transition to managing lakes for their sustainable use.

**Principle 1** : A harmonious relationship between humans and nature is essential for the sustainability of lakes.

**Principle 2**: A lake drainage basin is the logical starting point for planning and management actions for sustainable lake use.

**Principle 3** : A long-term, proactive approach directed to preventing the causes of lake degradation is essential.

**Principle 4** : Policy development and decision making for lake management should be based on sound science and the best available information.

**Principle 5**: The management of lakes for their sustainable use requires the resolution of conflicts among competing users of lake resources, taking into account the needs of present and future generations and of nature.

**Principle 6** : Citizens and other stakeholders must participate meaningfully in identifying and resolving critical lake problems.

**Principle 7**: Good governance, based on fairness, transparency and empowerment of all stakeholders, is essential for sustainable lake use.

For a basin management plan to be mandated for implementation, it has to prescribe details of the structural and non-structural actions to be carried out, as **a long-term plan with envisioned implementation provisions**, unlike a vision statement discussed above. The long-term goals must be met by a range of relevant organizations. Since the implementation of the plan may span longer than the time frame for usual budgetary considerations, the agencies responsible for to carrying out the plan may or may not be endowed with the needed level of financial and manpower resources. For the plan to be viable, it usually has to be scaled down to meet the budgetary constraints. The plan thus gets revised over time.

For example, the comprehensive plans for Lake Biwa provide an interesting insight of long-term plans with strong orientation in implementation. The Lake Biwa Comprehensive Plan (1972-1997), that included a large number of lake resource development and regional economic development projects, was originally designed to be completed in 10 years the long-term financial commitments coming from the national and downstream local governments through a special legal provision and institutional arrangements (the plan, after two project period extensions with additional resource commitments particularly for environmental components, were completed in 1997). On the contrary, Lake Biwa Comprehensive Conservation Plan (1998 – 2050) of which the first the three-phase planning durations is currently being implemented, does not have a special financial mechanism backed up by the legal provisions involving the national and the downstream local governments, and it is expected that many of the component projects included are likely not to be implemented as envisioned. The Lake Biwa case attests to the fact that implementation of a long-term plan will be significantly affected by the availability of financial resources over time, which will also depend on the long-term sociopolitical interest and commitments. Although not specifically mentioned in the lake briefs, many of the lake-basin plans in North America and Europe that involved infrastructure development such as construction of basin-wide wastewater treatment systems had to have long-term plans with firm resource commitment over a set planning period, with suitable institutional arrangements for project implementation.

While such long-term plans with firm resource commitment over time are rare to find in the financially strained developing countries to which many of the 28 lake cases belonged, there are cases of comprehensive plan for lake conservation with multiple intervention projects both of long and short term implementation arrangements such as one for Bhoj Wetland:

- The Lake Conservation and Management Project also known as Bhoj Wetland Project, envisages tackling of various issues associated with conservation and management of the Upper and Lower Lakes of Bhopal, under a multi-pronged strategy. Although these issues are deeply interrelated and inter-linked, for operational and management convenience, they are addressed under different independently executed sub-projects. The proposed action plan is not one time quick solution but should trigger a chain reaction so as to make the management sustainable. The Project identified 16 sub-projects.

and one for Lake Dianchi:

- As required by "The Approval on the 'Ninth-Five-Year Plan and the Tenth-Five-Year Program for Dianchi Basin Water Pollution Prevention and Treatment' by the State Council", Environmental protection department at Provincial and Municipal levels jointly carried out an "Zero O'clock Action" to force 253 major polluters located in the catchment of Lake Dianchi to bring their pollution into control before May 1st, 1999.

which may be regarded as emulation to some extent of the experience in comprehensive lake basin management over the past decades in Japan as well as in countries in North America and Europe.

The lake briefs also provided many examples of what may be called the "**action plans**". These action plans are more directly focused on a particular set of intervention schemes that is likely to bring about tangible improvement on the ground over a period of several years, if not shorter, continued to be upgraded over a longer time period. One such example is Lake Ohrid "Transbouandary Watershed Action Plan". The plan included the following four primary action items:

- Reduction of point source pollution through actions that stress septic system management and maintenance, homeowner education, and management of solid waste;
- Reduction of non-point source pollution through actions that focus on implementing conservation practices on farms and restoring impaired stream reaches;
- Habitat protection and restoration through wetlands inventory and the establishment of a no-net-loss policy, identification and protection of fish spawning habitat, and inventories of the native flora and fauna in the watershed;
- Comprehensive planning through the establishment of micro-watershed planning committees, and by creating a GIS system and building the planning capabilities within the municipalities.

While these actions are formulated with mobilization of funds from various external sources in mind, they are also to be coupled with the local actions, initiatives and commitments.

A more specific type of plan is **a short-term management intervention plan** developed by a particular sector for either development or conservation/remediation purposes. For example, New York, Vermont, and Québec signed a Water Quality Agreement for Lake Champlain in 1993 that included a phosphorus load reduction strategy from point and non-point sources. A recent (2000) review of progress showed that the three States had considerably exceeded their reduction commitments. This review also highlighted one of the limitations of such sectoral plans. In this case, the nutrient reductions were being offset by nutrient load increases in other sectors, principally conversion of agricultural land to urban uses.

These different levels of planning can be nested; i.e. vision exercise can be used to establish the agreed goals prior to a more comprehensive planning exercise, and sectoral management intervention plans can be scaled up to more comprehensive multi-sectoral plans, with a combination of short-term action plans.

The advantages of taking a planned approach to management, compared to an ad hoc approach, are essentially ones of efficiency and governance. Once the values to be extracted from the lake basin (the goals) and the management actions are agreed, then there is a much higher likelihood that resources will be used more efficiently to achieved these goals if they are expended in a planned way. In addition, if the planning has been carried out transparently and with stakeholder involvement, then there is also a higher likelihood that all parties will feel that their needs have been considered seriously and at least some will have been incorporated into the agreed plan.

In principle, a planned approach to management is particularly important for lake basin management because of the long time frames and complex dynamics involved in lake basin management. However, there are a number of pragmatic reasons why a comprehensive lake basin plan may be impractical, and why it is more realistic to commence with a more limited approach such as a sectoral development or remediation plan. A common reason is that there is no widespread agreement amongst all the stakeholder groups about sharing the resources of the lake basin—a lack of social agreement. A related reason is a lack of political commitment to implement any agreed actions. This can arise when the lake basin may be shared amongst a number of jurisdictions that have quite different commitments to its management, different levels of resources and different external drivers. Thus, Lake Malawi is of central importance to the economy of Malawi itself but of considerably less importance to the other two riparian countries—Tanzania and Mozambique. Unlike Malawi, the populations of the latter two countries are concentrated in areas away from the lake. Consequently, there is at this stage no shared imperative amongst the countries to manage the lake jointly.

Another common reason is that it is quite difficult to make an estimate of the potential gain associated with different management interventions. Commonly there is either inadequate knowledge about the long-term consequences of alternative management actions, or there is a disconnection between those who possess this knowledge (usually scientific institutions) and high-level decision makers. That is, decision makers do not understand the implications of the scientific findings or the scientists themselves are unable to articulate their findings in a way that is meaningful to decision makers. Further, the time horizon of policy making is generally much shorter than the time it takes for the lake to respond to interventions. This has been discussed in Chapter 7. Consequently, a lake management plan usually consists of various individual sector and local management interventions and initiatives rather than a self-contained comprehensive plan.

**A Framework for Analyzing Lake Basin Planning**

The level of social consensus and the extent of knowledge about a lake basin are two characteristics that, from the lake briefs, appear to determine the type and degree of integrated planning that can succeed in a lake basin. While these two characteristics form continua—the first runs from independent stakeholder group to societies where there is a high degree of social agreement; and the second runs from little understood lakes to ones where there is an extensive knowledge base about social needs, economic implications and biophysical processes—it is convenient for discussion to represent them by a simple 2x2 matrix (Figure 9.1).

Social consensus is an important determinant of integrated planning because of the diversity of stakeholder groups and the importance of externalities in lake basins. It is difficult to maximize the aggregate benefits from a lake basin unless these stakeholder groups appreciate the inter-dependency of their actions and the benefits that can be gained from cooperation. The long time frames and the complex dynamics of lakes make a reliable knowledge base (both socio-economic and biophysical) about a lake basin important at all stages of developing a lake basin plan. It informs the agreement on possible goals, the selection of management actions, and the implementation of those actions, especially monitoring progress in meeting the goals.

| | **Extent of Knowledge** | |
|---|---|---|
| **Social Consensus** | **Quadrant 1**<br>High Consensus<br>Good Knowledge Base | **Quadrant 2**<br>High Consensus<br>Limited Knowledge Base |
| | **Quadrant 3**<br>Low Consensus<br>Good Knowledge Base | **Quadrant 4**<br>Low Consensus<br>Limited Knowledge Base |

Figure 9.1. The influence of social consensus and state of knowledge on planning

**The top-left quadrant** (Quadrant 1) represents an ideal situation where there is social agreement on the goals to be pursued and adequate knowledge on how to implement management actions to reach those goals. Many small-scale sectoral resource development projects with quantifiable objectives (e.g., fishery development, tourism, etc.) fall into this quadrant, as do some conservation/remediation projects. Because of the limited sectoral focus, the social agreement about lake basin management and the ability to use good quality knowledge to guide implementation, sectoral plans in this quadrant tend to be very successful. Thus a series of programs to reduce nutrient loads from point sources in both USA and Canada received widespread public support and were based on a strong scientific knowledge base. These programs have been successful to the point where the majority of nutrients now enter the lake from diffuse sources, including internal sediment loads.

As the lake resources become scarce and the interactions between these sector-specific or localized developments and other sectors become more apparent, there is likely to be either less social agreement or less knowledge about the long-term effects of development and remediation interventions. Consequently there are fewer examples of cross-sectoral and transboundary lake basin plans that fit into this quadrant. The best examples come from the developed world where there are examples of cross-sectoral and transboundary institutions that have been established to implement the plans for lakes that fall into this quadrant. Thus the International Joint Commission for the Laurentian Great Lakes was established following the 1909 Boundary Waters Treaty between Canada and the United States to resolve disputes and to advise the governments of on a wide range of issues affecting the Great Lakes. It has been effective in promoting cooperative management of a range of pollution and ecological problems facing the Great Lakes. Elsewhere there are examples of cross-sectoral or transboundary institutions, such as the International Fund for Saving the Aral Sea (IFAS) and the Lake Chad Basin Commission, that have been established but which have not been fully effective because the necessary social consensus (and to a lesser extent, the knowledge) has not been present.

**The top-right quadrant** (Quadrant 2) represents the cases where there is good social agreement on the development and management of a lake basin but where there is limited knowledge on which this management can be based. Of course, management plans can be developed for lakes in this quadrant but the limited knowledge base implies that the outcomes of these plans will be difficult to foresee. These lake basin plans would typically include a knowledge development component such as an intensive monitoring program or a scientific or socio-economic research component to reduce the uncertainties. These plans would also be developed under the precautionary principle; i.e. management actions would be conservative so that the chances of causing unforeseen problems would be minimized. Examples of lakes that fit into this quadrant include Tonle Sap, Lake Dianchi, and Lake Issyk-Kul

Lake Nakuru in Kenya represents an example of a lake basin in **the bottom left quadrant** (Quadrant 3). There are a number of stakeholders in the lake basin completing for the lake basin's resources (Box 9.2). However, there has also been considerable amount of biophysical research undertaken by Kenyan government authorities with donor assistance, a local University and NGOs into the water quantity and quality problems of the lake and its catchment. The Lake Nakuru brief summarizes the situation as "It is now widely recognized that the constraints to lake basin management are mainly social, economic and institutional." Management plans for lakes in this quadrant tend to remain sectorally fragmented. Thus, the Kenyan Wildlife Service has developed an Ecosystem Integrated Management Plan for the Lake Nakuru National park surrounding the lake and the Nakuru Municipal Council completed a Strategic Structural Plan for the town. However, there is no overall plan for the basin that sets out agreed sharing of the resources of the Basin.

**Box 9.2. Competition for resources in the Lake Nakuru Basin**

Lake Nakuru catchment (1800 $km^2$) lies within the African Rift Valley. It is bounded to the west by the Mau Ranges, to the north by the Menengai Crater and the Bahati Highlands to the Northeast and the Eburru crater to the South. There are gently sloping open grasslands to the east. The lake receives water from these surrounding areas and has no surface outlet. The town of Nakuru abuts the northern end of the lake.

Prior to 1900 the Lake Nakuru basin was sparsely settled with abundant wildlife. During colonial times the area was occupied by large grazing and cropping properties. Since independence in 1963 there have been dramatic changes in the land uses in the catchment with consequent pressures on the water resources. Initially, the large farms were broken up into smaller settlement blocks for the indigenous population. These settlements continued to expand up into the surrounding ranges. Between 1967 and 1988 the area under forest and natural vegetation declined from 47% of the catchment to 26%. Even after the remaining forested areas were gazetted for protection in the late 1980s, the clearing continued. Between 1994 and today a further 30,000 ha of forest are estimated to have been cleared. Over 30,000 people are estimated to have settled in these areas.

Tourism is a significant industry in the area. The Lake Nakuru National Park was gazetted in 1968 and was expanded in 1974. This National Park is most famous for the massed gatherings of flamingoes. The Park receives the largest number of visitors of any National Park in Kenya.

The town of Nakuru has also grown dramatically from its inception in the early 1900s. It now contains over 400,000 people. Most of that growth has occurred in the last 20 years with the average growth rate being about 10% for the last decade. Apart from being a major administrative centre, the town is also an industrial centre with textiles, fungicide production (since closed), agro-chemical production, and production of household goods.

This rapid development has placed severe strains on the basin's limited water resources. Aquifers supplying Nakuru town are heavily utilized; rivers flowing into the lake have declined with upstream abstractions; water quality in the lake is believed to have declined as a result of polluted storm water from the town; and sediments loads to the lake have increased with the upstream land clearance.

Although there are sectoral plans of management, there is no overall plan of management that sets out how the further development of the catchment will be controlled and how the existing stresses will be managed so as to maximize the benefits to all those dependent on the catchment's water resources.

**The bottom right quadrant** (Quadrant 4) represents one of the most complicated and difficult situations facing lake basin management. A typical example of when this occurs is when a large-scale irrigation system is proposed upstream of the lake. The consequences of this development on the inflow of water into the lake can sometimes be difficult to predict if there are other influences on the lake's water level that are not well understood. In the case of Lake Chad, the Lake Chad Basin Commission (established in 1964 by Chad, Nigeria, Cameroon and Niger) has been unable to effectively manage the lake because some of the countries have pursued independent development of irrigation. In addition there is only a limited understanding of the combined effects of water withdrawals, climate variability and climate change on the lake's water level so that there is no accepted knowledge base from which management decisions can be made. While management actions will be undertaken in these lakes, it is difficult to develop any coordinated plans in the face of limited knowledge and lack of social agreement. Typically, these actions will be confined to individual sectors, such as fisheries or tourism, and should ideally be based on a careful risk assessment of a particular management intervention. However, this seldom happens.

It is important to note, however, that the forces (population growth, sectoral development, climate variability, external economic forces) that are driving development in the lake basin will change over time. If there is a sufficiently developed knowledge base (quadrants 1 & 3) then the likely changes in these driving forces can be investigated and absorbed into the planning process. Box 9.3 describes the "scenario planning" process used in the Lake Peipsi/Chudskoe lake basin management program to anticipate and examine the direction of future changes in the basin.

**Box 9.3. Anticipating Changes in Driving Forces in Lake Peipsi/Chudskoe**

Lake Peipsi/Chudskoe is managed by two countries, Estonia and Russia, that are each undergoing profound economic, social and political change. Newly independent Estonia will soon join the EU, while Russia struggles to find new political direction and regain economic growth after the collapse of the Soviet Union. Nevertheless, the two countries established a Transboundary Water Commission in 1997.

Eutrophication is agreed to be the key problem facing the lake. The principle sources of the nutrients causing eutrophication have been identified. Although there was a solid basis of scientific knowledge for the lake on which management could be based, a conventional approach to planning did not seem appropriate because of the high uncertainty about the economic, social and political development of the region. Planners could not assume that the current drivers of change would remain relevant in the longer term.

Consequently, planners drew up development scenarios for the region for the next 15-20 years. The scenarios were developed using a story-line methodology using both qualitative and quantitative information about the lake and the basin. The driving forces included population growth, wastewater treatment improvements, fertilizer use, livestock numbers, crop yields, atmospheric deposition of nutrients and the extent of agricultural land use. The five scenarios incorporating these drivers were:

I—Business-as-usual (BAU)—a continuation of present trends;
II—Target/fast development—Estonia makes a fast transition to the EU and Russia experiences rapid economic growth and social development;
III—Crisis—economic and social conditions in both countries deteriorate radically;
IV—Isolation—Estonia undergoes a slow and unwilling adaptation to the EU and Russia increasingly becomes isolated from Europe and more nationalistic;
V—A combination of scenarios II and III (Estonia develops rapidly but Russia remains in crisis)

The planners confirmed that, under all these scenarios, eutrophication represented the major threat to the lake's water quality, and that changes in the amount of land under cultivation was the major factor controlling nutrient loads to the lake. No scenario predicted a larger nutrient load than had occurred during the communist period. The Target/fast development scenario (II) resulted in a substantially larger total Nitrogen input to the lake, while the Crisis scenario (III) resulted in the largest total Phosphorus load.

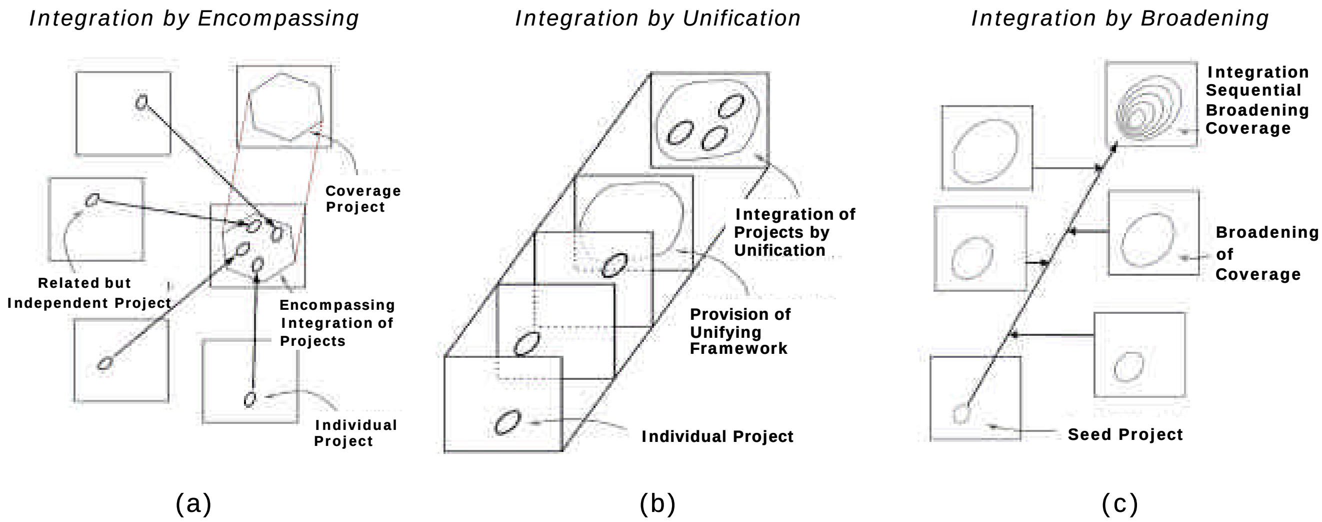
The above framework helps categorize and understand the wide range of lake basin management plans reviewed in this project. The framework also helps develop insights into how lake basin planning may be advanced through building of greater social consensus and developing a stronger knowledge base. Development of a management plan is only the initial step in systematically managing a lake basin. The plan has to be implemented through space and time with the involvement of a wide range of stakeholders.

Administrative institutions, such as local governments, typically do not have boundaries that follow lake basin boundaries, and management institutions are usually organized on sectoral lines with very specific objectives and mandates to promote the development of those sectors. These separate institutions compete for resources to achieve their objectives, contrary to the reality of lake basins where the resources are interlinked because of the complex dynamics and transmissivity of lakes. Because of these two reasons—the mismatch in management boundaries, and the divisive nature of sectorally based management—the management of many lakes around the world is inefficient and unable to provide the resource values that people require. Clearly an integrated approach is required if these management shortcomings are to be overcome. In fact, the integrated planning of lake basins is just a particular example of integrated water resources management (IWRM). However, achieving a more integrated approach to lake basin management is a great challenge.

**Integration of Management Interventions over Time and Space**

The common ways in which lake basin management is integrated across space and across sectors and institutions is discussed here with a particular focus on the time dimension. This is extremely important in public sector planning in general, but particularly so in lake basin management because of the special characteristics of lakes discussed in Chapter 1.

Given the way in which lake management problems cannot easily be quarantined because of the transmissivity of lakes, it is desirable that the management of a lake basin should be as integrated as is feasible across sectors, locations and social groups. Integration can be developed through different institutional structures (Chapter 3). Here we describe three ways (Figure 9.2) in which the lake Briefs how that management activities can be integrated over time.




*Figures 9.2 a-c. Three Forms of Integration.*

*Integration by Encompassing*

This type of integration (Figure 9.2a) occurs when an “encompassing” project or program is instituted to facilitate coordination of independently developed sectoral programs and projects that are operating at the same time. This kind of integration is usually introduced when it becomes apparent that greater benefits can be gained from coordinating existing activities so that the objectives of more than one beneficiary group can be achieved. Typically, this integration will include cross-sectoral coordination across different government Ministries, and even different countries for transboundary lakes, when the beneficiaries belong to more than one sector. For example, the Lake Biwa Department of Lake Biwa and the Environment in Shiga Prefecture, Japan was established for the purpose of bringing together and integrating existing projects in the areas of forestry conservation, sewerage construction, environment, and watershed management to implement the "Lake Biwa Comprehensive Conservation Plan".

*Integration by Unification*

Lake management interventions typically take place sequentially and intermittently as problems become apparent and responses become feasible as agreements are reached, funds become available and information on possible actions is acquired. Of course, if these interventions were the result of a plan, then there may be no need for "integration" because the integrative design should be imbedded in the plan. In reality though, these interventions are usually introduced because of changing social needs, deteriorating water quality, shifting ecosystem responses, etc. Consequently, a unifying program is introduced to ensure that these projects all contribute to longer-term goals. The Zoning and Management Plan for Aquaculture (ZOMAP) in Laguna de Bay provides a typical example. The competition for Laguna de Bay's aquatic resources has been fierce for decades, particularly during the 1970's and 1980's. It was due particularly to the introduction of fishpen culture technology during the mid 1970's that immediately became a lucrative operation for the large-scale commercial operations. In 1980s, Laguna Lake Development Authority (LLDA) attempted to introduce various measures both to conserve the fishery resource as well as to support small-scale local fishermen, and specifically in 1983, a zoning plan of the entire lake surfacewas introduced for the first time. It was an early version of more refined ZOMAP to be introduced later, designed to rationalize the management and regulate the utilization of the fishery resources. The comprehensive Master Plan of zoning was approved in 1996. The Plan was later in 1999 placed under LLDA's Lake Management Division. ZOMAP acted as a kind of unifying project, providing a basis for the new phase of sustainable fishery resource management for the lake, with clearer delineation of responsibilities and political commitments.

*Integration by Broadening*

The previous types of integration dealt with the pursuit of a specific objective over time. But the breadth of projects being integrated can also expand over time so that a broader and broader range of topics, areas and social groups are encompassed. If this is undertaken in a predetermined and planned way, then this is equivalent to moving from a series of sectoral or local plans to a more comprehensively planned management of a lake basin. For example, fringing wetlands around Lake Constance have been restored for biodiversity conservation over the past decades, with the extent of restored shoreline gradually expanding to provide for natural habitats. This is an example where the broadening has occurred over space. On the other hand, it was the extent of legislative involvement in eutrophication management was broadened considerably with the "soap movement" in Lake Biwa in the late 1970's. Initially this was a local movement that led to a "eutrophication control ordinance" that eventually culminated in the enactment of national legislation, "the Lake Law", that allows for a range of conservation interventions by the national government in lakes throughout Japan. This broadening took place over some decades.

**Integration Lessons**

Three lessons can be drawn from the lake briefs about successful integration;

(1) integration should first take place where the pressures are greatest
(2) integration should be phased over time
(3) integration should be pursued by necessity rather than by design

*Integration should first take place where the pressures are greatest*

For integrated lake basin management to be successful there needs to be good governance coupled with the necessary enabling conditions. These include a political commitment to managing the lake basin in the long term for the benefit of all stakeholders, effective institutions, a sense of consensus amongst the stakeholders, and a good level of biophysical and socio-economic knowledge about the lake basin. Experience shows that moving too quickly to integrated lake basin management before these conditions are established does not work (Lake Chad provides an example where the initial enthusiasm for a transboundary commission was not matched by long-term political and financial support). It is better to start small, by bringing together the management agencies and stakeholders where the issues are apparent and there is a developing social consensus that they need to be managed properly. This is often within a sector, such as fisheries, or with a problem such as pathogens from sewage where the pressures on the resources quickly becomes apparent. Success in correcting this problem builds confidence for tackling other problems. Examples of this incremental approach to integration are given in Box 9.4 for Lake Ohrid and Chilika Lake.

**Box 9.4. Building on Initial Success**

*Lake Ohrid, Macedonia and Albania*

Lake Ohrid, shared by Macedonia and Albania, is an important cultural, economic and environmental resource. It faces problems from water pollution from old mines, town sewage and stormwater, agriculture and groundwater inflows from a nearby polluted lake. Lakeshore wetlands and riparian areas are threatened and exotic fish species have been introduced to the lake. An important commercial and cultural fish species, the Lake Ohrid trout, is threatened by overfishing as well as by the pollution, loss of breeding grounds and the introduced species. Both countries have agreed that the fisheries are in immediate danger and rapid management action is required. Scientific studies show that the fish in the lake are one single, linked population, and so they must be managed collectively, with similar requirements in both Macedonia and Albania. With assistance from bi-lateral and multi-lateral donors, Government officials and fisheries experts in both countries have agreed to a unification of some of the fisheries regulation. For example, in 2001, both countries agree to the same allowable net size. While there are still significant differences in the organization of the fishing industries in the two countries, these early successes with fisheries management (coupled with the establishment of a non-executive Management Board for the lake, and agreements on treating the sewage from urban areas around the lake) provide a foundation for increasing cooperation in managing the lake.

*Chilika Lake, India*

Chilika Lake, on the east coast of India, is an estuarine lake system noted for its scenic beauty, its productive fisheries, its religious significance, and its importance as a resting place for migratory birds. However, due to diversion of inflowing rivers for irrigation, and increased silt loads from inflowing rivers, the lake exit has become silted up and fish catches have declined dramatically. Consequently, the overall average salinity was reduced by 33-34% by late 1995-1996. With the shift towards a more freshwater system fish landings declined from an average annual yield of 6000-8000 mt during 1970-1990 to 1270-1630 mt in 1990-1997. Over 200,000 people are dependent on this industry. To compound the threat to their livelihoods, the Revenue department introduced new licensing arrangements in early 1990's that effectively handed over their traditional fishing rights to investors in prawn farming. Apart from sedimentation and water withdrawals, there are also threats from wastewater, agricultural chemicals, weeds, and deforestation in surrounding catchments. A Management Authority was established for the lake in 1992 to coordinate and promote lake restoration and development across the operational agencies. A new entrance was dredged to the ocean in 2000 to provide more direct interchange between the lake and the ocean. The results were dramatic – salinity levels in the northern sector of the lake changed from 0.5 – 2.5 ppt to 0.1-36.00 ppt, and fish landings increased from 1600 mt before intervention to 11,877 mt in 2001-2002. there were other benefits in crab catches and in reductions in aquatic weeds. The obvious success of this engineering intervention in the lake has provided strengthened the hand of the Chilka Development Authority in implementing other aspects of lake management, including non-structural measures.

*Integration should be phased over time*

This lesson is a corollary of the previous one. It typically takes many years, even decades, for goals to be agreed by the stakeholders in single sector issues, let alone multi-sectoral problems; for sufficient knowledge to be accumulated for effective management; for institutions to be established or coordinated; for laws to be passed and rules developed; etc. Thus, the approach of starting small and building on successes towards a more comprehensive lake management plan will take many years. All stakeholders need to be committed for the long-term for these plans to be successful. The Lake Naivasha Riparian Association has evolved over several decades from the earlier Lake Naivasha Riparian Owners Association (1929) to take on an increasingly wider responsibility. Originally formed just to manage the use of the exposed lake bed by riparian owners, it now has a much wider role in environmental management of the lake and contributes to the lake's Management Implementation Committee which is in the process of being gazetted under the Environmental Coordination and Management Act (Box 3.1).

Externally funded assistance projects typically last for 3-4 years. While, at first sight, this is inconsistent with the need for long-term management, many of these projects include components to help develop the good governance and enabling conditions that are needed for long-term lake management. However, even this focus on establishing the conditions for long-term management needs to be maintained. As some lake briefs make clear (e.g. Lake Malawi) there are often no mechanisms established for sustaining this external assistance beyond the duration of the project.

*Integration should be pursued by necessity rather than integration by design*

Regardless of any of the above modes of integration, we should keep in mind that there will not be any perfectly integrated management plan. Naturally, a management plan that is subjected to only minimal integration may bring about a more desirable outcome than a plan that is subjected to highly complex and difficult integration. In the case of management of a system that is as complex as a the lake basin system, in general, integration by necessity is likely to bear better fruit than integration by design.

**Adaptive Management Planning**

The management plan describes what actions should be taken and activities implemented. A comprehensive management plan would include necessary policy changes, new or revised standards and guidelines, new or revised regulations, new legislation, proposals for the introduction of new technology and practices, and plans for remodeling existing infrastructure and introducing new infrastructure. There are a wealth of such actions and activities that could be included in the plan, but in most cases, skilled human resources, time and money are limited. Hence, the question is what should be the priorities and in what sequence should actions be taken and activities implemented.

Priorities are important, but there is another equally important problem associated with developing and implementing lake basin management programs. The kind of management plan that lake basin management programs need to focus on in the future is quite unlike traditional, static master plans that are largely based on forecasts and predictions. A blue print for achieving targets and outcomes on this basis is unlikely to be effective in the complex and highly dynamic context of lake basin problems today—there are too many uncertainties, unknowns and untested assumptions. For example, uncertainties about ecological processes and functions, the impact of different patterns of resource use, and uncertainty about political and social development and change in the future and hence what values and conflicts might constitute driving forces. The risk of wasting limited resources on actions and activities that do not bring major benefits in terms of the agreed targets is large in the face of these kinds of uncertainty. Hence, lake basin management planning in the future should have the character of *adaptive management planning.*

Adaptive management planning is a process for developing a management plans based on an explicit set of assumptions and hypothesis about the elements and components of the lake basin natural and man-made system and how they function and interact. In adaptive management, the monitoring program is designed to provide a feedback loop that enables the planning team to assess these assumptions, improve its model of the lake basin system, assess progress towards the targets, and *adapt* and adjust the plan to reflect what has been learned from the expanding knowledge base. In this approach scientific research, data gathering and monitoring is directly linked to management, and in turn, how resources are allocated to research and knowledge development is driven by management priorities. Adaptive management planning is therefore knowledge and data driven, and analytical because of its reliance on models. But it is also stakeholder based. It relies heavily on the participation of stakeholders to establish goals and targets, to manage competing objectives, and to weigh options and tradeoffs.

**Planning for Sustainable Lake Basin Management Institutions**

A lake basin management program is not a project, it is a long term process. The planning for lake basin management also have to reflect that long term process. It will also have to function in both the biophysical, administrative and political world. Significant amounts of information are needed for the management plan to function effectively, deriving from a knowledge base built over the long term. The changes it is designed to promote occur over long periods during which any number of key factors influencing the outcome and choice of activity can change dramatically. Hence, how such a long-term program is organized, staffed, resourced, and positioned within the administrative and political system is critical to achieving the desired outcomes of the plan at hand.

However, an important principle noted in Chapter 3 is that the chosen institutional arrangement, and the roles and responsibilities assigned to that institution, for the plan to bring forth the desired outcome, should be limited to those that cannot be effectively and efficiently done by others. There are several examples among the Briefs of experience in which effective progress has been achieved through local groups, partnerships and organizations—essentially local arrangements developed by stakeholders (including local and central government partners in some cases). This reinforces this principle, suggesting again the necessity of adapting the mandate, role, functions, and powers of a lake basin management organization to fit the particular circumstance and needs of the lake basin, and in doing so, to take advantage of, strengthen and enhance existing arrangements that have been effective.

There are instance in which governments have established a statutory body with broad functions and powers for lake basin management. However, more generally there are really few examples of effective basin management authorities. Laguna de Bay is an interesting case because this statutory Authority has only gradually exercised their full mandate and powers, allowing time for sufficient growth in capacity, and for learning, evolution of governance arrangements, and the emergence of key networks and constituencies. A lake basin management plan, thus should take into account such evolution in governance, organizational form, mandates and powers that appears to be the norm. Often, time can also be purchased with some early successes in the implementation of a management plan by tackling visible and do-able activities first.

Regardless whether the lake basin management organization is primarily a coordinating agency, a planning agency with little implementation authority, a regulator, or fully empowered statutory authority or commission, the importance of staff numbers, a lake basin management plan needs skills mix and continuity over the long term. Short-termism, or ad-hocism—expecting the problems to be solved in a relatively short project period, often with borrowed or seconded staff, is a major risk to the success of lake basin management programs. Projects formulated to promote or support a lake basin management program should, as first priority, invest in people and capacity, and only through that emerging capacity, undertake to implement the functions of the lake basin management organization.

Further, from a broader perspective, the initial steps and activities for development as well as implementation of a lake basin management plan should focus on establishing three things: effective collaboration with cooperating and partner organizations (even then they initially don't see themselves as partners, or for that matter, even concerned); effective coordination of the activities of agencies active in the lake basin; and a broad consensus on goals and objectives and hence on the option space.

Many traditional government agencies are not receptive to collaboration, which they see as needless interference in their affairs. Others are reluctant to collaborate because they see the potential to lose prerogatives or future opportunities to expand their activities. In the beginning, therefore, establishing effective collaboration, and hence partnerships, will be based on the persistence, state of mind and attitude of the agency in charge of lake basin management. Much the same can be said about the problem of coordination. Experience suggests coordination is relatively easy when agencies agree on the goals and the broad outlines of what is to be done, i.e., the lake basin management plan. Otherwise it runs aground on the same issues as collaboration. Achieving effective coordination of activities, policies, regulations, etc., often involves establishing formal mechanisms, but at no higher levels or with more overarching authority than is really necessary for effective and efficient action. Consensus building is achieved through a number of different mechanisms generally working at the same time, but the keys are awareness raising, inclusion and informed participation.

**Planning for Lake Basin Governance**

While the above frameworks of analysis are useful for development and implementation of a management plan within the confine of a particular lake basin system, in reality often, the focus of the management plan may have to be shifted to a broader scope of sustainable regional and national development. The policy and institutional context that must be navigated to meet such needs, then, may become daunting. The existing institutional arrangements (laws, policies, development and resource user organizations, and government bodies) in most lake basins, that were established to promote development and use of its natural resources or are intended to regulate these activities, are in most lake basins in the developing world an integral if not major part of the problem. Thus a key lesson is here is that the future of lake basin management in many cases will depend on how well the core partnership can be developed and enhanced about the plan for which governmental organizations at all levels, the private sector, NGOs, and other civil society, as well as resource user and stakeholder groups need to work together.

As discussed in Chapter 2, the progress of degradation and loss of resource values in a lake basin and the emergence of scarcity as a controlling factor, is often slow and relatively unnoticed. Hence, a decision maker is often the last to arrive on the scene, especially in developing countries. Development of the resource values in the lake basin may have been taking place for a considerable time. As a consequence, much of the governance framework (rights, policies, institutions) associated with the use and development of resources (land, water, forests, grazing land, river channels, etc.) may be well-established and strongly biased towards continued expansion and development. Limits on resources, the costs of externalities such as pollution or erosion, the gradual decline in resource values, or the spread of unsustainable practices caused by increased vulnerability of livelihoods or poverty may not be recognized. Indeed development and regulatory functions may be so fragmented that each narrow sector perspective is likely to believe that these are the problems of others.

Much of what is meant for lake basin management will aim to bring about beneficial changes in behavior and policy, the adoption of new technologies and practices, improvement and enforcement of environmental regulations and standards, as well as changes in infrastructure investment. Bringing about these changes depends importantly on the quality of governance, i.e., the accountability of this myriad of organizations, public access to data and information, the transparency with which decisions are taken, the extent to which rights, especially customary rights, are established and respected, and the adherence to policy provided in existing legislation and the regulations and rules that emerge from this legislation (Figure 9.3).

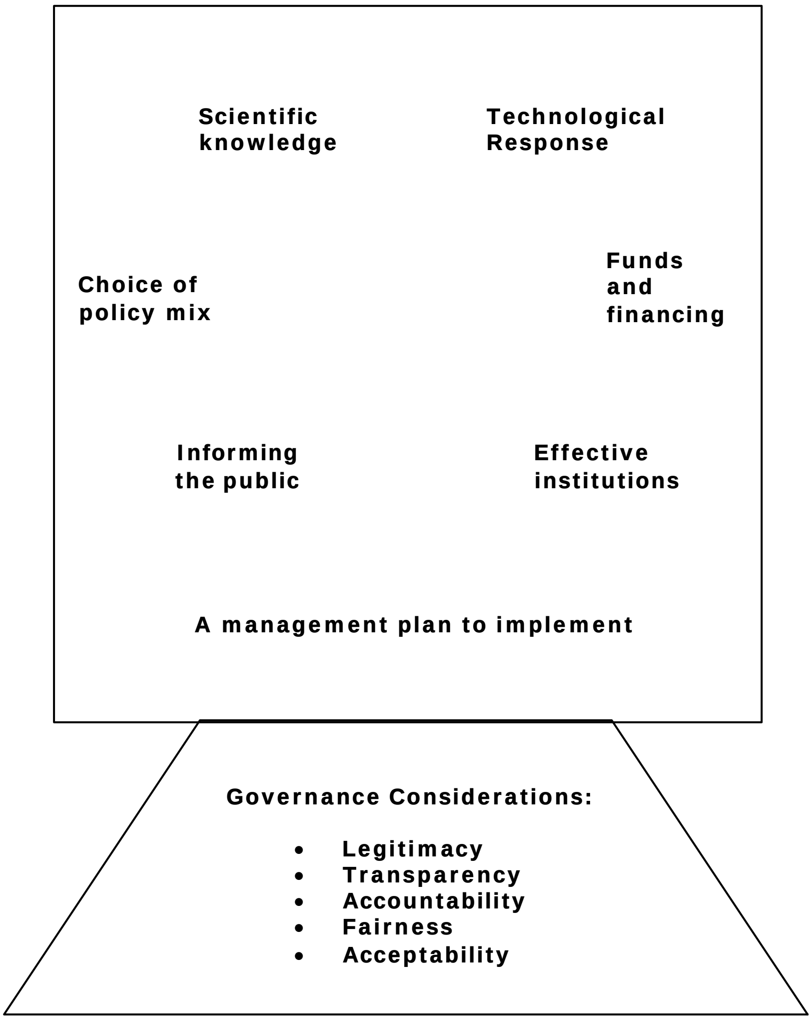



Figure 9.3. A Conceptual Framework of Lake Basin Management with Governance Considerations.

Where governance is especially weak, the lake basin management becomes a daunting task, especially so since it may certainly not be within the realm of lake basin management to pursue such broad and sweeping changes. However, in most developing countries, many of these aspects of governance are already undergoing change, and the decision maker can be a powerful voice in promoting and facilitating the acceleration and broadening of these changes. In doing so lake basin management today has access to several powerful tools whose use is central to management programs—stakeholder participation and partnerships, and an accessible knowledge base.

Like any plan for natural resource management, the political support, commitment and will to the success are indispensable for lake basin management. The fostering of political support must also be reinforced with public support, awareness and understanding. For that, the impacts of degradation and the benefits of restoration need to be communicated to the policy makers in terms that they can understand and relate to. In addition, for lake basin management plans to succeed, the role of the "champions" should not be overlooked. Often, they are the one who can provide or mobilize sufficient political will and support. On the other hand, in many developing countries, political factors are frequently subject to radical change. The instabilities can have major adverse effect on sustained lake basin management. Hence, it is important for a lake basin management plan to allow for flexibility as well as risk mitigation and adaptation.

# Chapter 10: Towards the Future

This report has discussed the major issues facing lake basin management and the range of options that might be considered to address these issues. It has also discussed the unique biophysical characteristics (long retention times, complex biophysical dynamics, and transmissivity) that make sustainable use and management of lake basin resource values a more complex environmental and natural resource management challenge.

Notwithstanding the unique resource values and character of lakes as a major feature in a river basin, the Report has not focused solely on the problems of lake water bodies. Instead, the Report tries to show how the lake water body and its associated resource conservation problems should be seen and addressed in a larger biophysical, ecological and political context in order to select effective, sustainable and integrated strategies and options that can address the causes of those problems. The Report has therefore focused on the major challenges—institutional arrangements, policy, knowledge and information, participation, and financing—and the broad range of governance considerations characterized with principles and options that emerge from our recent lake basin management experience.

The 28 Lake Briefs provide ample experience from which to draw lessons. But, it is also important to recognize that in the broader management context of a lake basin, there is much to learn from management efforts of other natural resources. For example, lake basin management has much in common with sustainable management of particular natural resources (land, forests, fisheries, rangelands, wetlands and other environmental values and services), or the sustainable use of multiple resource values within small and even micro-catchments as well as whole river basins. Those who are involved in lake basin management can join networks of these other natural resource managers by many means, but specially through the use of Internet facility.

Nonetheless, the future of lake basin management, both for individual lakes as well as for lakes across the world, won't become sufficiently promising unless the state of existing lake basin management programs is clearly understood.

## Reassessing Existing Lake Basin Management Programs

As noted throughout the Report, the lessons and experience learned from the 28 lakes brought forth a comprehensive picture of the global state of lake basin management today. The picture depicted is that among the selected programs, few seem to have succeeded in reversing the trend of lake environment deterioration and the associated degradation in resource values. Many lake basin management programs, however, have advanced far enough to pause and reflect, even though they may be overwhelmed by more roadblocks than they feel they can deal with. For them, the past, ongoing and emerging collective experience in lake basin management does give a great deal of insight in the future course of action that might be usefully undertaken. The lessons obtained suggest that we will have to make sure we understand the problems and issues facing individual programs. Where is the state of the lake today, both biophysically and managerially? What impact has the existing management program in terms of sustainable management of the lake, i.e., development and conservation/remediation of its resource values? Are we moving in the right direction and are we sure we know what that direction ought to be? What do we know now that we didn't know at the beginning? Specifically;

- What is the status of the knowledge base? Is a monitoring system in place that would enable you to measure changes in key indicators? Is the data base sufficient? What are the remaining key gaps? Are information management tools in good enough shape to be deployed effectively?
- Is the capacity building and training program effective? Still targeted on priority skills? Is it inclusive and open to cooperating agencies, community

groups, etc.? What mid-course corrections are needed, e.g., are there new skills not considered when you started?
- Has political will and commitment grown, or has it waned? Is sustaining and building this a part of your program and how well is it working? What can you do more of, what should you do less of, and what can you do better?
- Are effective mechanisms in place for effective stakeholder participation? All stakeholders? What has been the change in awareness and understanding of the problems and their linkage to stakeholder activities? What is the perception of stakeholders of the program?
- Are the priority elements of management plan properly implemented? Do we have an adequate management plan, or should it be brought up to date? Are priorities and phasing clear? Are resources sufficient? Have we built the coalitions that would enable the required actions to be implemented? Is coordination adequate? Have either technology options or costs changed, and are these changes reflected in the management plan?

It is comparatively easy to look outward from a program, but much more problematic to look inward with a "collective critical eye". A program might ask itself if we have a sufficient number of the right kind of skills—answers to this question depend not only on current bottlenecks and constraints that can be reasonably attributed to staff skills, but also on reassessing the organizations mandate and objectives, authority (powers and functions), and its work program. Specific questions to ask may include:

- Can we keep the staff we have or an expanded staff? Some programs are put together initially in an ad hoc manner with staff seconded from different sources for relatively short periods, an approach that can work relatively well in the short run. Has the program reached the point where a more permanent arrangement is going to be needed to sustain the program over the long-term, and what needs to be done to ensure this?
- Do we have an adequate statutory basis to enable us to do what we know must be done in the future? When should these changes be in place?
- What is there about the institutional capacity, beyond staffing, that limits achieving effective implementation and constrains choosing the right option among a range of possible actions? What can be done to remove these constraints?
- Is there a champion(s) to sustain support and activate political will? Is the champion listened to by politicians and senior officials? How can the situation be dealt with without the champion?

**Dealing With Roadblocks**

There seems to be no end to the range of issues and problems that lake basin management programs face in moving towards their objectives of restoration and sustainable use of lake basin resources. However, the 28 lake briefs gave us clear message that most issues can be overcome by building the knowledge base, effective stakeholder participation, partnerships or collaboration among the concerned agencies. But there are some really difficult issues that seem almost insurmountable. Among these are:

- Policy conflicts, especially those that arise from long entrenched sector interests, priorities or prerogatives, and that in many cases are inherent in existing laws and regulations;
- Political motives and agendas that run counter to the best interests of sustainable use of a lake basin's resources;
- Lack of a voice—an unresponsive political system or administration;
- Corruption that encourages the particular behaviors and actions the program is trying to change;
- Jurisdiction boundaries that are creating barriers to effective and coordinated action;

- Lack of money to do something.

These appear to be insurmountable questions to those in charge of management of individual lake basins. However, it is clear also that, as this experience and lesson database expands with the participation of other lake basin management organizations, it can be expected that we find and learn of new and even more innovative ways of dealing with these difficult issues. The emerging messages coming from the 28 lake briefs suggest, however;

- Be creative and proactive, with advocacy backed by analysis of good data;
- Help to build coalitions and constituencies for change by intensifying efforts to create awareness and understanding of the situation and the risks—try to put our case in the terms and forms most relevant to those who can support the changes;
- Leverage external support and access that will enable the program to have greater voice;
- Pursue sector policy reform (water, agriculture, forestry, energy, etc.) and seek out the champions of reform in different key sectors, join the reform process, and support it whenever possible. Marshal evidence that care of the lake basin will benefit various sectors dependent on the resources of the lake basin. Critical values can be added to that reform process by showing how additional benefits can be gotten from such reforms (and serious costs and risks of loss avoided), by showing how the special vulnerability and associated risks of lakes and reservoirs can be reduced through the reforms.

One of the most difficult questions is resolution of conflict over resources or access to resources. These conflicts are causing political bottlenecks to change or creating controversy that is hardening opposing positions and views. Seek if ”win-win” solutions can be created by giving opposing sides reason to come to agreement. The lake briefs collectively imply the following;

- Most conflicts over resources or access to resources (even the requirement to reduce pollution discharges) are seen by at least one party to the conflict as a “win-lose” situation—someone else gains but I have to give up resources or incur greater cost, or both—there are many ways around and through this mentality, but the most promising are approaches that work to increase the amount of resource available, or enlarge the idea of what is being shared, i.e., total benefits rather than water, so that each side feels they gain significantly from the agreement;
- Are there technologies or infrastructure which can change the ways in which resources and especially benefits can be equitably shared (storage, water saving technology, or waste reducing technology are good examples)? Is it possible, for example by improving efficiency to increase the level of resource availability? Who could pay for these changes? Much creative thinking is useful in this regard and there is experience globally on how one side of the dispute could pay for a technological change by the other side in return for a substantial share in the benefits without the other side losing benefits and perhaps even gaining as well.
- Are there policy and legal changes, such as the allocation of secure and tradable rights, or resource pricing, or access charges, that could alter demand and lead to resolution of the conflict;
- Water scarcity conflicts are often exacerbated by the traditional supply side mentality of sector organizations, hence, promoting a shift to demand management on their part may also help to alleviate conflict;
- Creating and sharing revenue streams through the imposition of user or access charges, or pollution charges for example, open new ways for stakeholders to share in the benefits of resource use that opens the door to compromise.

## From Lake Basin Management Initiative to Global Lake Basin Governance

*Toward Global Stakeholder Participation and Partnerships*

Every global natural resource management experience today points out the importance and the central role of effective stakeholder participation at every step in its process. The central lesson from this Lake Basin Management Initiative (LBMI) project also points to that direction. Essential awareness and understanding to overcome the barriers and opposition can be created only through broad participation of stakeholders. Improved governance, especially in terms of accountability, won't be achievable unless a large and committed constituency with a strong voice for change exists. When stakeholders are able to both understand and have an influence on the choice of goals and options, even those who may initially see themselves as losers can often become proactive supporters. In some contexts, the participatory approach may run counter to existing political, cultural and social norms. In these instances, the lake briefs suggests (Tonle Sap, for instance) that a gradual, very site specific approach that yields quick local benefits can be successful in gradually overcoming these barriers.

Similarly, the lake briefs illustrated that the typical institutional setting for lake basin management involves a large number of organizations both governmental and non-governmental. Implementation of a management plan thus requires effective partnerships with key organizations. The same is true globally. Most lake basin projects carried out in developing countries are supported in various capacities by more than one agency of technical collaboration and/or financial support, some with catalytic funding coming from GEF. It is evident that the role played by GEF has been extremely important and instrumental. It is also apparent that GEF alone won't be able to meet all the expectation of lakes in the world in need of basin management program. Exploration for new and innovative approaches for partnership among key agencies would become extremely important.

*Toward Enhancement of the Global Lake Basin Management Knowledge Base*

Amply evident throughout the process of LBMI Project was the importance of developing the broad and reliable knowledge base for lake basin management. Development and enhancement of knowledge base for better management of individual lakes is extremely important. However, with limited financial and manpower resources to go around, a great many lakes in developing world will continue to suffer from meager knowledge base that won't be effectively updated or upgraded. The international technical cooperation agencies, scientific communities, local and international NGOs specializing in lake basin management must collectively seek ways to mobilize resources to help those lakes to be able to take advantage of the exiting knowledge base for better management as well as for being able to generate important information resources that will themselves form the knowledge base useful for better management of lake basins elsewhere. This is particularly important today as the threats to lakes in the world have been increasing rather dramatically due to increased global risks leading to increased vulnerability. Perhaps, use of the modern information management technologies, be they planning tools like GIS, remote sensing, database management, computerized models, etc., will greatly facilitate the organization, management and use of the knowledge base as exemplified in many of the lake briefs.

# Appendix A: Economics, Total Value, and Total Economic Value (TEV)

### The concept of Total Value and Total Economic Value (TEV)

The **value**, or **economic value,** of the lake and its resources is composed of many different components. Some components are very tangible and visible (fish caught or water extracted) while other uses may be very intangible or difficult to measure (the cultural benefits of a lake; certain biodiversity values). When all the various uses and benefits are identified and their separate values are included in the analysis (to the extent possible) economists refer to this as the **Total Economic Value (TEV)** approach. This approach merely recognizes the reality that any natural resource system has many different uses and users, and each use has its own contribution in economic terms to the value of the resource. Whether one calls this approach a Total Valve approach, or a Total Economic Value approach, really does not matter—they are actually the same thing.

The TEV approach includes both use and non-use values alike (see Figure A.1). Use values are those benefits that come from direct use of, or interaction with the lake (e.g. fishing, extracting water, or transportation on the lake). Non-use values are benefits that do not require any direct interaction with the lake itself. Examples of non-use values include the benefit from just knowing that the lake is there, or the benefit from knowing that one's children will be able to enjoy the lake. Obviously a major challenge to estimating TEV is putting "prices" or economic values on many uses that are not normally bought and sold in the market (this is particularly true for non-use values).

Modern environmental economics has developed a number of valuation approaches and techniques that can be used to value the different components of TEV, including those that do not normally have a market price (such as the various types of non-use values). Numerous books exist on these techniques and their applications and Box A.1 in Appendix A gives a brief introduction to some of these major valuation approaches.

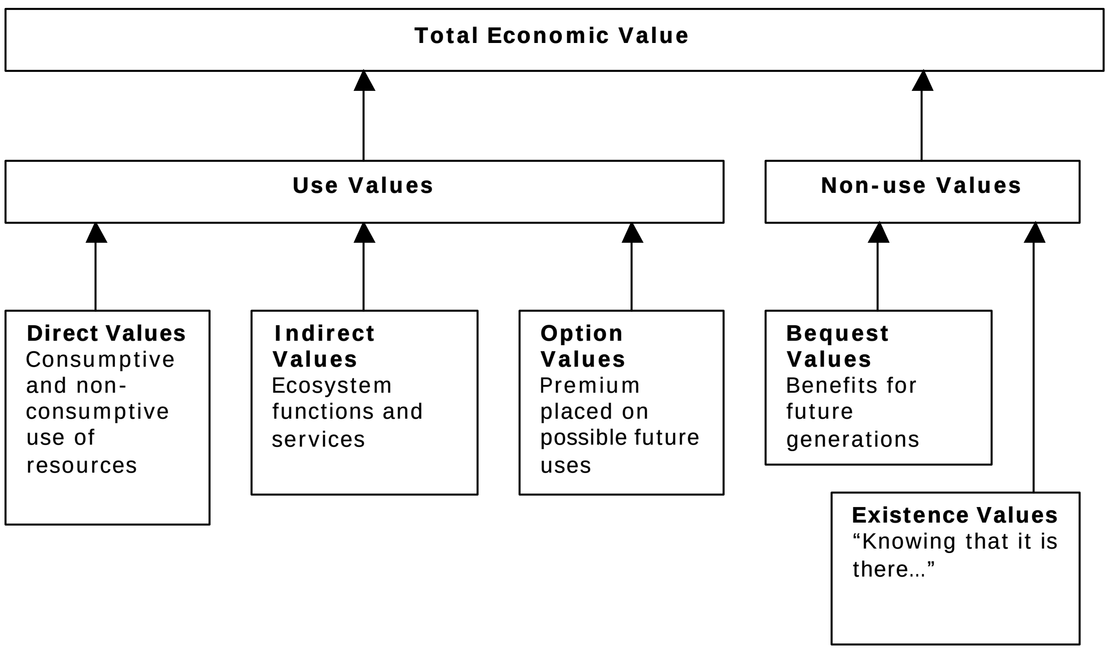



Figure A.1. Total Economic Value

While a complete, formal TEV calculation is rarely done (because of the data and time necessary to do it), the strength of the concept is in reminding us that there are a **number of components to the value of any resource**—some that are quite easy to identify and measure, others that may be quite difficult to value in monetary terms. As such, the TEV approach helps the decision maker/planner to think about who are the various stakeholders and whose values (welfare) will be affected by different management options.

Although doing a complete, formal TEV analysis can be time consuming and difficult, an informal, conceptual TEV analysis can be done quickly and at low cost by using an expert opinion approach (including of course representative stakeholders from the lake basin itself). This conceptual TEV can be done formally in a Delphi type exercise, or more informally in a roundtable guided discussion. (A Delphi approach is an expert-opinion based system where a facilitator is used to reach a consensus and reduce the impact of different experts personality on the final outcome.) Using either approach, reasonable qualitative results can be obtained relatively quickly. Appendix Boxes A.2 and A.3 illustrate the use of the TEV approach at Laguna de Bay and Lake Sevan, respectively. The Laguna de Bay lake brief explicitly carried out a TEV exercise and attempted to estimate the economic values for a number of different components of the TEV. In the case of Lake Sevan a TEV exercise was not done but could have been carried out based on the material presented in the lake brief.

Since the TEV approach is a “social welfare approach”—one in which the “whole” (the total social welfare) is equal to “the sum of the parts” (individual welfare measures)—the differing values and preferences of ALL of the stakeholders in the lake basin should be reflected. The implication of this assumption is that since changes in well-being (or welfare) of ANY stakeholder is part of the total analysis, an appropriate management structure will take into account welfare changes anywhere in the lake basin, not just for any narrowly defined group (e.g. fishermen, water users, transportation providers). As such, the TEV approach is very appropriate when the decision maker is trying to take a lake basin perspective, and reflect the concerns and interests of ALL of the participants/ stakeholders in the lake basin economy. Note that the TEV analysis is NOT done by a group process—stakeholders views obviously are crucial in identifying the different components of the TEV but the actual quantitative work is usually done by highly trained economists. The decision makers then uses or presents the results to all stakeholders to receive their comments and reactions.

TEV is not a short cut analytical approach—it does not come up with any “easy to implement” solutions where everyone will be happy or satisfied. TEV can, however, explicitly (and often quantitatively) identify the causes of problems and who are the likely winners and losers from any proposed changes in policy. As such, a TEV analysis helps identify areas where decision makers need to place special attention.

In addition to the problem of identifying prices or values (the valuation issue discussed in Box A.1) the implementation of a TEV-type study will also require that the analyst explicitly consider externalities and equity concerns. Externalities are pervasive in the environment and are related to a “dis-connect” between where an action is taken and those affected by the action (see Box 2.1). Equity concerns relate to who benefits and who losses from any change, and the relative economic position of each group (see Box 2.2).

*A With-project and Without-project Framework is Applied*

The economic analysis should be done in a with-project/without-project framework. That is, it asks what would happen with the proposed project or policy and what would happen without it. As such the analysis tries to understand the impact of the proposed intervention, not merely describe what will the situation before and after the intervention. This is illustrated by Figure A.2 where the without-project state (perhaps water quality) is seen by line A. Water quality degrades over time. Two with-project outcomes are illustrated. In the outcome shown by Line 1 water quality improves over time, while with the outcome shown by Line 2 water quality decreases over time, but still is an improvement over the without-project state (Line A).

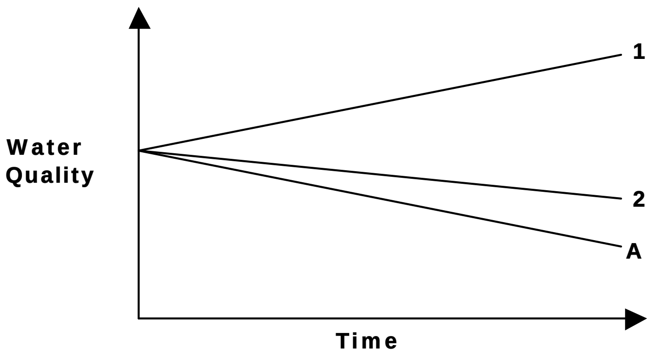



Figure A.2. With/Without Project Analysis

With-project and without-project analysis is very important since in some cases even with a management intervention, the "after" situation is worse than the "before" case. Does this mean the project or new policy was a failure?? No, because, as seen in Figure A.2, the relevant comparison is what will be the "after" situation with and without the project. Although water quality continues to decrease even with the project (Line 2), without the project the "after" would have been much worse (Line A). The economic measure of the benefit of the project is the difference in the space between Line A and either Line 1 or Line 2. Clearly scientific information is needed to draw the without-project line A and project the change in water quality due to the project—either line 1 or line 2. It should be noted, however, that in some cases, the results of a project could actually make things worse than doing nothing: that would be illustrated by line 2 being *below* line A. While this is certainly not common, it does happen and it reflects the complex properties of lakes and their basins.

When controlling water pollution in a lake, for example, it may take many years to turn the tide and start to see improvements in water quality (see the discussion of hysteresis in Chapter 2). In Lake Nakuru, sediment loads have begun to decrease many years after the first management interventions were begun. Industrial and municipal pollution, such as measured in Lake Dianchi in China, can take years to clean up (and with rapid population and economic growth, the problem may increase rapidly in the future). But without the investments water quality would never get better.

*A Note of Caution*

Decision makers are cautious about the usefulness of the economic approach. They worry that the data requirements are too large and that the approach does not reflect both their longer time horizon, and the political realities of lake management (which result in very short time horizons). These are real concerns and therefore it has to be stressed again that an economic analysis should be seen as an **aid to decision making**, not as an analytical approach that gives the definitive answer. Nevertheless the economic approach can be a powerful aid.

The economic approach can also be applied at several levels. At the more micro, project level the approach is used to make quantitative economic estimates of benefits and costs of proposed alternative policies or interventions and calculate the net benefits (usually measured in terms of money) of the proposed change. This is often done for individual projects (such as World Bank financed irrigation or water treatment projects). At the macro, basin-wide planning level the economic approach is an organized way to think about how people interact within the lake basin and what are the impacts of individual actions on the whole basin. Actual quantitative analysis (e.g. putting actual numbers on each use) is rarely done.

The economic framework for evaluating options offers a great deal of flexibility and identifies why the actions of individuals (each of whom we assume is doing the best that they can given the conditions that they face) may result in overall decreases in aggregate well-being (or welfare). The approach also allows consideration of new policies or investments and the potential impacts of them.

The real strength of an economic framework is probably the insights gained—decision makers gains a deeper understanding of the economic forces driving the system—"why" something happens (identification of the root causes of problems), and the obstacles that have to be overcome at the individual level to implement change—the gains and losses to individuals associated with any policy change. The heavy data requirements of the more detailed, formal approach mean that in practice a full economic analysis is rarely done. None of the 28 case studies explicitly carried out such a TEV analysis (although Boxes A.2 and A.3 show limited applications of the technique in Laguna de Bay and the potential for Lake Sevan).

**Summary: The Goal of an Economic Analysis**

An economic analysis is not an easy solution to the problems of managing a lake and its resources. It should be considered an aid, an input, into the decision making process and an approach that offers a powerful analytical framework that helps the decision maker to understand a number of important features of lake ecosystems. Even if no numbers are estimated, the process of setting up the analysis and talking through the links can produce valuable insights for improved management. These insights include the following:

First, who are the stakeholders and who are the likely "winners" and "losers" of any proposed action? How large are the economic values and are these gross values (e.g. value of fish catch) or net values (e.g. the actual "profit" from fishing—that is revenue minus costs) for each affected group?) How much resistance might be expected from any proposed change? (Resistance to change is often closely linked to perceptions of individual loss of income or entitlements.)

Second, what are the economic (and sustainability) costs of the present situation and what are the potential NET gains from improved management? In theory an improved management structure is one whereby the winners can compensate the losers and still have a "surplus" left over—thereby increasing total social welfare. What transfer mechanisms are needed to help compensate potential losers?

Third, what policies are needed (and what are their costs) to change the incentives or "rules of the game" so that total well-being (social welfare) is maximized? Remember, the present pattern of mismanagement and resource degradation is the result of many individual decision makers doing the best that they can from their own perspective. They are unlikely to change what they are doing without some change in the "rules of the game" or the costs and benefits that they perceive. This can take the form of economic or institutional measures, incentives or policing.

Fourth, how are equity and distributional issues addressed in order to insure that those whose well-being has been hurt by any change in management are actually helped in practice (not just in theory) from the proposed changes? It is one thing to say that total social welfare has increased, it is quite another to say that the needed transfers have actually taken place!

Fifth, the need for trained professionals to do the analysis. As with any other science, economic analysis requires special training. It is important that whoever does an economic analysis should be a trained and experienced economist. The decision maker, however, has an important role to play in setting the boundaries for the analysis, and may want to discuss the following issues in defining the terms of reference for any study:

- Whose values to include in the analysis and how much weight to give to different stakeholders? Might values differ depending on the social-economic position of different groups (e.g. marginalized groups, citizens vs. non-citizens, differing economic levels)?

- Where should the physical boundary for the analysis be drawn (that is, how much of the lake basin should be included in the study), and how does one incorporate regional and international concerns?

- How can both "social" and "economic/financial" objectives be incorporated in the management scheme?

- How can international concerns from "stakeholders" who are not physically present in the lake basin be recognized or included? This is particularly relevant when there are important biodiversity benefits in the watershed and the non-use values of other global citizens may be important benefit of the lake.

- How can scientific uncertainty and global change processes be handled (e.g. climate change, protection of genetic diversity, others). Some form of sensitivity analysis may be required to address uncertainty.

Any economic analysis that is carried out should, of course, have a peer review to validate the results. Fortunately there is a growing international literature and experience on doing analyses of this sort that can be called upon. Among this growing literature are the following references: Pearce and Turner (1990), Tietenberg (1992), Dixon et al. (1994), Kolstad (2000), Field and Field (2002), and Sterner (2003) among others.

**Box A.1. Economic Valuation of Environmental Goods and Services**

A wide range of valuation techniques exist that can be used to value environmental goods and services and the various categories found in the TEV approach. The following paragraphs list some of the most commonly used valuation techniques and gives a one-sentence description for each technique. For more information on the techniques see standard references such as Tietenberg (1992), Pearce and Turner (1990), Winpenny (1991) or Dixon et al (1995). The following typology is from Dixon et al. (1995).

**Generally Applicable Techniques** (valuation techniques that rely on observed changes in quantities and market prices):

- Change in production approach—relies on physical changes in the production of some good and services (e.g. a fishery; reeds; peat) valued at appropriate market prices.
- Cost of illness approach—uses information on changes in human health and the costs of treatment, lost work time and pain and suffering (e.g. from polluted water); does not handle premature death well.
- Opportunity cost approach—examines what is given up to protect or conserve some resource (e.g. a national park or a wetland) by measuring the value of the alternative use that is denied.
- Preventive expenditures—uses information on expenditures people take to protect themselves or their property from some environmental problem (e.g. flooding, poor water quality, noise, others)
- Replacement costs—uses information to estimate the cost of replacing a good or service damaged by changing environmental conditions (e.g. relocating water intakes or other facilities as a result of changes in shoreline or aquatic weed infestation).

**Potentially Applicable Techniques** (valuation techniques that rely on surveys and inferred values):

- Travel cost approach—uses information on the time and costs of travelers (often to a recreational site like a park or protected area) to derive a demand curve and estimate unpaid for value (consumer's surplus) enjoyed by visitors.
- Property value (hedonic) approaches—uses information on land or property values to estimate the premium associated with changes in environmental quality (e.g. cleaner lake water, better views).
- Survey-based valuation techniques—also referred to as contingent valuation methods (CVM), these techniques use surveys of individuals to estimate willingness-to-pay for various changes (or states) in environmental quality; commonly used to value such non-use values such as option value, bequest value and existence value. Also used to value premature loss of life.

**Box A.2. Laguna de Bay Partial TEV Analysis**

The only lake brief that attempted even a partial application of the Total Economic Value approach is Laguna de Bay in the Philippines. The actual analysis focused on the environmental resources in the lake watershed and estimated changes in their values due to a pollution control project. It used the TEV approach to help organize thinking about what to include in the project analysis. As the lake brief states (Laguna de Bay brief, p.14):

"the approach started with an examination of the uses of Laguna de Bay, such as for fisheries, irrigation, sources of domestic water, recreation, bird sanctuary, habitat of a variety of flora and fauna. The notion of "use" does not imply that absence of "observable" use is no use at all. All resources have a use even if it is not directly observable, thus the total economic value was computed as:

**Total economic Value = Use Value + Non-use Value**."

The case study further discussed the ideas of direct uses and indirect uses, as well as non-use value like existence, option and bequest values. Although the case mentioned the wide range of values usually found in the TEV framework, the actual analysis was a partial analysis since it confined its estimates to "important direct uses only and (did) not include other direct and indirect uses, option and non-use values".

As presented in the case study the following economic values were calculated for the Laguna de Bay system for fisheries and water-related uses (using a with-project and without-project framework and the methodology described in Table 1 from the Laguna de Bay Brief):

**Fisheries**: Fish catch were valued using market prices and the values for 1984 (about P53 million) were compared to the year 2000 (P28 million). A link to increased water pollution was made and the expected benefits of a pollution control project were estimated. Using a with-project and without-project framework the value of avoided fishery losses with the project was some **P7 million** per year (based on changes in fish catch and market prices for fish).

**Irrigation, domestic water supply, and recreation**: The TEV analysis also identified benefits from irrigation, domestic water supply, and recreation as components of the TEV that would be affected by the project. Using a "cost avoided" approach which looks at the costs savings by not having to supply water uses from alternative, presumably more expensive, sources, the analysis estimated the benefits to be **P70 million** per year for irrigation, **P0.5 million** per year for domestic water supply, and some **P5 million** per year for tourism.

**Discussion**:

While these estimates have to be considered as "rough", the change in the economic value of these 4 uses due to the project was estimated at about **P82 million** per year. The quantitative analysis did not include estimates in the changes in other values—e.g. indirect use values, or various non-use values. These would have increased the benefits from the project. Still, this example illustrates how one can apply the concept of values based on the TEV framework and then carry out a partial analysis on selected values. If the estimates reported in the study are correct, the analysis points out the economic importance of irrigated agriculture and fisheries, and their direct link to lake water quality.

Table 1 (from Laguna de Bay Experience and Lessons Learned Brief)

| **Nature of Direct Use** | **Method used to compute benefits** |
|---|---|
| Fisheries | Value of fish catch lost without the project |
| Irrigation | Additional cost of sourcing water without the project |
| Industrial cooling | No benefits computed, but the benefits equal the additional cost of adopting alternative technologies for industrial cooling |
| Domestic | Cost avoided in extracting drinking water from alternative source |
| Recreational activities | Value of recreational benefits lost without the project |
| Power generation | No economic benefit (for hydropower plants) |

**Box A.3. Socio-Economic Valuation in Lake Sevan, Armenia**

Lake Sevan and its basin provide numerous services to Armenia. In the Lake Sevan brief the discussion of the socio-economic values can easily be arranged into different categories used in the Total Economic Value approach. The main focus in the brief is on direct use values; the brief states "all these products have direct use values because they have market price(s)". But other types of values are also mentioned. Based on the information presented in the brief (see pages 9-11) the following groupings of goods and services can be made:

**Direct use (consumptive)**: sand, gravel, mineral water, peat, reeds, willow branches, wood, mushrooms, other plants, fish, birds, mammals for meat and fur, frogs, and benthic invertebrates.

**Direct use (non-consumptive)**: tourism, water recreation, bird watching, education, research, and aesthetic appreciation.

**Indirect use**: hydroelectric power generation, irrigation downstream, water supply for livestock and human consumption.

**Non-use values**: option, existence and bequest values related to the cultural and historical importance of Lake Sevan to Armenians—both in Armenia and abroad.

No quantitative estimate of any of these values is presented in the brief. However by listing these different categories of use it quickly becomes clear that the lake and its ecosystem provides a wide range of goods and services, only some of which are captured in market prices. The direct-use values (both consumptive and non-consumptive) could be calculated fairly easily. It will take more work to estimate the indirect use and non-use values. However, the cultural/historical values (non-use values) are considered so important that an investment project to help stabilize and restore the lake level is being re-evaluated incorporating some of these values (the project originally did not pass a narrow benefit-cost analysis test).

The analysis of Armenian willingness-to-pay for restoration of the lake's level was done using various survey based techniques (the contingent valuation approach—CVM). Later work will extend the survey to Armenians living abroad—a very large population (larger than in Armenia itself) and with much higher incomes. The preliminary results from Armenia (Wang, 2003) indicate an average monthly willingness-to-pay by Yerevan residents (the capital city) to a special "restore the lake level fund" of about $0.50 per month for 3 years (a total of about $18 per person). This is largely a payment for non-use values since most Armenians do not visit the lake frequently. (Lake visitors are expected to have a larger willingness-to-pay since they have direct interaction with the resource).

**Discussion:**

The Lake Sevan brief does a good job of discussing the various types of values associated with a healthy Lake Sevan. Although not done for the brief it would be possible to make monetary estimates of many of the direct use values (and some of the indirect use values) using available information. The CVM survey to estimate non-use values yielded useful information on the size of these values. It is expected that if a collection mechanism could be devised, the expatriate Armenian WTP values would be much larger and could yield a sizeable amount of money.

The TEV approach has yielded an immediate benefit. The potential funders of several schemes to stabilize or raise the lake level have decided to re-evaluate their decision NOT to fund these investments, and re-consider the decision and take into account non-use values. Note that the non-use values themselves may be sufficient to change the investment decision, even if all the other use values are not included.

## Appendix B: Project Details

### Key Organizations Involved in this Project

The main sponsor of this project, as well as a funder of projects at half of the lakes studied here, is the Global Environment Facility (GEF: www.gefweb.org). GEF is unique in that it provides co-financing to cover the "incremental cost" of the portion of projects that provides international environmental benefits (such as biodiversity conservation and greenhouse gas reduction). The GEF in principle does not fund the part of projects that provide national-level benefits; this cost is to be met by other co-financers including the national governments themselves. GEF co-financing for this project is based on the assumption that the output of the project will have global benefits for the management of lakes everywhere.

The GEF has three agencies which implement its co-financed projects: The World Bank (implementing agency for this project: www.worldbank.org), United Nations Development Programme (UNDP; www.undp.org) and United Nations Environment Programme (UNEP; www.unep.org). The World Bank is providing financial support for this project through a grant from the Bank Netherlands Water Partnership Program. Each of these implementing agencies has projects involving lakes in addition to the GEF funded projects described here. Although not a GEF-implementing agency, the RAMSAR Convention on Wetlands (an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources signed in Ramsar, Iran, in 1971) is an important organization in this project as most of the lakes covered here contain a RAMSAR site.

The International Lake Environment Committee Foundation (ILEC, www.ilec.or.jp) is the executing agency for this project. ILEC is an international NGO formed in 1986 with the support of Shiga Prefectural Government (along with ILEC, Shiga is also a financial sponsor of this project; www.pref.shiga.go.jp) in order to foster sustainable management of the world's lakes. ILEC has worked in close partnership with LakeNet (www.worldlakes.org), an NGO headquartered in Annapolis, MD, USA, to carry out the project and to produce this report. LakeNet is a global network of over 1000 people and organizations in over 80 countries dedicated to the conservation and sustainable development of lake ecosystems. LakeNet's participation in this project is supported by a grant from USAID (www.usaid.gov).

All of the agencies discussed above (with the exception of ILEC and LakeNet) are members of the project's Steering Committee, which is chaired by the World Bank, and has approved this document.

### Objectives and Outcomes

This project draws lessons from the implementation and achievements of lake management projects funded both by the Global Environment Facility (GEF) and by other sources. Its particular objectives are (1) to document the management experiences through lake case studies; (2) to facilitate the sharing of experiences between decision makers and stakeholders; (3) to accelerate learning and implementation of effective lake and reservoir management; and (4) to improve the quality of lake and reservoir management.

The outcomes of this project include (1) lessons for improving GEF and World Bank-supported lake management projects; (2) improved understanding and enhanced capacity for implementing principles of sound lake management; and (3) improved sharing and dissemination of information on lake management programs to national and local governments, lake management practitioners, non-governmental organizations, donor organizations and other stakeholders in lake basins.

## Lake Selection and Characteristics

The project was based on a review of experiences and lessons learned at 28 lake basins around the world. A list of those lakes, along with some basic information, is given in Table B.1. Because there are around five million lakes (the exact count is not established and changes through time) on the earth, the sample of 28 is unlikely to cover all issues related to lake management. We have tried, however, to select lakes that would yield significant lessons about management while maintaining a good balance among features such as location, climate, water type, and other variables. The 28 lakes nonetheless represent some of the major freshwater and saline lakes in the world and all of the lakes with projects funded by the GEF.

Table B.1. Characteristics of the 28 Selected Lakes Needs finishing

| Lakes | Water type | Origin | Climate | Drainage Basin Type | Basin Countries |
|---|---|---|---|---|---|
| **Africa** | | | | | |
| Baringo* | Fresh | Tectonic (?) | Semi-arid (various types within basin) | Closed | Kenya |
| Chad* | Fresh (due to high groundwater loss) | hydrographic? | | Closed | Cameroon, Central African Republic, Chad, Niger, Nigeria plus others? |
| Kariba | Fresh | Artificial | | Open | Zambia, Zimbabwe plus up/downstream? |
| Malawi/Nyasa* | Fresh | Tectonic | | Usually open (but with major evaporation; closed 1915-37) | Malawi, Mozambique, Tanzania |
| Naivasha | Fresh (due to high groundwater loss) | | Semi-arid | Closed (for surface) | Kenya |
| Nakuru | Saline | Tectonic | Semi-arid | Closed | Kenya |
| Tanganyika* | | | | | |
| Victoria* | Fresh | | | Open | |
| **Asia** | | | | | |
| Aral* | Saline | | Arid | Closed | Kazakhstan, Uzbekistan; Afghanistan, Iran, Kyrgyz Republic, Tajikistan, Turkmenistan |
| Baikal* | Fresh | Tectonic (rift valley) | | Open | Russia; Mongolia |
| Bhoj Wetland | | Artificial | | | India |
| Biwa | Fresh | Tectonic | Temperate | Open | Japan |
| Chilika | Brakish | | Tropical | Coastal | India |
| Dianchi | Fresh | Tectonic | | Open | China |
| Issyk-kul | Saline | Tectonic | | Closed | Kyrgyzstan |
| Laguna de Bay | Fresh (with salinity intrusion) | | Tropical | Open | Philippines |
| Toba | Fresh | Tectonic | Tropical | Open | Indonesia |
| Tonle Sap* | Fresh | Floodplain | Tropical | Mixed Flow | Cambodia |
| Xingkai/Khanka* | Fresh | | | Open | China, Russia |
| **Europe** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Constance | Fresh | Glacial | Temperate | Open | Austria, Germany, Switzerland; Liechtenstein |
| Ohrid* | Fresh | Tectonic | | Open | Albania, Macedonia; Greece |
| Peipsi/Chudskoe* | Fresh | | | Open | Estonia, Russia; Latvia (Or do we say EU, Russia?) |
| Sevan | Fresh | Tectonic (Volcanic p3?) | | Open | Armenia |
| **North America** | | | | | |
| Champlain | Fresh | Glacial | Temperate | Open | Canada, USA |
| Cocibolca | Fresh | Tectonic | Tropical (see p 9) | Open | Nicaragua; Costa Rica |
| Great Lakes | Fresh | Glacial | Temperate | Open | Canada, USA |
| **South America** | | | | | |
| Titicaca* | Fresh | | Tropical Mountain | Open | Bolivia, Peru |
| Tucurui | Fresh | Artificial | Tropical | Open | Brazil |

Note: Lakes with a GEF project are marked with an asterisk. In the list of basin countries, the countries following a semi-colon are non-riparian basin countries.

### Lake Briefs, Thematic Papers and Regional Workshops

Experience and Lessons Learned Briefs (lake briefs) were developed for the 28 selected lakes. The lake briefs were meant to highlight the management experiences in diverse lake basins, organized in a consistent manner to facilitate comparisons between lakes. The full outline given to the lake brief authors is included on the CD-ROM. A list of authors is also included.

Three regional review workshops were held in North America (hosted by Saint Michael's College, in Burlington, Vermont in June 2003), Asia (hosted by the Lake Laguna Development Authority in Manila, Philippines in September 2003) and Africa (the Pan-African START Secretariat in Nairobi, Kenya, in November 2003), attracting participation and input from over 200 people representing stakeholders from XXX countries. The workshops were the main opportunity for discussion and debate on the lake briefs.

A total of 16 Thematic Papers were also prepared during the course of the project in order to compliment the lake briefs and to highlight specific global or regional issues. These papers, as well as a list of authors, are included in the CD-ROM.

### Website Clearinghouse and e-Forum

To facilitate the widespread dissemination of the lake briefs and thematic papers, the project also supported the enhancement of LakeNet's website, where the documents were posted, and from which a number were downloaded. A e-forum also was developed, although it did not appear to provoke much public comment on the lake briefs or thematic papers.

### Steering Committee

To be completed.

### Working Group Meetings

To be completed.

# Appendix C: List of Experience and Lessons Learned Brief and Thematic Paper Authors

To be finalized. Approximately 3-4 pages.

# Appendix D: Workshop Agendas and Participant Lists

To be developed. Approximately 8 pages.

# Appendix E: Summaries of 28 Project Lakes

2-page summaries of each lake, with a basin map, to be supplied by LakeNet from material on the project website.

## References

(To be completed and format unified.)

Benería, Lourdes and Martha Roldán. (1987). The Crossroads of Class and Gender: Industrial Homework, Subcontracting, and Household Dynamics in Mexico City. Chicago: University of Chicago Press

Berkes, Fikret and Carl Folke. "Linking social and ecological systems for resilience and sustainability," in Fikret Berkes and Carl Folke, eds., Linking Social and Ecological Systems: Management practices and social mechanisms for building resilience (Cambridge: Cambridge UP, 1998): 1-25.

Clague, Christopher, "The New Institutional Economics and economic development," in Christopher Clague, ed., *Institutions and Economic Development: Growth and governance in less-developed and post-socialist countries* (Baltimore: Johns Hopkins,1997)

Dixon, J, LF Scura, R Carpenter, and P Sherman (1994). Economic Analysis of Environmental Impacts. London: Earthscan.

Duda, Alfred. 2002. Monitoring and Evaluation Indicators for GEF International Waters Projects: Monitoring and Evaluation Working Paper 10. Washington, DC: Global Environment Facility.

Edmondson, W.T. 1970. *Phosphorus, nitrogen and algae in Lake Washington after diversion of sewage*. Science 169:690-691.

Field, Barry C. and Martha K. Field. 2002. Environmental Economics: An Introduction. New York: McGraw-Hill.

Glantz, M.H. 1999. Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin. Cambridge University Press. United Kingdom. 291 p.

GEF (Global Environment Facility). 2003. International Waters. Operational Strategy of the Global Environment Facility, GEF, Washington, D.C. Chapter 4.

GWP (Global Water Partnership). 2000. *IWRM & the Toolbox*. Secretariat, Global Water Partnership, Swedish International Development Cooperation Agency, Stockholm. 5 p.

GLWQA (Great Lakes Water Quality Agreement). 1978. *Great Lakes Water Quality Agreement of 1978.* U.S.-Canada International Joint Commission, Great Lakes Regional Office, Windsor, Ontario, Canada.

Holdren, C. W. Jones, J. Taggart. 2001. Managing Lakes and Reservoirs. North American Lake Management Society: Madision, WI, USA.

Jorgensen, S.E. XXXX.

Kolstad, Charles D. 2000. Environmental Economics. Oxford: Oxford University Press.

Laszlo, J.D., G.N. Golubev and M. Nakayama. 1988. *The environmental management of large international basins. The EMINWA Programme of UNEP*. Water Resources Development 4:103-107.

National Research Council (Committee on Restoration of Aquatic Ecosystems: Science, Technology and Public Policy). 1992. Restoration of Aquatic Ecosystems. National Academy Press: Washington, D.C., USA.

Ostrom, Elinor. "Investing in capital, institutions, and incentives," in Christopher Clague, ed., Institutions and Economic Development: Growth and Governance in Less-Developed and Post-Socialist Countries (Baltimore: Johns Hopkins, 1997): 153-181.

Pearce, D and K Turner (1990). Economics of Natural Resources and the Environment. Baltimore: Johns Hopkins University Press.

Ramsar Bureau. (2001). Additional Guidance on Reviewing and Action Planning for Wetland Communication, Education and Public Awareness (CEPA), to assist Contracting Parties in implementing Resolution VII.9, the Convention's Outreach Program, 1999-2002. [http://www.ramsar.org/outreach_reviewsactionplansI.htm]

Rast, W. and J.A. Thornton. 2004. *The phosphorus loading concept and OECD Eutrophication Programme. Origin, application and capabilities*. In: P. O'Sullivan and P. Reynolds, The Lakes Handbook, Vol. 2, Blackwell Science Publishers. IN PRESS.

Ryding, S.-O. and W. Rast. 1989. The Control of Eutrophication of Lakes and Reservoirs. Man and Biosphere Series, Vol. 1, UNESCO, Paris. 314 p.

Schindler, D.W. 1977. *Evaluation of phosphorus limitation in lakes*. Science 195:260-262.

Sonzogni, W.C., P.D. Uttormark and G.F. Lee. 1976. *The phosphorus residence time model*. Water Research 10:429-435.

Sterner, T (2003). Policy Instruments for Environmental and Natural Resource Management. Wshington DC: Resources for the Future.

Sutherland, William J. (2000). The conservation handbook: research, management and policy. Malden, USA: Blackwell Science, Inc. 278 pp.

Tietenberg, T (1992). Environmental and Natural Resource Economics. Third Edition. New York: Harper Collins Publishers.

Trudel, M., E. Wysokinska, W. Williams and W. Rast. 2002. Lakes and Reservoirs: How to involve the public in protecting them from degradation. Kusatsu, Japan: UNEP-IETC and ILEC.

USEPA and Government of Canada. 1995. The Great Lakes: An Environmental Atlas and Resource Book. Chicago: Great Lakes National Program Office.

Vollenweider, R.A. 1976*. Advances in defining critical loading levels for phosphorus in lake eutrophication*. Mem. Ist. Ital. Idrobiol. 33:53-83.

Wang 2003.

World Bank. 2000. Participation review. Washington, D.C.: World Bank.

World Lake Vision Committee. 2003. *World Lake Vision*. International Lake Environment Committee, Shiga (Japan) Prefectural Government, and International Environment Technology Centre, United Nations Environment Program. 36 p.

# Glossary