Managing Lakes and their Basins for Sustainable Use

A Report for Lake Basin Managers and Stakeholders

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ABOUT THE COVER

The front and back covers display the 28 lake basins that are the foundation for this report. Each lake basin is numbered, and the corresponding names may be found in Figure 1.1 on page 5. On the cover, each lake basin spreads over an equal area; however, in actual size, the difference in area between the largest and smallest basin is over 6,000 times. The lake basins are grouped by color depending on the continent on which they are located. Designed by Maki Tanigawa and Thomas Ballatore.

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Foreword

This report is the main output of a Medium-Sized Project supported by the Global Environment Facility (GEF) known formally as "Towards a Lake Basin Management Initiative: Sharing Lessons and Experiences from GEF and Non-GEF Lake Basin Management Projects." The project was conceived after the Second World Water Forum in The Hague in 2000 and launched at the Third World Water Forum in Kyoto in March 2003. This report was launched in October 2005 at the 11th World Lake Conference in Nairobi, Kenya, and also disseminated at the 9th Meeting of the Ramsar Convention in Kampala, Uganda in November 2005. Detailed experience and lessons learned briefs on 28 lake basins are available on the companion CD-ROM. All project materials, including 17 thematic papers, are available at http://www.ilec.or.jp. These final outputs will be launched at the Fourth World Water Forum in Mexico in March 2006.

The need for this project has been growing over the past 20 years. In spite of being central to the lives of much of the world's population and providing habitat for aquatic biota, lake and reservoir basins have not received sufficient attention in the global water policy discourse. Further, while the science of limnology has provided much new knowledge about the biophysical and chemical processes operating in lakes and reservoirs, our knowledge of how to apply their findings to the development and implementation of lake basin policy has been quite limited.

This concern was broadly reflected in the World Lake Vision presented at the Third World Water Forum (World Lake Vision Committee, 2003; http://www.ilec.or.jp/wlv/WLV_Final.pdf), which highlighted key principles of lake basin management. The international development agencies have also been aware of such needs; examples include the recommendation of the World Bank to develop a Lake Basin Management Initiative (Ayres and others 1996), and the World Bank's Environment Strategy (2001) and Water Resources Sector Strategy (2004). Sustainable lake basin management, the aim of this project, also supports the Millennium Development Goals (MDGs) on sustainable water resources management and reinforces some of the central recommendations from the Millennium Ecosystem Assessment (MA) (http://www.milleniumassessment.org/en/index.aspx).

This report underscores the central role lakes and reservoirs play in integrated water resources management. It advocates that lakes and reservoirs need to be managed as integrated units with their basins. The concept of Integrated Lake Basin Management (ILBM) complements the Integrated Water Resources Management (IWRM) approach supported by a variety of parties (see, for example, http://cap-net.org/iwrm_tutorial/). As discussed in the main text, lakes and reservoirs possess characteristics—such as their integrating nature, long retention time, and complex response dynamics—that often affect the way their basins need to be managed. The lessons learned from this project provide important perspectives about IWRM that have yet to be fully recognized, appreciated, or internalized by water resources planners and managers.

The project makes four major contributions. First, it has ***focused on practical lessons learned*** from the management efforts of lake basins around the world—mostly natural lakes, but some artificial ones as well. In the past, although much work has been done to share scientific and technical experiences on lakes, less attention has been devoted to analyzing the effectiveness of their alternative management approaches, particularly in relation to policy, institutional, economic, and social dimensions. 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 regional 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 around the world, as well as 17 cross-cutting thematic papers. Regional workshops held in the United States, the Philippines, and Kenya brought together 288 participants from 41 countries to review and comment on the briefs and thematic papers as well as to discuss in general lake basin management. Knowledge creation and sharing was also supported by an 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 basin management experiences on ***tropical lakes, arid and semi-arid lake zones, saline lakes, groundwater-dependent 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. Saline lakes, valuable but often ignored, and groundwater-dependent lakes, precious but often taken for granted and neglected, are also covered in the project. Further, the project included a particular focus on management experiences of lake basins from developing countries, where the lessons have not yet been adequately synthesized or disseminated. It also includes numerous examples of lakes in countries in economic transition that have many of the same management challenges.

Fourth, the report ***derives lake basin management lessons from internationally funded projects***, principally the lake basin projects financed through the GEF and implemented by the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP) and the World Bank, as well as those projects financed by the World Bank and other agencies and governments. 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 on other lakes and reservoirs.

Overall, the report provides a rich record of experience that lake and reservoir managers can draw on when developing lake basin management policy and when putting it into practice.

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Rafik Hirji of the World Bank was task team leader of the Lake Basin Management Initiative project and Masahisa Nakamura of ILEC was project manager of the project implementation team. David Read Barker of LakeNet was senior advisor to the project. A project Steering Committee consisting of Stephen Lintner, Chair (The World Bank), Barbara Best (USAID), Peter Bridgewater (Ramsar Secretariat), Alfred Duda (GEF), Sean Khan (United Nations Environment Programme—UNEP) and Dann Sklarew (United Nations Development Programme—UNDP) provided overall guidance on project implementation and the preparation of this report and other project outputs.

The project management team and secretariat also included Thomas Ballatore, Genjiro Furukawa, Naoko Kimura, Yasuo Kinoshita, Hiroya Kotani, Victor Muhandiki, Akiko Murano, Atsuko Touge, and Chiharu Uyama from ILEC, and David Read Barker, Lisa Borre, and Laurie Duker from LakeNet. Mohammed Bekhechi, Robin Broadfield, Richard Davis, Sharon Esumei, Dianne Flex, Samson Kaber, Katherin George Golitzen, Siree Malaise, and Kisa Mfalila from the World Bank supported data collection, project administration and review. Task managers from the World Bank, UNDP and UNEP for the various GEF and agency supported lake basin management projects were interviewed at the outset of the project. They provided helpful assistance during the data collection process and suggested participants for the regional workshops. Some even provided review comments on the lake briefs. Jeffrey Lecksell of the World Bank provided advice on the maps, while Fuad Bateh and Charles Di Leva also of the World Bank provided legal advice on the text.

The authors of the lake basin management briefs, 17 cross-cutting thematic papers, and the chapters of this report are listed in Appendix B. The briefs were reviewed by 288 participants from 41 countries who attended workshops in Burlington (United States), Manila (the Philippines), and Nairobi (Kenya). These workshops were organized by St. Michaels College, Laguna Lake Development Authority, and the Pan-African START Secretariat in Burlington, Manila, and Nairobi repectively. The lake briefs were edited by Thomas Ballatore (Asian Lake Briefs), David Read Barker (North American, South American and European Lake Briefs), and Victor Muhandiki (African Lake Briefs).

Masahisa Nakamura was senior editor of this report, Thomas Ballatore and Richard Davis were the technical editors, and Robert Livernash was copy editor. The report was prepared by Thomas Ballatore, David Read Barker, Lisa Borre, Richard Davis, John Dixon, Walter Garvey, Victor Muhandiki, Masahisa Nakamura, James Nickum, and Walter Rast. Oyugi Aseto, Adelina Santos-Borja, Eric Odada, Sonia Davila-Poblete and Sven Erik Jorgensen provided specialist input to the writing team. Maps were prepared by Thomas Ballatore and Maki Tanigawa. Walter Rast copy-edited the lake briefs and compiled the glossary; Darryl Feldmeyer handled the desktop publishing of the report and lake briefs. Michael Glantz from the National Center for Atmospheric Research, Colorado, was peer reviewer. ILEC interns Evan Gach and Don Harris assisted with editing of the lake briefs and this report.

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Acronyms

BOD	biological oxygen demand
CAC	command and control
CBOs	community-based organizations
CEPA	communication, education, and public awareness
CETP	common effluent treatment plants
CITES II	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLEAR	Conservation of Laguna de Bay Environment and Resources
COD	chemical oxygen demand
COP	Conference of the Parties
CTC	Centre for Transboundary Co-operation (Lake Peipsi/Chudskoe)
CWA	Clean Water Act (United States)
DO	dissolved oxygen
ECHO	ecology, culture, history, opportunity (educational center at Lake Champlain)
EIA	environmental impact assessment
EPA	Environmental Protection Agency (United States)
EU	European Union
EUF	environmental user fee
GEF	Global Environment Facility
GLC	Great Lakes Commission
GLWQA	Great Lakes Water Quality Agreement
GNI	gross national income
IBK	International Bodensee Conference
IDA	International Development Association
IGKB	International Commission for the Protection of Lake Constance
IJC	International Joint Commission
ILBM	integrated lake basin management
ILEC	International Lake Environment Committee
IPCC	Intergovernmental Panel on Climate Change
ITC	International Institute for Geo-Information Science and Earth Observation, The Netherlands
IUCN	International Union for the Conservation of Nature and Natural Resources
IW	International Waters (one Focal Area of GEF)
IW:LEARN	International Waters Learning Exchange and Resource Network
IWRM	integrated water resources management
LAGBIMO	Lake George Basin Integrated Management Organisation
LBCDP	Lake Biwa Comprehensive Development Project
LBMI	Lake Basin Management Initiative
LCBP	Lake Champlain Basin Program
LLDA	Laguna Lake Development Authority
LNGG	Lake Naivasha Growers Group
LNRA	Lake Naivasha Riparian Association
LTBP	Lake Tanganyika Basin Project
MA	Millennium Ecosystem Assessment
MDGs	Millennium Development Goals
MOU	memorandum of understanding
MSP	medium-sized project (of the GEF)
NGO	nongovernmental organization
OECD	Organisation for Economic Co-operation and Development
OM&R	operations, maintenance, and replacement
OSIENALA	Friends of Lake Victoria (NGO)
PCBs	polychlorinated biphenyls
PIL	public interest litigation
PRA	participatory rural appraisal
SAP	strategic action program
SEA	strategic environmental assessment
SOLEC	State of the Lakes Ecosystem Conference (Great Lakes, Canada and United States)
TAC	Technical Advisory Committee (Lake Champlain)
TDA	transboundary diagnostic analysis
TEV	total economic value
TMDL	total maximum daily load
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WUP	Water Utilization Programme (Mekong Basin)
WUP-FN	Finnish Government assistance to WUP
WWF	World Wildlife Fund for Nature
ZACPLAN	Zambezi River Basin Action Plan
ZOMAP	Zoning and Management Plan for Aquaculture (Laguna de Bay)

Summary

This report is the main output of the GEF-supported "Lake Basin Management Initiative" (LBMI). The project's purpose was to ***synthesize practical lessons learned on lake basin management*** from experience around the world, with a particular focus on lakes in developing countries as well as on transboundary lakes. The following is a summary of the key lessons learned.

Section I: Understanding the Resource

Characteristic of Lakes (Chapter 2, pp. 9-14)

The properties of lake basins, including the resource values they provide, vary widely. Whether or not the resources can be used in a sustainable way depends on how they are managed. Uncontrolled exploitative development of the resource base of lake basins, including their lands and waters, typically results in overuse and degradation, invariably degrading water quality and destroying ecological integrity. These problems may be exacerbated by the three behavioral characteristics of lakes, namely their "integrating nature", "long retention time", and "complex response dynamics". ***Integrating nature*** means that connections between users are particularly strong. For example, a polluter is often a victim of pollution. Also, the connections among the water flows, substances and biota are also quite strong, establishing complex limnological properties. The relatively ***long retention time*** of most lakes (compared to rivers) means that the "lake time scale" is not equal to the "political time scale". There is usually a significant delay between an action (positive or negative) and the change in a lake. The ***complex response dynamics*** of lakes means that connections are often indirect and not easy to determine. Changes are often irreversible (Figure 2.2, p. 13) and dependent on path. These behavioral characteristics apply not only to natural lakes but also to man-made lakes, all essential components of river basin systems.

Values and Threats (Chapter 3, pp. 15-26)

Lakes are the most dramatic and picturesque features of our global landscape, have rich endowment of resource values, and are major components of the hydrologic cycle. They sustain human livelihoods, support economic activities, provide habitat for biodiversity, and offer important aesthetic and spiritual values. They also provide buffering capacities against hydrologic and climate fluctuations, as well as being sinks for inflowing materials collected across their basins. While lakes provide indispensable goods and services, a majority of these are not directly bought and sold on markets and are therefore ***often undervalued or even ignored.*** Once they are lost, however, their value becomes apparent.

Impairment of a given lake use arises through overuse and/or when two or more users are in conflict. While some problems originate in a lake itself (such as overfishing), the vast majority of problems originate from activities on the land surrounding a lake (Table 3.2, p. 22). Therefore, ***management of a lake means management its drainage basin***—the two cannot be separated. Unfortunately, it is rare when the boundaries of the basin and political system coincide. In some cases, the origin of a given problem may lie beyond the lake's basin, such as with long-range transport of toxic materials. These problems are perhaps the most challenging to address as they are likely to cross many political jurisdictions, including international ones.

Many lake management issues originate within drainage basins. The inflow of sediments to lakes was the most commonly-cited issue for the lakes studied in the project. Introduced fauna and flora, and unsustainable fishing practices were the major issues that originated within the lakes themselves. These basin, in-lake and shoreline issues were found in both transboundary and national lakes. Global management issues were not commonly mentioned. Some issues are well-known, but have not received adequate attention, an example being dropping lake levels because of reduced groundwater flows. Other emerging issues are less well known. They include atmospheric nutrient pathways, climate change, shrinking lake size, trade globalization impacts, and environmental flows.

Section II: Meeting the Governance Challenge

The goals of lake basin management vary from lake to lake as well as through time at a particular lake. Goals range from efforts to preserve pristine conditions all the way to a *de facto* acceptance of complete ecosystem destruction. Between these extremes, however, there is usually an attempt to minimize problems and maximize values derived from a lake while achieving some equitable distribution of benefits and responsibilities. The key question is how to best reconcile the diverse objectives inherent in lake basin management. The main contribution of this project and this report is to provide a framework for management of lake basins, or IWRM, based on the lessons learned in the 28 case studies regarding the six necessary components of any effective management response:

- Adequate ***institutions*** for implementing change;
- Efficient, effective and equitable ***policies***;
- Meaningful ***participation*** of all stakeholders involved;
- ***Technical measures*** to ameliorate certain problems;
- Appropriate ***information*** about current and future conditions; and,
- Sufficient ***financing*** to allow all the above to take place.

Institutions (Chapter 4, pp. 29-38)

Institutions are the "who" of lake basin management; that is, they are the ones who have the authority to make changes in behavior that a society deems desirable.

- In the 28 case studies, there is ***no single institution with authority over all aspects*** of a lake basin's management. In general, the most important institutions are the national-level, sectoral institutions (Table 4.1, p. 33).
- ***A sectoral approach is problematic***, though, because of the integrating nature of lakes. Various users are likely to have an impact on each other, but their activities often fall under the jurisdiction of different sectors.
- ***Transboundary lake basins*** face the additional hurdle of international jurisdictions.
- Because lake basin boundaries cannot change and because the sectoral institutions within most nation-states are not likely to change, a compromise is necessary. This usually means the ***creation of a coordinating mechanism*** that serves to bring the sectors (and states) together on issues related to a given lake and its basin.
- However, goals may not be necessarily achieved by a single, coordinated lake basin management organization if the other necessary governance conditions described in chapters 5-9 are not met.
- The success of transboundary lake basin management depends on the member states' ***political will, commitment, and fulfillment of obligations***, rather than the particular form of institution or its legal status. Nonriparian basin countries of a lake that may be reluctant to join a formal lake basin management authority may be successfully engaged through informal mechanisms.
- It is hard to anticipate all the types and magnitudes of problems that will face a lake basin in the future. Therefore, ***an institutional arrangement that can accommodate change*** is more likely to be effective in meeting goals than one that is inflexible.

Policies (Chapter 5, pp. 39-46)

Policies are what institutions implement in order to change or reinforce certain behaviors. Policy options range from awareness-raising (Chapter 6), to creation of rules and incentives (Chapter 5).

- Simply ***raising awareness among resource users*** is one of the most effective and easiest policies to implement. People will often modify a behavior if they learn it has a negative effect on others.
- ***Command-and-control policies*** (rules) are effective when there is good capacity to implement; a clear environmental goal is known; and the number of regulatees is low. Direct regulation has contributed to large stress reductions in the lake basins in high-income countries in this survey.
- The cases show that declaring an area protected is easy; actually ***protecting it by restricting activities is much harder***.
- Economic instruments such as taxes and fees on discharge of pollutants to the environment may be politically difficult to initiate (as polluters have to pay something for something that was free before), but the ***revenues from economic instruments can be used to build institutional capacity***—key point when capacity is low.
- For a given lake, ***there is invariably a mix of policies***; "pure policies" only appear in textbooks (Table 5.1, pp. 44-45).
- ***Meaningful participation*** of all relevant stakeholders is essential for the legitimacy of an institution's policies.
- Broader national-level policies, particularly ones related to ***development and poverty reduction***, have great bearing on a lake and its management. This further supports the need for policy coordination among sectors.

Involving People and Stakeholders (Chapter 6, pp. 47-56)

People are central to lake basin management. They are the ones who use a lake's resources; the ones who create and suffer from problems; the ones who work in institutions; and the ones who are affected by any management decisions. Because of this central role, key lessons about involving people are found in all sections of this summary (and report). A few highlights include the following.

- Participation in decision making can either be direct or indirect (as through an elected representative). The cases show that if a person or group ***feels left out of the decision-making process,*** the decisions will not have legitimacy and implementation will be hard, if not impossible. If they are included, then even policies that require significant sacrifice are usually accepted.

- To achieve an equitable decision, all affected stakeholders including historically-marginalized stakeholders such as ***Indigenous Peoples and women*** must be meaningfully included in the decision making process.

- Without proper understanding and appreciation of the local ***cultural beliefs, values, and norms,*** a lake basin management plan will not be accepted and properly implemented by the community.

- Efforts should be made to create a positive link between ***livelihoods of local communities and lake basin management***.

- ***Women play a central role*** in the provision, management and safeguarding of water. Their participation in a full civil society, using a participatory approach and using culturally sensitive methods, will enhance efforts to achieve effective lake basin management.

- ***Non-governmental organizations (NGOs) and community-based organizations (CBOs)*** play a critical catalytic role between individuals and governments.

Technological Responses (Chapter 7, pp. 57-66)

Changing people's behavior through rules, incentives/disincentives, or awareness raising to achieve management goals is not easy. For some problems and under particular circumstances, a technological solution can be an effective response (Table 7.1, p. 59).

- ***Root causes of a problem*** must be addressed for any technological intervention to have its desired long-term impact. For example, dredging a lake's sediment to remove nutrients to control eutrophication is only effective in the long-term if external nutrient loads are controlled.

- Many apparently technical interventions, such as development of ***sewerage systems*** might seem like environmental protection but are actually undertaken for broader development reasons such as provision of amenity and/or promotion of employment.

- The extent of conventional and advanced sewage treatment is ***highly correlated to the population density and per capita income*** of a given lake basin. In low- and middle-income countries with high population densities, international funding is common (Box 7.1, p. 61).

- ***Littoral wetlands*** are the "kidneys" of a lake and protection of existing wetlands should be a priority.

- Appropriate ***provision of environmental flows is necessary*** to maintain the ecological health and resource uses of a lake when dams and weirs are constructed upstream for water storage and regulation.

Information (Chapter 8, pp. 67-76)

Accurate, impartial and accessible information is central to lake basin management. Without it, institutions can be inefficient, rules can be ineffective, people can be disempowered, and technologies can be misapplied.

- Decision making requires ***not just "scientific" knowledge,*** but also social, economic and cultural information.

- Information comes not just from monitoring and assessment but is also embedded in local knowledge held by non-scientists. ***Efforts must be made to access the knowledge of local people*** such as fishers who often have detailed, long-term understanding of lake resources.

- ***Science can be used*** to show the limits of lake basin resources, to enlighten hard-to-see connections, and provide innovative solutions to problems. However, even if perfect information exists, it is not necessarily used.

- The long-term and complex nature of lake ecosystems means that information is particularly valuable to decision makers. Accordingly, there must be ***a long-term commitment to information acquisition***, including development of resident research institutes and local capacity.

- Information must be translated into the language of policymakers to have an effect. It is important to ***develop easily understood indicators***, such as the Process Indicators, Stress Reduction Indicators and Environmental Status Indicators used in GEF International Waters projects.

- ***Models do not need to be complex to be useful***: some of the most effective models were simple ones that matched the local capacity and told decision makers something they would not otherwise have known (Box 8.2, p. 69).

- Simply collecting and agreeing on information about a lake basin is ***a key first step to international cooperation***, as promoted by the GEF's Transboundary Diagnostic Analysis (pp. 74-75).

Financing (Chapter 9, pp. 77-82)

A common observation is that sufficient funding is not available to meet all the management goals at a given lake. It is clear that, like all resources, money is scarce and available funds must be put to the best possible use.

- ***Locally generated funds***, such as water user fees, fish levies and pollution charges can provide a stable and important part of the financial base for lake basin management. However, unless there is a high value use extracted from the lake's resources, these funds are not usually sufficient for lake basin management.

- It is important that ***locally generated funds are largely retained locally*** and that there is involvement of resource users in establishing and administering the fees.

- Most funding for lake basin management comes from national and/or local sources. ***External funds should play a catalytic, rather than a primary role*** for implementing lake basin management activities and investments.

- 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.

- National funding, sometimes supplemented by external loans and grants from development organizations, is often used ***for large capital-intensive investments***.

- ***The GEF is a major source of funds*** for improving the management of transboundary and globally important lake basins. These funds are used to establish the enabling environment for successful ongoing lake basin management.

- To ensure global benefits from lake projects, particularly in the case of international lake basins, ***a programmatic approach*** from the GEF and other funding bodies would be better than a project-by-project approach. This approach would also require a longer-term commitment from lake basin countries to sustainable management.

Section III: Synthesis

Planning (Chapter 10, pp. 85-94)

Planning is where everything comes together. Each of the six components of lake basin management discussed in Section II are essential, but without a plan of some sort, attaining management goals will be elusive. In particular, the long-term, integrating and complex nature of lakes requires that management responses are not ad hoc and that they are carried out as comprehensively as possible.

- Planning for lake basins require the integration of the components of good management discussed in Section II. Any plan for a lake basin needs ***to be aligned with regional and national plans*** for development and environmental protection.

- Plans vary in their levels of detail and breadth. By focusing on agreed goals, ***vision statements can be useful first steps*** to developing more detailed management plans.

- ***Comprehensive plans*** have the advantage of improving effectiveness by integrating actions across sectors. However, they can be expensive to implement, costly to coordinate, and inflexible in the face of changing political priorities.

- As promoted by the GEF International Waters projects, ***Strategic Action Programs*** have been largely beneficial in promoting contact between sectoral and national institutions and have laid the foundation for joint management interventions.

- Coordination between sectoral and regional plans ***should first take place where the pressures are greatest***. They should be phased over time and be opportunistic.

- ***Sectoral or regional plans can be coordinated*** through (1) a separate coordinating project, (2) a post-hoc unification of outputs, or (3) a broadening in the scope of an initially narrow project as it achieves success and gains credibility (Figure 10.2, p. 91).

- ***Plans need to be flexible*** in the face of changing social needs and external factors. They also need to be responsive to the results of monitoring. Some activities may be less successful than expected and new issues may be identified through the monitoring program.

- Overall, ***lake basin management is a process, not a project***.

Lake basin management must be integrative to be successful, given the nature of lakes and their basins. Integrated Water Resources Management (IWRM) and Integrated River Basin Management (IRBM) therefore serve as the foundations for Integrated Lake Basin Management or ILBM that this report, in essence, is addressing. ILBM, however, is more than a simple application of IWRM or IRBM principles. It is a management approach that provides many subtle but crucial dimensions of basin system management that have in the past tended to be neglected. After all, every basin system has a downstream where impoundments of importance, if not natural lakes, serve as the focal reserves of resources as well as the barometers of basin vulnerability.

Section I

Understanding the Resource

The three chapters in Section I provide the background necessary to understand the challenges facing lake basins 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 introduces the report and the project and contains reference material on the 28 lake basins in this study. Chapter 2 discusses biophysical aspects of lakes and what differentiates one lake from another, as well as lakes in general from other types of waterbodies. Chapter 3 looks at how lakes are used and what problems, current and emerging, they face.

Chapter 1

Learning from Others:

Drawing Lessons about Lake Basin Management

Motivation: Why Lakes? Why Now?

Lakes, natural or artificial, are important for human development and for the preservation of sound ecosystems and biodiversity on our planet. They contain 90 percent of the liquid freshwater on the earth's surface; are critical elements of the water cycle; sustain aquatic biodiversity; and provide livelihoods and social, economic, and aesthetic benefits that are essential for the quality of life in lake basin communities.

Increasingly, human activities are impacting the ecological integrity of lakes. However, in spite of their importance and the growing threats to them, lakes have not received sufficient attention in the global discourse on water policy. While Integrated Water Resources Management (IWRM) is becoming increasingly accepted as the appropriate framework for managing water resources in river basins, IWRM has yet to take account of the particular characteristics of lakes that may lie within the basin. These characteristics—integrating nature, long retention time, and complex response dynamics—with peculiar management implications will be discussed in Chapter 2. It is essential that water resources managers understand that the implications of these characteristics mean that management institutions and their policies and plans need to be established and funded for the long term, that scientific knowledge is particularly important for unraveling the complex responses of lakes to exogenous changes, and that management instruments need to be adapted to the integrating nature of lakes.

In particular, there is an urgent need to draw practical lessons on lake basin management, especially in developing countries in tropical, semi-arid, and arid regions where these systems are under increasing pressure. In addition, a synthesis of early lessons from projects implemented by international organizations—such as the GEF and its implementing agencies—could contribute to feasible, incremental changes in policy that lead to improved lake basin management.

In 1996, the World Bank recommended a Lake Basin Management Initiative to focus more attention on lake basins and help improve their management (Ayres and others 1996). The World Lake Vision (Box 1.1), presented at the Third World Water Forum and highlighting key principles of lake basin management, was a step in this direction (World Lake Vision Committee 2003). This project, the Lake Basin Management Initiative, follows on from the Vision report by providing practical lessons from a study of 28 lake basins in different geographic and socioeconomic settings around the world. The findings of this project also reinforce the main recommendations of the 2005 Millennium Ecosystem Assessment (MA).

Box 1.1 The Seven Principles of the World Lake Vision

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.*

Source: ILEC (http://www.ilec.or.jp).

Objectives: Drawing and Disseminating Lessons

A diverse group of organizations (Box 1.2) came together to support this project, whose overall objective was to strengthen the capacity for improved lake and reservoir basin management at the local, basin, national, and global levels. Specific objectives included:

1. Documenting management experiences through lake basin case studies;

2. Facilitating the sharing of experiences between decision makers and stakeholders; and,

3. Accelerating learning and implementation of effective lake and reservoir basin management.

Intended Audience

This report is for a wide spectrum of people involved or interested in lake basin management. The term "lake basin manager" is used in the broad sense, since lake basin management is usually characterized by multiple stakeholders, fragmented lines of authority, and various sources of funding. In this report, it is used as shorthand for the collection of people involved in lake basin management, noting that this collection of people and institutions is different in every case. The report is particularly intended for water resources managers who are implementing an IWRM approach at the local, regional or national level; it describes the need to take a different approach when river basins include significant lakes. The report will also be useful to the staff of non-governmental agencies, and research and policy institutions. The report is also intended for the GEF, the World Bank and other international development assistance agencies to help them design more effective lake basin management programs. A companion document (World Bank 2005) has been produced with lessons specifically targeted to the World Bank and the GEF.

Project Method and Approach

The Lake Basins and their Characteristics

Twenty-eight lake basins were selected for study in this project (Figure 1.1). Table 1.1 provides details of the 28 lake basins and Appendix E contains maps of the lake basins.

These 28 lake basins represent a wide range of climatic conditions, sizes, problems, political jurisdictions, and management challenges. Included among the lakes are some of the major freshwater and saline lakes in the world. Twenty-two of the lakes contain globally significant biodiversity. Twelve lakes are national lakes; that is, they have basins that lie within a single nation-state. Sixteen of the lakes are transboundary, where more than one country has jurisdiction over their basins or waters. Three of these transboundary lakes (Lakes Baikal, Cocibolca/Nicaragua, Tonle Sap) lie entirely within one country but have other countries in their basins.

Among national lakes, often the challenge is to address upstream and downstream concerns over different sectoral interests. Transboundary lakes face similar concerns to national lakes. However, their management is more difficult because of different national interests and priorities and because there is

Box 1.2 Key Organizations Involved in the Lake Basin Management Initiative

The main sponsor of this project, as well as programs at approximately half of the lakes studied here, is the Global Environment Facility (GEF, www.gefweb.org). GEF provides cofinancing to cover the "incremental cost" of the portion of projects that provide global environmental benefits (such as improved transboundary waterbody management, biodiversity conservation, and greenhouse gas reduction). GEF cofinancing for this project emphasizes "the collection of global and regional projects that provide programmatic and strategic benefits for the global environment through technical support, assessment, and derivation of lessons learned..." 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.

The World Bank, the implementing agency for this GEF project, also provided financial support through a grant from the Bank-Netherlands Water Partnership Program as part of its development of a Lake Basin Management Initiative. The UNDP and UNEP, the other GEF implementing agencies, supported the project through provision of information and membership on the project Steering Committee. The United States Agency for International Development (USAID, www.usaid.gov) provided financial support through an associated project and was a full member of this project, sitting on the Steering Committee. The Secretariat of the Ramsar Convention on Wetlands—an intergovernmental treaty for the conservation and wise use of wetlands—helped guide the project, since most of the lakes covered here contain a Ramsar site.

Shiga Prefecture, Japan, is also a financial sponsor of the project. The International Lake Environment Committee Foundation (ILEC, www.ilec.or.jp), a Shiga Prefecture-based scientific organization formed in 1986 to foster sustainable management of the world's lakes, is the executing agency and a financial sponsor for the project. ILEC worked in partnership with LakeNet (www.worldlakes.org), a U.S.-based NGO that operates a global network of people and organizations in more than 100 countries working to protect the health of lakes. In addition to supporting this project, USAID awarded a grant to LakeNet and Saint Michael's College of Vermont in the United States to provide technical assistance on lake basin management in eight countries.

The GEF, World Bank, UNDP, UNEP, USAID, Shiga Prefecture, and Ramsar Secretariat formed the project's Steering Committee.

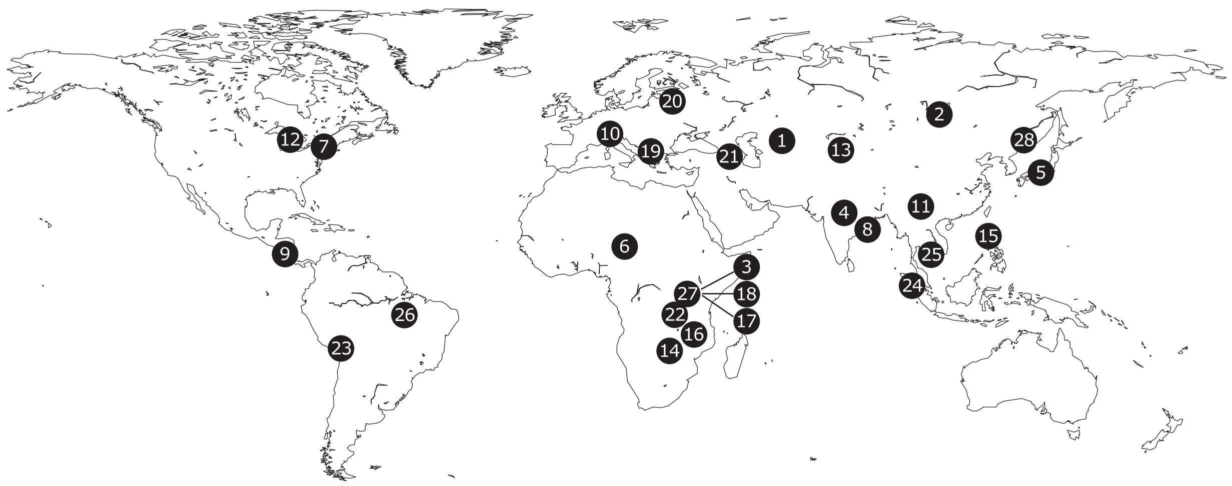

Figure 1.1 The Global Distribution of the 28 Lake Basins in this Study.

often no overarching authority; instead, the riparian countries need to reach a mutually acceptable agreement on common and complementary management actions, which often have to be codified in international law. Developing such agreements is typically a complex and lengthy process because of concerns over sovereignty, as well as differences in legal and policy frameworks and information, capacity, and institutions.

The study includes all but three lake basins (Lakes Manzala and Volta and the Caspian Sea) which have had GEF-funded projects, including ten in GEF's International Waters focal area and six in its Biodiversity focal area. Several lakes with proposed GEF projects were also incorporated. The North American Great Lakes, Lake Champlain, and Lake Constance were included to provide some non-GEF transboundary lake basins for comparison. Similarly, the project included several non-GEF lake basins that contain important biodiversity: Chilika, Issyk-Kul, Naivasha, Nakuru and Sevan. Three of the lake basins—the Aral Sea, Issyk-Kul and Lake Nakuru—are saline inland waters, and one—Chilika Lagoon—is a brackish coastal lagoon. The remaining are freshwater lakes. Four of the lakes—Lakes Constance, Champlain, and Biwa and the North American Great Lakes—are from high-income countries; seven are from countries in economic transition; and the remainder are from developing countries. The median gross national incomes of high-income countries, countries in economic transition and developing countries with lakes in this study are US$31,855, US$1,302 and US$712 respectively.

Three of the lakes are reservoirs of which one—the Bhoj Wetland—dates back to the 11th century and two—the Kariba and Tucurui Reservoirs—were constructed in the second half of the 20th century for hydropower generation. Reservoir basins share many characteristics with lake basins. However, there are also some problems as well as management opportunities that distinguish them from lake basins. The construction of reservoirs can affect people who were previously reliant on either the land and water now flooded for the reservoir, or on flows from the river downstream of the dam. In extreme cases, such as the Kariba Reservoir described in this study, it can lead to the displacement of people without adequate compensation. On the other hand, new reservoirs open ecological niches which can be exploited for productive purposes (such as the introduction of food and sport fish species at the Kariba Reservoir), and they are generally constructed for high value purposes (such as hydropower, domestic and industrial water, and irrigation supply) which can yield an income stream for management of the reservoir basin. Also, with sufficient planning and technical investigations, they can also be designed and managed to reduce problems such as siltation and lack of evironmentally sustaining flows. For example, high volume, low level releases can be used to scour sediments and prevent infilling, while environmental flow releases can be incorporated into the dam operating rules to ensure that aquatic ecosystems continue to function for the benefit of downstream communities.

Table 1.1 Key Features of the 28 Project Lake Basins.

Lake Basin		Basin Countries		Area (km²)		Pop. Density (per km²)	GNI[b] (per capita)
#	Name	Riparian	Non-Riparian	Lake	Basin[a]		
1	Aral Sea	Kazakhstan, Uzbekistan	Afghanistan, Islamic Rep. Iran, Kyrgyz Rep., Tajikistan, Turkmenistan	17,158	1,549,000	2.7	1,100
2	Baikal	Russian Fed.	Mongolia	31,500	571,000	9	2,610
3	Baringo	Kenya		108	6,820	...	400
4	Bhoj Wetland	India		32.3	370	1,351	540
5	Biwa	Japan		670	3,848	338	34,180
6	Chad	Cameroon, Chad, Niger, Nigeria	Algeria, Central African Republic, Libya, Sudan	1,350	2,400,000	9	355
7	Champlain	Canada, United States		1,127	21,325	28	31,170
8	Chilika Lagoon	India		906-1165	4,300	47	540
9	Cocibolca/ Nicaragua	Nicaragua	Costa Rica	8,000	23,844	211	740
10	Constance	Austria, Germany, Switzerland	Liechtenstein	572	11,487	261	30,920
11	Dianchi	China		300	2,920	1,082	1,100
12	Great Lakes (North American)	Canada, United States		244,160	765,990	43	31,170
13	Issyk-Kul	Kyrgyz Rep.		6,236	22,080	19	340
14	Kariba Reservoir	Zambia, Zimbabwe	Angola, Botswana, Namibia	5,580	687,049	20	430
15	Laguna de Bay	Philippines		900	3,820	1,570	1,080
16	Malawi/Nyasa	Malawi, Mozambique,Tanzania		29,500	100,500	68	223
17	Naivasha	Kenya		140	2,240	76	400
18	Nakuru	Kenya		30	1,800	222	400
19	Ohrid	Albania, FYR Macedonia	Greece	358	3,921	49	1,860
20	Peipsi/Chudskoe	Estonia, Russian Fed.	Latvia	3,555	47,800	21	3,995
21	Sevan	Armenia		1,236	3,708	74	950
22	Tanganyika	Burundi, D.R. Congo, Tanzania, Zambia	Rwanda	32,600	223,000	45	218
23	Titicaca	Bolivia, Peru		8,400	56,270	15.6	1,520
24	Toba	Indonesia		1,103	3,658	162	810
25	Tonle Sap	Cambodia	China, Lao PDR, Myanmar, Thailand, Vietnam	2,500 - 16,000	70,000–795,000[c]	59	300
26	Tucurui Reservoir	Brazil		2,430	803,250	6.8	2,720
27	Victoria	Kenya, Tanzania, Uganda	Burundi, Rwanda	68,800	193,000	155	317
28	Xingkai/Khanka	China, Russian Fed.		4,000 - 4,400	21,766	16	1,855

... Not available.

Notes: Most of the information is derived from the lake briefs. Parameters such as basin type and water type are explained in Chapter 2.

a. Basin area includes lake area.

b. Gross National Income (GNI) per capita in US Dollars is for 2003, based on World Bank figures available at http://www.worldbank.org. Values are arithmetic average for riparian countries; nonriparian states not included.

c. The Tonle Sap basin is 70,000 km²; the Mekong River basin is 795,000 km².

Table 1.1 (Cont.)

Lake Basin	Basin Type	Water Type	Climate[d]	Origin	Altitude (m)	Max. Depth (m)	Vol. (km³)	Retention Time (yrs)
Aral Sea	Closed	Saline	Dry: Arid	Glacial	30 (Small Sea) 40 (Large Sea)	46	108 (in 2003)	...
Baikal	Surface Open	Fresh	Cooler humid: Subarctic	Tectonic	456	1,637	23,600	330
Baringo	Subsurface Open	Fresh	Dry: Semi-arid	Tectonic	975	3.5	...	...
Bhoj Wetland	Reservoir	Fresh	Warmer humid: Humid subtropical	Constructed	504	11.7	0.121	less than 1
Biwa	Surface Open	Fresh	Warmer humid: Humid subtropical	Tectonic	86	104	27.5	5.5
Chad	Subsurface Open	Fresh	Dry: Arid	Tectonic	283	7	20	...
Champlain	Surface Open	Fresh	Cooler humid: Continental cool summer	Tectonic/ Glacial	29	120	25.8	3 (Main Lake) 0.17 (South Lake)
Chilika Lagoon	Coastal	Fresh to Saline	Tropical humid; Savanna	Coastal	Sea Level	3.7	4	...
Cocibolca/ Nicaragua	Surface Open	Fresh	Tropical humid: Savanna	Tectonic/ Volcanic	31	45	104	...
Constance	Surface Open	Fresh	Cooler humid: Continental cool summer	Glacial	395	254	48.5	4.3 (upper lake) 0.07 (lower lake)
Dianchi	Surface Open	Fresh	Warmer humid: Humid subtropical	Tectonic	1,887	8	1.56	2.74
Great Lakes (North American)	Surface Open	Fresh	Cooler humid: Continental cool summer	Glacial	183 (Superior) 74 (Ontario)	406	22,684	191 (Superior) 2.6 (Erie)
Issyk-Kul	Closed	Saline	Highland: Semi-arid	Tectonic	1,608	668	1,738	305
Kariba Reservoir	Reservoir	Fresh	Dry: Semi-arid	Constructed	485	97	185	3
Laguna de Bay	Coastal	Fresh	Tropical humid: Rain forest (Monsoon)	Tectonic/ Coastal	2	7.3	2.25	0.67
Malawi/Nyasa	Transition	Fresh	Tropical humid: Savanna	Tectonic	474	700	7,775	114
Naivasha	Subsurface Open	Fresh	Warmer humid: Humid subtropical	Tectonic	1,885	18	...	...
Nakuru	Closed	Saline	Warmer humid: Humid subtropical	Tectonic	1,759	4.5	0.092	...
Ohrid	Subsurface Open	Fresh	Warmer humid: Mediterranean	Tectonic	690	289	58.6	70
Peipsi/Chudskoe	Surface Open	Fresh	Cooler humid: Continental cool summer	Glacial	30	12.9	25.1	2
Sevan	Surface Open	Fresh	Dry: Semi-arid	Tectonic	1,896	80	32.9	...
Tanganyika	Surface Open	Fresh	Tropical humid: Savanna	Tectonic	773	1,470	18,880	440
Titicaca	Transition	Fresh	Highland: Tropical	Tectonic/ Glacial	3,810	283	930	56
Toba	Surface Open	Fresh	Tropical humid: Rain forest	Volcanic/ Tectonic	904	505	240	109-279
Tonle Sap	Mixed Flow	Fresh	Tropical humid: Savanna	Riverine	10	10	72.9 (max.)	...
Tucurui Reservoir	Reservoir	Fresh	Tropical humid: Rain forest	Constructed	78	72	45	0.12
Victoria	Surface Open	Fresh	Tropical humid: Savanna	Tectonic	1,134	80	2,760	23
Xingkai/Khanka	Surface Open	Fresh	Cooler humid: Continental cool summer	Tectonic	69	10.6	18.3 (avg.) 22.6 (max.)	10

d. Source: *The Times Atlas of the World*, Tenth Comprehensive Edition, pp. 36-37.

Lake Briefs, Regional Review Workshops, and Thematic Papers

Local and international experts were commissioned to prepare briefs on experience and lessons learned for the 28 lake basins. The briefs document not just the biophysical conditions but also the socioeconomic conditions and management experience, including lessons learned, at each lake basin. A list of lake brief authors is given in Appendix B. The full set of briefs can be found on the companion CD-ROM.

The lake briefs were reviewed in three regional workshops: Europe, Central Asia, and the Americas (hosted by Saint Michael's College, in Burlington, Vermont, USA in June 2003), Asia (hosted by the Laguna Lake Development Authority in Manila, Philippines in September 2003) and Africa (hosted by the Pan-African START Secretariat in Nairobi, Kenya in November 2003). The workshops brought together 288 participants from 41 countries who provided additional valuable information on lake basin management (Appendix C). In addition to the 28 lake briefs, this report draws on information on the development of community-based management at Lake George in Uganda; these experiences were presented at the African regional workshop.

In addition to the briefs, 17 thematic papers were commissioned on cross-cutting or regional/global issues. A list of these papers and their authors can also be found in Appendix B.

Website Clearinghouse and e-Forum

A project e-forum (www.worldlakes.org) was established to facilitate communication and dialogue among project participants, including public review of the briefs, thematic papers, and this report.

Structure of the Report

The report is divided into three sections containing eleven chapters. These are followed by five appendices. A companion CD-ROM contains the lake briefs and the thematic papers.

Section I: Understanding the Resource covers the key biophysical aspects (Chapter 2) and human use aspects (Chapter 3) that make lake basin management such a challenge. The 28 lake basins are used to illustrate the wide range of values, uses, and problems facing lakes, and typical management responses. The key components of lake basin management are presented.

Section II: Meeting the Governance Challenge forms the core of the report. Each chapter in this section presents lessons learned on the main components of lake basin management: namely, Institutions (Chapter 4), Policy Tools (Chapter 5), People (Chapter 6), Technological Responses (Chapter 7), Information (Chapter 8) and Finance (Chapter 9). While these components can be read as stand-alone chapters, they are best read as a whole.

Section III: Synthesis is where all the lessons are brought together into a coherent whole, first in Planning (Chapter 10) and then in Toward the Future (Chapter 11).

Appendix A is a glossary of terms used in this report. The list of lake briefs and thematic papers and their authors can be found in Appendix B. Appendix C provides the summary outcomes from the three regional workshops. Appendix D is a list of references. Appendix E provides a map for each of the 28 lake basins. Appendix F presents the Conference Statement and Ministerial Resolution from the 11th World Lake Conference, Nairobi, Kenya; and the Main Points of the Declaration from the 9th Meeting of the Ramsar Convention, Kampala, Uganda.

Chapter 2

Biophysical Characteristics of Lakes

This chapter highlights those features of lakes and their basins that have the greatest implications for human use and management. A more thorough treatment is available in Wetzel (2004), Klaff (2002) or Horne and Goldman (1994).

Global Extent and Distribution of Lakes

According to the most comprehensive study of the global distribution of natural lakes (Meybeck 1995), there are approximately 5.3 million lakes over one hectare in size (Table 2.1). Overall, lakes hold 100,000 km^3 of freshwater—90 percent of the earth's liquid surface total (Shiklomanov 1993). Saline lakes hold a nearly equal volume of water.

The global water cycle has been profoundly changed by the construction of artificial lakes by damming rivers; these reservoirs contain over 14 percent of global annual runoff. While construction of large reservoirs is a modern phenomenon, older, smaller reservoirs such as the Bhoj Wetland have been around for over a thousand years.

The distribution of lakes is governed primarily by variations in geology and climate. Lakes are most abundant in Canada, the Nordic countries, and the Russian Federation, where there are numerous depressions and a surplus of rainfall over evaporation. However, they are found on all continents of the world, even on Antarctica, which is home to many saline surface lakes, and even has some lakes buried under kilometers of ice (for example, Lake Vostok). Even arid and semi-arid areas have lakes, many of which are naturally saline due to high evaporation rates.

Table 2.1 Origin, Number and Extent of the World's Lakes (› 1 ha).

Origin	Number	Total Area (ha)	Number in our survey[1]
Glacial	3,875,000	1,247,000	4
Tectonic	249,000	893,000	17
Coastal	41,000	60,000	2
Riverine	531,000	218,000	1
Volcanic	1,000	3,000	1
Other/Unknown	567,000	88,000	0
Constructed	45,000	...	3
Total	5,309,000	2,509,000	28

... Not available.
Source: Adapted from Meybeck (1995).
1. Several lakes have multiple and/or unclear origins. They are categorized here under the origin listed first in Table 1.1. Number of reservoirs from World Commission on Dams (2000).

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). The World Commission on Dams (2000) estimates there are over 45,000 large dams (15 m high or between 5-15 m high with a reservoir volume greater than 3 million m^3); most were constructed in the latter half of the 20th century.

A Typology of Lakes: What Differentiates one Lake from Another?

This section looks at five key characteristics of lake basins—basin type, climate, origin, salinity and mixing—that have major implications for human use of lakes.

Basin Type

At one time, lakes were seen as worlds unto themselves (Forbes 1875). The existence of a shoreline implied that a lake is a discrete entity. Advances in knowledge, driven in part by research on problems at lakes around the world, have led to the understanding that lakes are intimately connected to their drainage basins. This is articulated as Principle 2 of the World Lake Vision (Box 1.1). An analysis of issues in the 28 lake briefs (see next chapter) confirms the intimate link between what happens in a lake with what is happening in its drainage basin (the terms catchment, watershed, and drainage basin are used almost synonymously). The cases also show that sometimes lakes can be influenced by activities happening in their airshed beyond their surface water basins.

Lake basins can be categorized by their water balance: that is, how water gets into and out of the lake. Scientists distinguish between open and closed lake basins, or those that have rivers draining the lake and those that do not. The categorization in Figure 2.1 builds on and extends this simple dichotomy to account for the diversity of basin types in the 28 project lakes.

Surface Drainage Basin. An open basin with surface 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. Many of the lakes in this report are

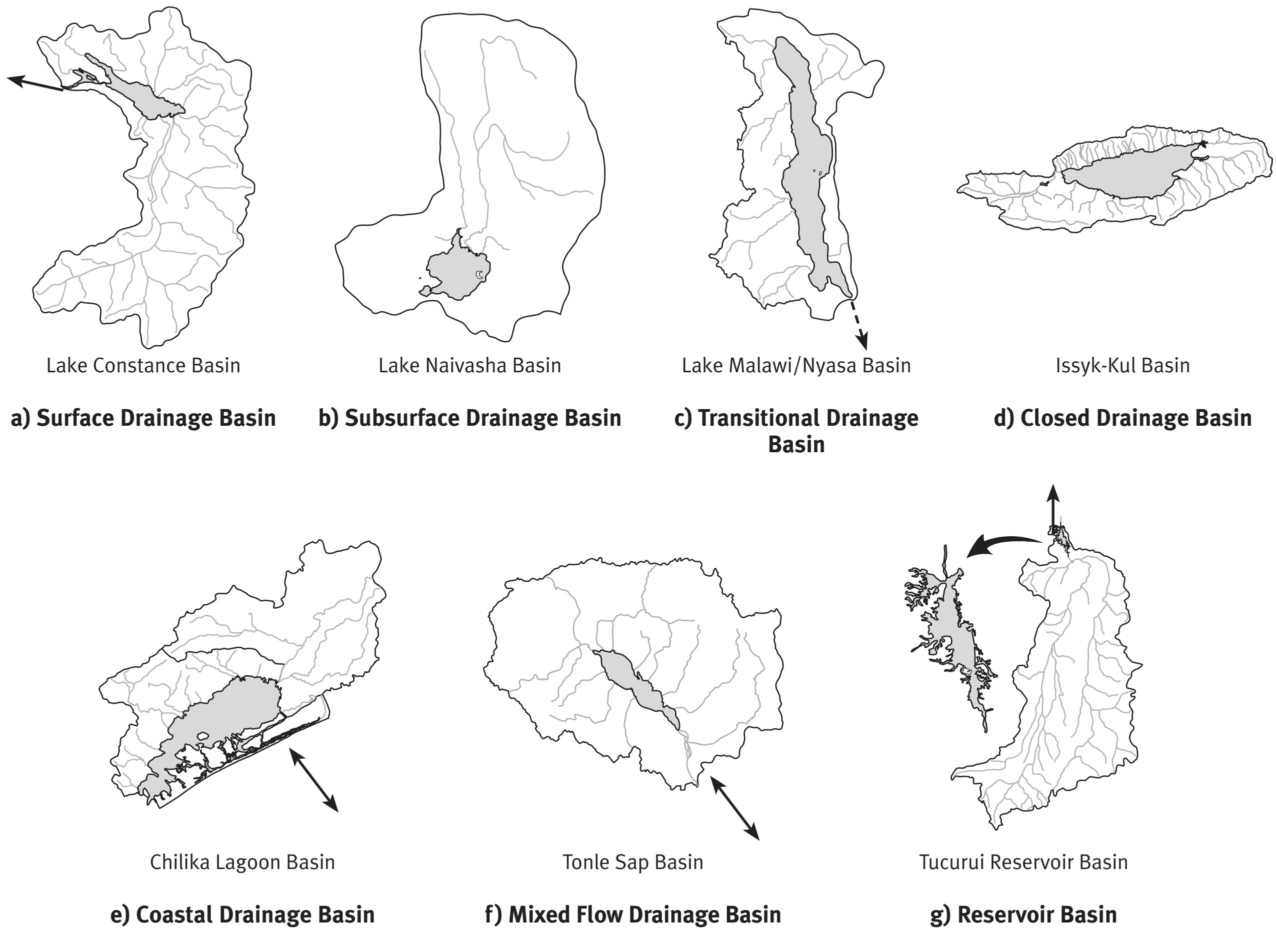

Figure 2.1 The Variety of Lake Basin Types.

in open drainage basins, with rivers being the major water outflow. Water also leaves this type of lake via evaporation and groundwater, but those components are relatively minor compared with river outflows. Examples are Lakes Baikal, Biwa, Constance, Dianchi, the North American Great Lakes, Peipsi/Chudskoe, Toba, and Xingkai/Khanka.

Subsurface Drainage Basin. An open basin with a significant subsurface inlet/outlet(s). Many lakes have no surface river discharge, yet remain fresh due to substantial flow of water (and salt) via groundwater. Lake Naivasha in Kenya is an excellent illustration of a lake dominated by groundwater flow. Lake Ohrid is an interesting case where much inflow to the lake comes from groundwater from a different surface lake basin. Examples include Lakes Baringo, Chad, Naivasha, and Ohrid.

Transitional Drainage Basin. A basin with some surface or subsurface outflow but with significant evaporation. This type of lake occurs mainly in low latitude, and arid/semi-arid areas where solar radiation—and hence evaporation—is strong. Small changes in climate or human use can switch a transition basin lake between open and closed states. Greater relative dependence on direct precipitation and evaporation makes these lakes more sensitive to atmospheric inputs than other open basins of equal area. The Lake Malawi/Nyasa Basin has a discharge in the south that sometimes fails to flow, sometimes making it a closed basin. Examples include Malawi/Nyasa, Sevan, Tanganyika, Titicaca, and Victoria.

Closed Drainage Basin. A terminal basin with neither significant surface nor subsurface outflow. Water leaves the lake only through evaporation, which generally leads to higher salinity (total ionic concentration). 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, Issyk-Kul, and Nakuru.

Coastal Drainage Basin. A drainage basin with flows to and from the ocean. Freshwater typically enters the lake through rivers draining to it. The lake periodically/seasonally drains to the ocean; sometimes the ocean drains to the lake. This can lead to a complex and seasonally dependent salinity gradient that is important for the biota. Examples include Chilika Lagoon and, to a lesser extent, Laguna de Bay.

Mixed Flow Drainage Basin. A drainage basin with inflowing rivers that reverse direction depending on the season. In contrast to a coastal lake, the flows come from a freshwater river. This reversal of flow leads to large fluctuations in lake water level and area. These lakes commonly occur in internal deltas. Tonle Sap is a prime example of this type. For this type of basin, the size of the lake's drainage basin is seasonal, since the connecting river inflow is seasonal.

Reservoir Basin. A drainage basin with a dammed river. In many areas where geology and climate do not favor the formation of natural lakes, reservoirs are constructed, although the reasons for construction are quite diverse. Reservoirs tend to have large basin-to-lake area ratios and often have a highly dendritic shape; both of these characteristics are illustrated in Figure 2.1 for the Tucurui Reservoir and its extensive basin. The transition from river to lake environments within the reservoir proper is gradual and progresses with proximity to the dam. Examples include the Bhoj Wetland, and the Kariba and Tucurui Reservoirs.

Origin/Age

Table 2.1 shows that about 75 percent of the world's lakes were formed as a result of the last ice age, which ended around 10,000 years ago. Coastal lakes are even more recent, having been formed when sea levels stabilized around 6,000 years ago. Tectonic lakes range greatly in age, but tend to be very old. The oldest, Lake Baikal which lies in a tectonic rift in Siberia, is thought to be over 20 million years old. The Great Rift Valley of Africa contains similarly old and deep lakes such as Lakes Malawi/Nyasa and Tanganyika. Eight of the world's 15 ancient lakes (greater than two million years old) are included in this study.

A lake's origin has great implications for its characteristics. For example, coastal lagoons are naturally susceptible to siltation, as they usually lie at the end of large riverine catchments. They go through an aging process in which they gradually fill in with silt, become more-and-more closed off from the sea, and lower in salinity. On the other hand, tectonic lakes tend to be deeper and older, and therefore have longer retention times. They are likely to contain endemic species with significant biodiversity value.

Climate

Solar energy input affects the quantity and seasonality of flows into a lake, the thermal properties of the lake, and biological processes in the lake. Table 1.1 in Chapter 1 classifies lake basins by the Köppen climate system, which recognizes six major climatic types—polar, cooler humid, warmer humid, dry, tropical humid, and highland—each of which can be further subdivided.

The 28 project lakes cover a wide range of climate types. Most are in tropical (10) or subtropical (5) climates, which are characterized by abundant rainfall and strong solar radiation. A further six lakes are in arid or semi-arid regions (areas with between 25-200 mm and 200-500 mm annual rainfall respectively). Many of these arid and semi-arid regions are low in latitude and therefore subject to strong solar radiation and high evaporation. The majority of the world's saline lakes occur in closed drainage basins in arid and semi-arid regions (Williams 1998). Lake Titicaca occupies a unique position as a high-elevation, tropical lake. The remaining six lakes are located in temperate regions.

Shallow lakes are particularly sensitive to climatic variation. For example, Lake Nakuru has little buffering capacity to withstand both intra-seasonal and inter-seasonal climate variability because of its shallow depth, high evaporation rates, and seasonal inflowing rivers. The first peak flow occurs in May (a month after peak rainfall), while the second peak coincides with rain in the month of August. The Lake Nakuru basin is a closed basin so only evaporation accounts for water loss from the lake. Consequently, long drought periods, such as 1993 to 1996, have resulted in excessive lake-level decline.

Scientific knowledge of lakes has primarily come from studies of temperate lakes in Europe and North America. In order to expand the knowledge base, we have included many non-temperate lakes and lakes from developing countries in this study.

Salinity

Williams (1998) has defined saline waters as those with total ionic concentrations greater than 3 g/L. Waters less saline than this are considered fresh. When water evaporates, most of the ions remain behind. When evaporation is the dominant way for water to leave a lake, there is a gradual increase in the lake's salinity. All three saline lakes in our survey—the Aral Sea, Lake Nakuru, and Issyk-Kul—occur in closed basins (the fourth saline waterbody is the coastal Chilika Lagoon).

The study lakes cover the spectrum of salinity from freshwater to hyper-saline lakes. The salinity of a lake is of utmost importance to the biota, and consequently to human users. The Aral Sea was once a moderately saline water body, but due to upstream diversions of rivers, the lake's water balance has become dominated by evaporation and its salinity has dramatically increased, leading to the complete loss of the fishery. However, increasing salinity can be beneficial. The Chilika Lagoon brief shows how a reduction in inflow of saline (ocean) water led to a drop in salinity that led to a decline in fish that were attuned to the saline ecosystem. Lake Nakuru, a sodic lake in the Kenyan portion of the Rift Valley, provides an example of where extreme salinity is the basis of the lake's most important and unique values (Box 2.1).

Mixing/Stratification

Water movement in lakes is multidirectional and complex. For many lakes, there can be periods when the lake stratifies; that is, the upper water of a lake does not mix with the lower water. Effectively, the lake is separated into two waterbodies, one lying on top of the other. Stratification can be caused by warming of the upper waterbody through solar radiation, or by differences in salinity between upper and lower waters. Strong stratification—that is, large density differences between upper and lower waters—occurs particularly in tropical lakes.

The principal consequence of stratification is that the bottom waters become disconnected from the atmosphere and do not receive a regular supply of oxygen. Oxygen levels drop in these waters as various chemical and biological processes use up the existing oxygen. Fish and many other biota cannot live in these oxygen-depleted waters. Undesirable reactions can occur that lead to pollutants, such as methane and phosphorus, being released from the bottom sediments.

Stratification and mixing can occur in various patterns including monomictic (mixing once a year), dimictic (twice a year), polymictic (many times a year), and meromictic (continuously stratified). Mono- and dimictic lakes are usually found in temperate regions where the seasonality of solar radiation is most pronounced. Shallow lakes tend to be well-mixed (polymictic) year round, with only brief periods of stratification. Some lakes, such as Lakes Malawi/Nyasa and Tanganyika, are permanently stratified because wind cannot supply the energy needed to mix the huge volumes of water in these very deep lakes. Any material that sinks into the lower layer of these lakes is virtually gone forever.

Features Common to Lakes: What Differentiates Lakes from Other Waterbodies?

Lakes have three fundamental characteristics in common—integrating nature, long retention time, and complex response dynamics. Individually, these characteristics are not unique to lakes—for example, groundwater also has a long retention time, and estuaries can have complex dynamics. But the combination of these characteristics is unique to lakes and has an important influence on the application of IWRM principles to lake basin management.

Integrating Nature

Lakes receive inputs from diverse sources in various forms from drainage basins and beyond. The inputs to a lake come in the form of atmospheric precipitation; flows from rivers and other inflowing channels; heat- and wind-induced energies that cause waves; thermal energies that affect mixing properties; and land-based and airborne pollutants and contaminants, nutrients, and organic substances, both living and non-living matter.

Integrating nature refers to the mixing of these inputs within a lake so that both resources and problems are disseminated throughout the volume of a lake. There are important limits to mixing—stratification can prevent complete vertical mixing, and restricted embayments can limit horizontal water movement. Nevertheless, valuable resources such as fish and invertebrates, as well as problems such as floating plants and pollution, are able to move throughout most of the upper parts of a lake.

Long Retention Time

Lakes are slow to respond to changes. They are able to absorb floodwaters, pollutants, and heat without showing immediate changes. Water residence time is calculated as the volume of a lake divided by the annual flow of water in (or out). It gives an indication of the average time water spends in a lake. Table 1.1 gives the residence times for many of the lakes in the study. The shortest time is 2 months (Tucurui Reservoir) and the longest is 440 years (Lake Tanganyika). The world average for lakes is 17 years, compared to two weeks for undammed rivers (Klaff 2002).

Long retention time has several important implications. One is that lakes are relatively stable. Even in severe droughts, most lakes still have some water in them: their large volumes in most cases buffer short-term variations in flows. In severe droughts, lakes can dry out, especially if they are in closed basins. The Aral Sea is known to have greatly shrunk several times in the last two-thousand years, and Lake Nakuru was largely dried out in the 1980s. As a reliable "pool" of water, they present a flat surface allowing for easy navigation. Additionally, long retention time allows for suspended materials to settle to the bottom. This means that lakes act as high-efficiency sinks for many materials. Because of their relative permanence, many lakes have fostered civilizations and become symbols of cultures. Lakes Sevan and Ohrid provide examples. Settlement at the former is known to date back more than 9,000 years, while the Macedonian side of Lake Ohrid has been designated a World Heritage site, partly because there are physical remains from its long history of settlement.

Another implication is that the long-term stability of the older lakes has allowed complex, often unique ecosystems to evolve. Lake Malawi/Nyasa provides an example of what

Box 2.1 Lake Nakuru—Saline and Sublime

Lake Nakuru is an extreme example of a saline lake with salinity levels that range between 8 and 200 parts per thousand. Owing to its strongly sodic nature, Lake Nakuru has limited uses for man. Its waters render it unsuitable for irrigation, contact sport, fishing, or domestic consumption. Such highly alkaline lakes are characterized by low species diversity and simple community structures where a few tolerant and adapted species attain high population densities. In the case of Lake Nakuru, the Cyanophyte, *Arthrospira fusiformis* (Voronichin), thrives in the highly saline waters and forms the food source for the lesser flamingos. This is a specialized feeder, whose feeding habits are restricted to those wetlands in which *Arthrospira fusiformis* flourishes. The lesser flamingo is a vulnerable species (CITES List II).

Primarily because of the large assemblages of flamingos, Lake Nakuru is a highly valued national park and a major source of revenue for the local and national economy. In addition to its value as a national park, it also serves as a reservoir for the assimilation of wastes generated within its drainage basin. Managing this lake involves balancing these two apparently conflicting uses.

millions of years of relative isolation, coupled with natural selection, can produce—over 500 endemic fish species exist in this lake. However, this biodiversity can be rapidly destroyed, as demonstrated by the major loss of fish community structure following the introduction of Nile perch and the increasing eutrophication of Lake Victoria. Lake ecosystems are resilient when faced with stresses that have existed over evolutionary time scales, but can be extremely vulnerable to "new" stresses, such as the introduction of exotic species.

The long retention time also means that, once a lake is degraded, it takes a very long time—if ever—for it to recover or be restored. Evidence from the lake briefs—such as the long-term release of toxic chemicals from sediment in the North American Great Lakes—shows that reversing degradation is hard, costly, and often impossible. The long retention time of lakes leads to lags in ecosystem response that are poorly matched to the human management time-scale.

Complex Response Dynamics

Unlike rivers, lakes do not always respond to changes in a linear fashion. Figure 2.2 shows the highly non-linear response (hysteresis) of many lakes to increases in nutrient concentration. The consequence is that a lake's degradation in response to a developing pressure, such as increased nutrient concentrations (from A to B), may not be apparent until nutrient concentrations are high and the lake abruptly switches its status. In the figure, plankton concentrations only become high when nutrient concentrations increase from B to C. 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, so recovery follows a path from C through D down to A. That means that politically difficult decisions (such as regulations on nutrient discharge to push the lake from C to D) do not yield an immediate positive change (a drop in algal blooms).

Lake Victoria provides a well-known example of this complex response. The diatom, *Aulacosiera*, the previously dominant phytoplankton, was last recorded in the lake in 1990. Nitrogen-fixing cyanobacteria (particularly *Cylindrospermopsis sp.*) and, to a lesser extent, *Anabaena,* now dominate the phytoplankton.

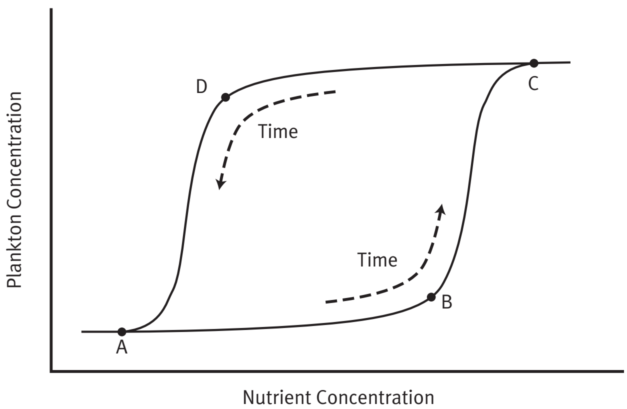

Figure 2.2 An Example of Complex Response Dynamics of a Lake.

This abrupt switch in the basis of the lake's foodchain was the result of gradually increasing nutrient loads and has major implications for the lake's entire ecosystem. Lake Naivasha is another lake where aquatic ecologists speculate that the lake switched state when alien species were introduced in the lake. The introduction of the Louisiana crayfish especially has changed the original submerged macrophyte-dominated ecosystem into a rather macrophyte-depleted ecosystem.

Biomagnification is another example of complexity in lake ecosystems. Biomagnification refers to the increase in concentration of certain compounds in organisms as one goes up the food chain. Toxic compounds such as PCBs and dioxins are extremely soluble in fat and therefore remain in the bodies of organisms that consume them and so get concentrated as lower order organisms are consumed by higher order ones. Table 2.2 shows how the concentration of PCBs increases up the North American Great Lakes food chain.

Table 2.2 Biomagnification of PCBs in the North American Great Lakes.

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

Source: Adapted from USEPA and Government of Canada 1995.

Implications for Lake Basin Management

Lakes are part of river basins and are best managed according to the principles of IWRM. These include devolution of responsibility to the lowest applicable level, coordination across sectors affecting lakes, and involvement of all relevant stakeholders. Figure 2.3 shows how water resources management requires coordination across all the water-using sectors. However, water resources managers also need to be cogniscent of the special characteristics of lakes and the implications of these characteristics for lake basin management. This special form of IWRM is termed Integrated Lake Basin Management (ILBM).

The integrating nature of a lake means that many lake resources as well as lake problems are shared throughout the lake. As a result, it is not sensible to subject different parts of a lake to different management regimes. This is particularly relevant for transboundary lakes basins. For example, a sustainable fishery cannot be achieved for a single population of fish unless all riparian countries implement sustainable fishing practices. Thus, for transboundary lake basins, some form of transboundary cooperation is needed—some successful examples described later in this report involve transboundary, coordinating institutions covering both lakes and their basins. A related consequence of their integrating nature is that it is

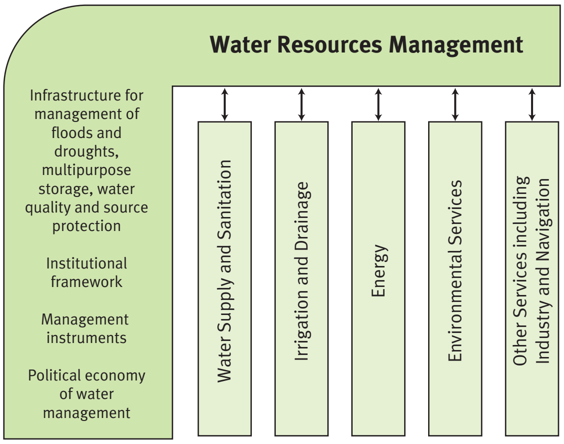

Figure 2.3 Conceptual Framework Showing the Relationship between Water Resources and Sectoral Use of Water.

Source: The Global Water Partnership.

difficult to exclude users from accessing a lake's resources. In the absence of effective regulatory institutions, ease of access coupled with self-interest can lead to over-use and destruction of the resource base. The methods of controlling peoples' behaviors, whether through command-and-control type rules, economic instruments, or public education and involvement, need to be designed for this characteristic of lakes (discussed in more detail in the next chapter).

Long retention time has a number of implications. Because problems can build up slowly and take equally as long to be managed, institutions involved in lake basin management (including those in upper basins) need to be prepared to engage in sustained actions. Their institutional structure, including the establishment of strong links with sectoral agencies and community groups, should be designed for the long term and their sources of funding need to be sustainable.

Scientific knowledge has a particularly important role in ILBM because of both the long retention times and the complex response dynamics of lakes. The former characteristic means that problems need to be anticipated as far in advance as possible through monitoring, development of indicators and analytical studies; the latter characteristic means that detailed scientific studies may need to be carried out to unravel these complex processes and their implications. Scientific studies may also develop novel solutions to these problems.

At present, the special characteristics of river basins that include lakes are not widely understood by water resources managers. The lessons identified during this project are intended to help sensitize water resources managers to these characteristics and their management implications.

Chapter 3

Human Use of Lakes:

Values, Problems, and Responses

Resource Values of Lakes and Their Basins

Lakes and reservoirs and their basins provide many uses of different values to humans. They supply water for drinking, agriculture, industry, and livestock uses and energy generation; they buffer downstream areas against both floods and droughts; they provide sinks for sediments and contaminants to protect downstream areas (although this can cause problems in the lake itself); they provide a path for transportation; and they offer habitat for important food species. Though we construct lakes artificially to create such values, the endowed values from natural lakes generally far exceed the ones that artificial lakes can provide. Tonle Sap provides a novel example of buffering against floods and drought to the benefit of both lakeshore communities and those downstream. From mid-May to early-October, the flow of the Mekong River system becomes so great that the Mekong Delta cannot support the volume, and the water backs up the Tonle Sap River to fill Tonle Sap and its surrounding flood plain. This annual replenishment gives rise to one of the most productive fisheries in the world. Subsequently, the delayed release of floodwater from the lake to the Mekong River between October and April provides water for a second rice crop and controls seawater intrusion in the Mekong Delta.

These uses give rise to the many values of lakes and their basins (Box 3.1).

Box 3.1 Common Lake and Lake Basin Uses

Lakes
- Water extraction for urban and rural use
- Artisanal and commercial fisheries and aquaculture
- Transportation
- Recession cropping and grazing
- Disposal of wastes, including sewage
- Tourism based on biodiversity, scenery, or sporting activities
- Cultural and religious uses

Lake Basins
- Rainfed and irrigated agriculture
- Grazing of livestock
- Industry
- Mining
- Human settlements
- Forestry

Most human communities surrounding lakes in developing countries are heavily dependent upon lake biota and natural lake processes for their water, food, and livelihoods; as populations grow, lake resources come under increasing pressure (Box 3.2). Thus, many lake basin communities in this study, which include some of the world's poorest people, depend on freshwater biota for their protein needs. For example, Lake Malawi/Nyasa provides 70 percent to 75 percent of the animal protein consumed in Malawi, and Tonle Sap provides about 230,000 tons of fish/year, almost half of Cambodia's total fish production. Lake Victoria supports the largest freshwater fishery in the world, with annual fish yields exceeding 300,000 tons and worth $600 million annually. While the two main exotic fish species—Nile perch and Nile tilapia—have contributed positively to the riparian countries through increased export earnings, recreational opportunities, increased supply of protein, and increased employment and earnings for fishermen, they have also contributed to the loss of many endemic fish species, particularly cichlids. However, recent studies have revealed that a significant portion of the cichlid fauna, considered lost from the main lakes of the Lake Victoria region, is still extant in marginal habitats in the periphery of the main lakes and in the small satellite waterbodies around the main lakes.

Lakes also support important ecosystems and provide habitat for rare and threatened species that are valued by global communities. Many of the study lakes have high international biodiversity value (Table 3.1). Twelve of the 28 lake briefs cite national or provincial designations—including the creation of national parks, nature reserves, or other protected areas—as being important to the lake basin management framework, while 18 of the 28 lake basins contain wetlands of international importance (Ramsar sites). Five of the lake basins are designated by the United Nations' Man and the Biosphere Programme as Biosphere Reserves. Two are designated by UNESCO as World Heritage Sites. At Lake Ohrid, the designation is for both natural and cultural features in the lake basin; at Lake Baikal, the most biodiverse freshwater body in the world, the designation is for natural features. In several cases (Lakes Ohrid, Champlain, and Issyk-Kul), the attainment of these international designations has helped raise awareness about the importance of the lake resources and paved the way for national water resources management efforts.

Protection of biodiversity is being combined with productive use of threatened lake resources at a number of the study lakes:

- At Lake Ohrid, the native trout species are threatened through overfishing, loss of fish spawning habitat, and the introduction of exotic fish species. Efforts to harmonize fishing regulations between FYR Macedonia and Albania and the protection of shoreline vegetation will both help conserve the threatened native trout species and maintain a commercially valuable source of food;

- Tonle Sap is part of the Mekong Basin, where the Water Utilization Programme (WUP) commenced in early 2000 to help achieve "reasonable and equitable water use among the member countries while maintaining the Basin's ecological integrity"; and,

- At Lakes Tanganyika and Malawi/Nyasa, fish biodiversity provides the basis of a trade in ornamental fish species.

Box 3.2 The Connection between Environmental Degradation and Livelihoods: Lakes Chad and Nakuru

Lake Chad

Lake Chad is known to fluctuate naturally in response to climatic cycles. Recently, the demand for water for irrigation has increased fourfold, magnifying these fluctuations and leading to dramatic environmental changes. In 1963, the lake surface covered 25,000 km^2; today it covers 1,350 km^2. Vegetation in the northern part of the lake has disappeared, and sand dunes have begun to form on the dry lakebed. The decrease in river flow has led in places to the degradation of river channels. Accelerated siltation and weed growth, particularly *Typha australis*, have done great damage in the Hadejia-Jama'are-Yobe basin and elsewhere. The problem is expected to worsen in the coming years as population and irrigation demands continue to increase.

This environmental degradation has had a direct impact on the livelihoods of people in the basin. Pasturelands have only 66 percent of the carrying capacity they had prior to the drought; irrigation channels have been clogged and river channels blocked by siltation and water weeds; and, some of the natural fauna and flora have disappeared. All economic activities—such as fishing, livestock rearing, and farming—have been adversely affected and many people have had to migrate as environmental refugees. People whose economic activities were dependent on water (such as fishermen) kept following the receding water without consideration of the national borders. By 1983, a crisis had developed. Migrants found themselves in other countries without fully realizing the change. Conflicts developed between these migrants and local communities. Territorial disputes also erupted between some member countries over emerging islands in the lake.

Lake Nakuru

Lake Nakuru is one of several shallow, alkaline-saline lakes lying in closed hydrologic basins in the eastern African Rift Valley. Climatic variations have caused large changes in its depth and salinity on annual, decadal, and longer time scales, as well as having major consequences for the lake's ecology. The town of Nakuru is the fourth largest in Kenya, supporting a population of 400,000 people. The urban population has been growing at a rate of 10 percent per year over the last three decades, placing considerable stress on water supply and making the environmentally safe disposal of wastewater difficult.

There has also been an increase in water abstraction along the upstream parts of the rivers for irrigation, domestic, and industrial uses. Deforestation and cultivation exert effects that alter the area's hydrological regime. The hydrological impacts of the destruction of forests are manifested in higher water runoff rates, higher and more destructive peak discharges in rivers and other water courses, marked seasonality in streamflows, and significant declines in the stable yields of wells and boreholes. As the demand for water grows and abstraction rates increase, the drainage basin's capability to harvest and hold rainwater appears to be diminishing.

Issues regarding equitable access to natural resources and sustainable environmental conservation and economic development have arisen in the drainage basin. The ever-increasing human population, poor enforcement of environmental regulations, and unsustainable exploitation of natural resources are root causes for human-resource conflict. The poverty and human-wildlife conflicts around Lake Nakuru National Park (LNNP) exemplify the prevalence of conflict between the catchment's natural resources and human population.

The communities in the catchment area are from different ethnic groups, having coexisted peacefully for over 30 years until 1992, when politically-instigated ethnic clashes erupted, resulting in many deaths, property destruction, and population displacements. The inter-ethnic fighting recurred at the beginning of 1998 with the same disastrous results. The human-wildlife conflict has continued, with wild animals damaging crops and property in adjacent farms, while the activities of the basin's inhabitants have continued to degrade the environment.

The conflict between the need for urban expansion and the need to protect the lake has resulted in a complex situation posing vast challenges to sustainable urban development. The city's fragile ecological setting induces severe constraints and calls for limiting its growth. Conversely, the rapid population growth and economic potential calls for enhanced urban development and appropriate planning strategies. The views of all stakeholders in the development process are vital to achieve desirable future outcomes.

Source: Lake Chad and Lake Nakuru briefs.

However, many of these colorful cichlid species are highly localized and threatened with extinction if harvesting rates are not carefully controlled. While these fish have the potential to provide a sustainable, albeit minor, industry, there is little oversight of this trade at present in either lake to ensure its sustainability.

Finally, lakes possess important cultural and religious values for many societies in both the developed and developing world. There are numerous examples in the lake briefs. At Laguna de Bay, religious rites such as baptisms and a parade in honor of the patron saint reflect the close link of lakeshore inhabitants to the lake. The Laguna de Bay basin also has many cultural sites, such as the century-old churches in the towns of Pakil, Pangil, and Majayjay in Laguna Province, and petroglyphs located in the lakeshore town of Binangonan Rizal. Lake Ohrid provides another example. The long history of settlement around the lake shores led to the Macedonian side of the lake being declared as a mixed cultural/natural world heritage site by UNESCO's World Heritage Committee in 1980. The Lake Ohrid community now benefits from the growing market in cultural tourism.

Total Economic Value

The Total Economic Value (TEV) of a lake basin is the summation of all values of all identified uses and benefits. This approach recognizes the reality that any natural resources system has many different users and uses, and each use has a contribution in economic terms to the value of the resource.

The TEV approach includes both use and non-use values (Figure 3.1). Use values are those benefits that come from direct use of or interaction with the lake—such as 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 of knowing that the lake is there (an existence value), or the benefit from knowing that one's children will be able to enjoy the lake (an inheritance value). Box 3.3 provides an example of the range of values at Lake Sevan.

A major challenge to estimating TEV for a lake basin is estimating the economic values of the many uses that are not normally bought and sold in the market (this is particularly true for non-use values). 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

Table 3.1 International Biodiversity Designations for Lake Basins in the Study.

Lake Basin	National or Provincial Designation	Ramsar Site	Biosphere Reserve	World Heritage Site
Baikal	✓	✓		✓
Bhoj Wetland		✓		
Baringo	✓	✓		
Biwa	✓	✓		
Champlain	✓		✓	
Chad		✓		
Chilika Lagoon	✓	✓		
Cocibolca/Nicaragua		✓		
Constance		✓		
Great Lakes (North American)			✓	
Issyk-Kul	✓	✓	✓	
Laguna de Bay	✓			
Malawi/Nyasa	✓		✓	
Naivasha		✓		
Nakuru	✓	✓		
Ohrid		✓		✓
Peipsi/Chudskoe		✓		
Sevan	✓	✓		
Tanganyika		✓		
Titicaca		✓		
Toba	✓			
Tonle Sap		✓	✓	
Xingkai/Khanka	✓	✓		

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.

The Laguna de Bay Brief is the only brief to describe the calculation of TEV. The TEV analysis was carried out to estimate changes in values due to a proposed pollution control project, the USAID-assisted Environmental and Natural Resources Accounting Project. Although the analysis considered a wide range of use and non-use values, it only costed four use values. The benefits of the proposed project were estimated to be about:

- $125,000 per year for fisheries (based on changes in fish catch and market prices for fish);
- $1.25 million per year for irrigation;
- $9,000 per year for domestic water supply; and,
- $90,000 per year for tourism.

Typical Problems Facing the World's Lakes

The proximate causes of lake 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. Thus, farmers who settle in the catchment above a lake can cause problems for lake fishermen through excess sediment reaching the lake because of erosion or agro-chemical residues (for example, from fertilizers, pesticides or herbicides) carried through runoff into the lake. Downstream users also 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. Such externalities (where one group receives the benefits and another group bears the costs) are particularly important for lakes.

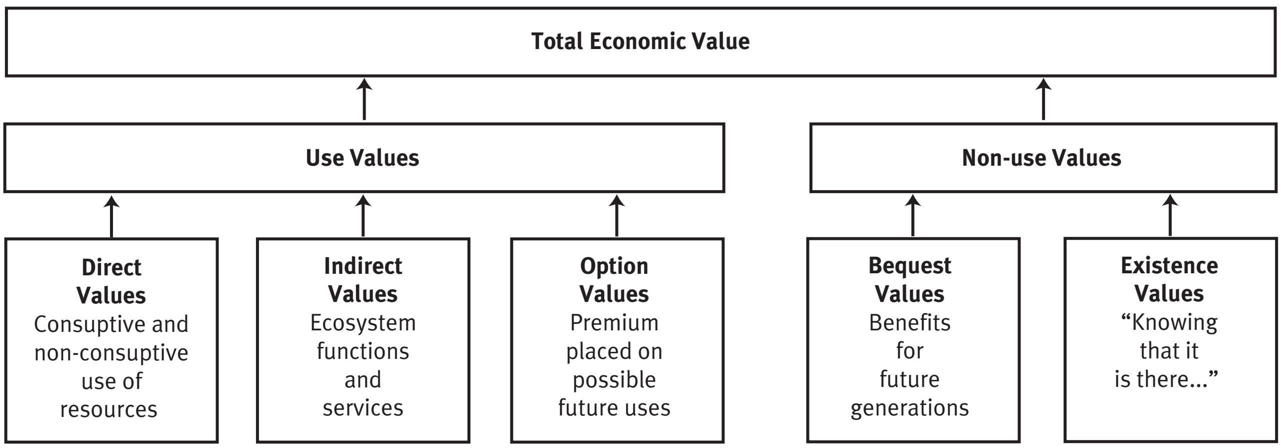

Figure 3.1 Total Economic Value

Box 3.3 Socioeconomic Valuation in Lake Sevan, Armenia

Lake Sevan and its basin provide numerous goods and services to Armenia. In the Lake Sevan brief, the discussion of socioeconomic values can easily be arranged into different categories used in the TEV approach. The main focus in the brief is on direct use values, although other types of values are mentioned. Based on the information presented in the brief 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.

Only part of this wide range of goods and services are captured in market prices. The direct-use values (both consumptive and non-consumptive) can be calculated fairly readily. While the indirect use and non-use values are more difficult to estimate, the cultural/historical values at this lake are considered so important that an investment project to help stabilize and restore the lake level is being reevaluated incorporating some of these values. These non-use values themselves may be sufficient to change the investment decision, even if all the other use values are not included.

Problems with lakes have been documented in the *Survey of the State of the World's Lakes*, compiled in the late 1980s and early 1990s by ILEC and UNEP (http://www.ilec.or.jp/database/database.html). 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. More detailed information on lake problems can be found in the National Research Council (1992), United Nations Environment Programme (1994), Dinar and others (1995), Ayres and others (1996), Nakamura (1997), Duker (2001), Jorgensen and others (2003), Davis and Hirji (2003), and the World Lake Vision (2003).

The occurrence and management of lake problems is influenced by the three defining characteristics of lakes—their integrating nature, long retention time, and complex response dynamics. The integrating nature of lakes means that problems can seldom be localized within lakes. 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 much of the lake.

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, alterations to the lower levels of the lake's food chain (caused by sediments in the water, which change the light regime) may not be immediately apparent to the users of the lake.

The complexity of lake dynamics also influences the way in which problems become apparent. 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. The high productivity of the lake means that the bottom waters of the lake are now seriously depleted in oxygen for extensive periods. Given the lake's mean depth of 40 meters, this implies that a significant volume of the lake is now unsuitable as habitat for commercial and noncommercial fish species for part of the year. It is known, from experience in other lakes, that it is very difficult to shift such a lake back to its previous state.

The types of problems and opportunities in reservoirs (and, to some extent lakes that are operated like reservoirs) can differ from those that arise with lake basin management. For example, during the construction phase, reservoirs offer an opportunity for exploiting new ecological niches. Thus, the Kariba Reservoir was stocked with a pelagic fish species from Lake Tanganyika that has become the basis for a deepwater commercial fishing industry; a cichlid species for artisanal fishing; and a tiger fish for a highly popular sport fishing industry. However, reservoir construction can also lead to the displacement of local people, sometimes without adequate compensation. This is described in the both the Kariba and Tucurui Reservoir briefs. Reservoirs are constructed for particular purposes—irrigation water supply, hydropower, town water supply, etc.—and these purposes dominate their operations. Consequently, their levels can rise and fall dramatically in response to water demands, although there are a number of examples in the lake briefs—Lakes Naivasha, Baringo, Victoria, Chad, Toba and Sevan—where lake levels also rise and fall in response to climate variability and water demands. On the other hand, this same dominant purpose also means that reservoirs often have access to high value uses that make them a potential source of local, national or regional income for reservoir basin management.

Lake and reservoir problems in the present study are here grouped into 20 categories based on the frequency with which they are mentioned in the lake briefs (Table 3.2). While the briefs do not comprehensively describe all problems in the study lake basins, it is reasonable to assume that they do include the major problems. In the table, the problems are identified by their biophysical origins. For example, excess nutrients are listed as a problem rather than eutrophication, which is a consequence of excess nutrients. Loss of biodiversity is also not included explicitly since it arises from other primary problems such as loss of habitat (Lake Dianchi), introduced species (Lakes Ohrid and Victoria), or overfishing (Lake Malawi/Nyasa).

The problems have been grouped into their regions of origin: within the lake basin; around the lake's littoral zone; from the lake basin; or from a wider region outside the lake basin, including global threats. While there is inevitably some repetition of problems between regions, this grouping provides some guidance on the focus of management if the issue is to be tackled at its source.

In-Lake Problems

Unsustainable fishing practices. Fish are one of the most commonly exploited resources from lakes. But overfishing or use of destructive fishing practices can lead to the decline of these important resources for a short-term gain but a long-term cost.

Introduced faunal species. Alien fish and invertebrate species have been introduced to many lakes, sometimes with severe consequences for native species. These introductions can be either deliberate or accidental. They can alter physical habitat, can compete for food resources, or can predate on native species. In extreme cases, they can lead to a loss of aquatic biodiversity. However, some introductions, such as bream and whitefish at Issyk-Kul and Nile perch in Lake Victoria, have provided commercial and nutritional benefits to local populations.

Weed infestations. Excess growth of aquatic plants can cause problems in lakes by altering the habitats of native fauna, interfering with water transport, harboring nuisance species such as flies, blocking water intakes, impeding water flows, and even increasing evapotranspiration from the lake surface. Often these plants are exogenous to the lake and their dominance is promoted by increased nutrient levels.

Changes in salinity. Lake ecosystems become adapted to particular salinity levels. When these levels are significantly altered, either increased or decreased, these ecosystems can be disrupted with consequent disruption for communities dependent on them.

Nutrients from fish cages. Nutrients can also enter lakes from the excreta of caged fish and from excess food. In lakes where there are high densities of fish cages, these nutrients can promote eutrophication and aquatic weeds. This problem is particularly common in Asian lakes.

Littoral Zone Problems

Shoreline effluent and stormwater discharges. Untreated or poorly treated effluent from lakeshore communities can contaminate lakes. Bacteria and other pathogens can threaten human health, BOD can reduce oxygen concentrations, and nutrients can increase the eutrophication of the lake. In addition, urban stormwater runoff is commonly contaminated with effluent and other urban contaminants (oils, organic matter, heavy metals), which add to the pollution load.

Shoreline industrial contaminants. Direct discharge to a lake is a convenient method for disposing of industrial wastes from shoreline industries. However, it adds toxic chemicals, BOD, and effluent to lakes and, in some cases, can change physical lake characteristics such as temperature and turbidity. These contaminants can also reach shallow groundwater systems and be transported to the lake through subsurface pathways.

Shoreline water extraction. Where there are high population densities or extensive irrigation enterprises, water extraction can affect the levels of a lake. Even when water is extracted from groundwater systems, these are often connected to the lake aquifer.

Loss of wetlands and littoral habitat. Fringing wetlands and the littoral zones are closely connected to the ecological health of a lake. They provide refuges and sites for breeding. They can also be involved in the exchange of nutrients with the lake and can act as filters, trapping incoming sediments and pollutants. Development around the littoral zone of a lake often results in the destruction or degradation of these important adjuncts. For example, the extensive wetlands around Lake Victoria are being destroyed or degraded through conversion to cultivation for crops, excavation for sand and clay, and use as disposal sites. It is estimated that about 75 percent of the lake's wetland area has been significantly affected by human activity, and about 13 percent is severely degraded.

Lake Basin Problems

Excess sediment inputs. This threat can originate from land use clearance, and from poor land use and riparian management in lake basins. In extreme cases, these sediments can infill a lake (although a reservoir can be designed to flush sediments downstream); in less extreme cases, they can destroy wetlands, reduce the penetration of light into the water column, and act as a carrier of nutrients and other pollutants.

Excess nonpoint-source nutrient inputs. These nutrients most commonly originate from soil erosion, but in many places come in significant amounts from fertilizer use and animal effluents within the basin. They contribute to overall increases in nutrient levels in lakes, which are associated with algal outbreaks and growth of aquatic weeds. This can result in reduced oxygen levels and associated fish kills.

Agro-chemical pollution. These chemicals can come from rural land uses, including agriculture and forestry. They can affect aquatic food chains and render fish unsuitable for human consumption. Some long-lived agro-chemicals can persist in lake sediments for long periods.

Excessive water withdrawals or diversions. This threat commonly occurs as development intensifies upstream of the lake with concomitant demands on water resources. Even if the total quantity of water inflowing into a lake is not significantly changed, the change in timing of inflows to a lake, from, for example, a run-of-river hydropower scheme, can affect ecological processes in the lake. In some cases, these water demands can come from downstream of the lake for hydropower production, urban water use, or irrigation.

Changes in runoff patterns. The hydrology of inflowing rivers can also be altered by changes in land use in the river basin, particularly clearance of forests and drainage of wetlands.

Effluent and stormwater pollution. Untreated or poorly treated effluent and stormwater can contaminate rivers and lakes. Bacteria and other pathogens can threaten human health, BOD can reduce oxygen concentrations, and nutrients can increase the eutrophication of the lake. Urban stormwater runoff commonly contains contaminants such as oils, organic matter, and heavy metals. Biogeochemical and physical processes intercept significant fractions of these contaminants before they reach lakes—a valuable ecosystem service provided by rivers and wetlands.

Industrial pollution. Direct discharge to a lake is a convenient method for disposing of industrial wastes from shoreline industries. However, it adds toxic chemicals, BOD, and effluent to lakes and, in some cases, can change physical lake characteristics such as temperature and turbidity.

Regional/Global Problems

Long-range transport of airborne nutrients. Nutrients can be transported through the atmosphere to lakes from sources outside their drainage basins. Although nitrogen has long been known to be transported via this pathway, there is now evidence that, in some circumstances, phosphorus can also be transported this way.

Long-range transport of airborne industrial contaminants. Industrial pollutants, including acid rain from industrial and transportation sources and volatilized chemicals, are now known to be transported long distances through the atmosphere. They can be deposited into lakes or lake basins through either dry or wet (i.e. rainfall) deposition.

Climate change. Climate change or global warming is predicted to cause changes in precipitation and runoff, changes in the thermodynamic balance of lakes, and changes in the ecological balance of lakes.

Not all problems in a given lake are of equal importance. For example, the Lake Sevan brief makes it clear that the abstraction of water for hydropower and irrigation is the most important issue, even though five others are mentioned. A number of briefs describe potential problems that, if they occur, would seriously threaten a lake's viability. For example, Lake Tanganyika may be showing some early signs of warming from climate change. These potential problems are only included in the table if there is sufficient evidence to make them credible.

Most problems are not isolated to specific regions, but are distributed around the world, with most lakes facing multiple threats. About half of the identified problems originated in the lake basins, illustrating the importance of managing the lake basin as a whole. Even when problems originate at localized sites within a lake or a lake basin, the integrating nature of lakes means that these problems often eventually extend to other parts of the lake.

Assessing whether, at the time the lake briefs were written, lake basin problems were improving or not required considerable judgment, since the briefs were often not explicit about changes in environmental status. In some cases, there was conflicting evidence—for example, Lake Biwa shows some improvements in the concentrations of phosphorus and biodegradable organic compounds (BOD), but it also shows some degradation or inconsistent changes in the concentrations of nitrogen and non-biodegradable organic compounds—and some improvements were likely to be of only short duration. In spite of these limitations, the arrows in Table 3.2 provide a snapshot of the current direction of change in the status of the problems in the study lakes.

Overall, the table shows that most problems affecting lakes are not improving. In a few cases there has been substantial improvement in some lake problems, although there are no lakes in this study where all problems showed improvement. Lakes Ohrid and Peipsi/Chudskoe provide examples of effective measures being taken for cooperative management of transboundary lakes. Chilika Lagoon and Lake Dianchi and Laguna de Bay show the greatest signs of improvement in the developing countries. Chilika Lagoon has experienced a major improvement in its major problem—reduced salinity—although the discharge of pollutants from the upstream basin is still to be tackled successfully. Lake Dianchi has successfully introduced reductions in factory-level nutrient discharges (although there has been a large increase in the number of polluting enterprises) and has controlled nutrient losses from fish cages. Even so, much remains to be done in reducing total nutrient loads and retaining and restoring shoreline habitat. Laguna de Bay has made progress in controlling BOD discharges and some in-lake problems, but problems with introduced species, nutrients from fish cages, and nonpoint-source pollution remain. Thus, even in lake basins where some problems have been managed, other problems remain.

The major problems included introduced fauna and flora (16 out of 28 lakes) and unsustainable fishing practices. Discharge of untreated or poorly treated effluent from shoreline communities is a very common littoral zone issue, while loss or damage to wetlands and shoreline vegetation occurred in lakes in both developed and developing countries. High sediment loads were the most common basin problem, affecting 21 out of the 28 lakes. This problem is difficult to control, even in developed countries, because the sediments normally originate from nonpoint sources over large areas and are only transported during rainfall events. Thus, nonpoint-source sediment loads are identified as the major threat to Lake Tanganyika, one of the world's largest and most biodiverse lakes. The sediments originate from large-scale deforestation and poor farming practices that have caused a dramatic increase in soil erosion rates.

Global problems are not seen as affecting the study lakes as much as in-lake, littoral, and lake basin problems. Of these, climate change was identified as affecting seven lakes, although the evidence for this problem is still limited.

Emerging Problems

Groundwater Flows

Although the link between river inflows and outflows and lake levels is easily recognized, the relationship between lake levels and groundwater is less obvious. The briefs provide a number of examples where the functioning of lakes and the delivery of services to humans is dependent on either inflows or outflows of groundwater. For example, Lakes Baringo, Chad, and Naivasha all remain fresh and useable for humans (even though they have no surface outlet) because of substantial groundwater drainage that removes both water and salt. A water balance model developed for Lake Naivasha indicates that about 25 percent of the lake's river inflow exits via groundwater pathways (the remainder is accounted for by evaporation and direct pumping for irrigation).

The extent to which groundwater inflows contribute to lake water levels is less well known. However, Lake Ohrid provides one graphic example. A little over 50 percent of the inflows to the lake come from subterranean water delivered through limestone channels that link Lake Ohrid to the Prespa Lakes sitting 150 m higher in the catchment. High nutrient loads as well as water are delivered through these channels.

Table 3.2 Summary of Problems Affecting the 28 Study Lake Basins as Described in the Briefs[1].

Lake Basin	In-lake					Littoral				Basin origin							Regional/ Global		
	Unsustainable fishing practices	Introduced faunal species	Salinity changes	Weed infestations	Nutrients from fish cages	Shoreline effluent discharges	Shoreline industrial discharges	Shoreline water extraction	Loss of wetlands	Excess sediment inputs	Non-point source nutrients	Agro-chemicals	Water abstraction	Changes in run-off	Effluent and stormwater	Industrial pollution	Atmospheric nutrients	Atmospheric industrial contaminants	Climate change
Aral Sea			→						→				→						
Baikal						↓	→			↓								→	
Baringo	→									↓			↓	↓					↓
Bhoj Wetland				→		→	↓			→	→	→			→				
Biwa									↓		→	→	↑ [2]		↑				↓
Chad									↓	↓			↓						↓
Champlain						↑					↑				↑			→	
Chilika Lagoon			↑	↑						↓	↓	↓	↓		↓				
Cocibolca/Nicaragua						↓				↓		↓			↓				
Constance		↓				↓			→		→	→			→				
Dianchi					↑	→	→		↓	↓ [3]	↓ [3]	↓ [3]	↓		↓			→	
Great Lakes (N. American)		↓				↑	↑				↓	↓			↑	→		→	
Issyk-Kul		→								↓	↓	↓				↓ [4]			↓
Kariba Reservoir					↓	→					↓								↓
Laguna de Bay	→	↓	→	→	↓	→	→			↓	↓				↓	→			
Malawi/Nyasa	↓ [5]			↓						↓	↓	↓		↓	↓		↓		↓
Naivasha	↑	→		↑		↓		→	→	↓							↓		
Nakuru										→	→		↓	↓	↓				
Ohrid	→	↓				→	↓		↓	↓	↓	↓			↓				
Peipsi/Chudskoe	↓			→		→					→ [6]				↓	→ [6]			
Sevan	↓	↓				↓			↓	↓			↓						
Tanganyika	↓ [5]					↓	↓			↓					↓				↓
Titicaca		↓				→	↓			↓					↓	↓			
Toba	↓	↓		↓	↓	→			↓	→	→	↓	↓	→	↓		↓		
Tonle Sap	↓	↓								↑ [7]					↓				
Tucurui Reservoir				→						→									
Victoria	→	↓ [8]		↑		↓	↓		↓	↓	↓				↓	↓ [4]	↓		
Xingkai/Khanka	↓					→	→		↓	↓		↓			↓	↓ [9]			
Total Occurrences	12	11	3	9	4	18	10	1	11	21	16	12	9	4	19	7	4	4	7

Legend A ↓ symbol means that the problem is not improving significantly; a → symbol means that it has improved somewhat; and a ↑ symbol means that there has been significant improvement.

1 The lake briefs are not exhaustive in their description of problems; a blank cell in the table does not mean that the lake does not experience the problem. In many lake briefs, there is only limited information on the extent of improvement of a problem; the direction of change shown in the table is based on this information.

2 Most water abstraction for Kyoto/Osaka/Kobe is downstream of Lake Biwa.

3 Despite considerable investment, nutrient and chemical concentrations in Lake Dianchi have yet to show improvements. There is some evidence that COD is improving.

4 Mining in the basin is the source of toxic chemicals reaching the lake.

5 Includes loss of fish biodiversity through overharvesting for aquarium trade.

6 Improvements in the nutrient and pollutant status of the lake are the result of a decline in use of nutrients in agriculture and industrial production following the collapse of the Soviet Union rather than from a deliberate policy intervention.

7 There is a large amount of sediment deposited around Tonle Sap each year, but this is regarded as an essential service rather than as a problem.

8 Introduced species, particularly Nile perch and Nile tilapia, have contributed to the loss of many native species as well as providing a valuable source of income for the regional community. Here they have been assessed for their effect on the lake's biodiversity.

9 High copper (Cu) concentrations are recorded in Lake Xingkai/Khanka, but the origins are unknown.

These connections between lakes and groundwater systems are not always appreciated. People pump groundwater in the belief that it is separate from the lake water. Box 8.2 provides an example from Lake Naivasha where this connection was only apparent to irrigators after extensive scientific modeling. For lakes with significant connections to groundwater systems, the subsurface basin as well as the surface drainage basin needs to be managed as an integral part of lake management. Many managers do not yet fully understand the link between groundwater and lakes. This is likely to be an issue of increasing importance with the expanding use of groundwater for municipal, industrial, and agricultural purposes in many lake basins.

Atmospheric Nutrient Pathways

Surface runoff has conventionally been regarded as the mechanism by which nutrients enter lakes. Nutrients, primarily nitrogen and phosphorus, originate from three major sources: urban effluent discharges, urban runoff during storms, and nonpoint sources, mostly agricultural activities. In the North American Great Lakes, there has been a significant effort to reduce the nutrient loads from sewage, to the point where nonpoint catchment sources are now the major contributors to the lakes.

However, atmospheric transport of nutrients can be a significant factor where the surface area of the lake is a significant fraction of the basin area, and where there are mechanisms for injecting nutrients into the atmosphere. Four lakes in this study have small lake surface:basin surface ratios—the North American Great Lakes (1:3.1), Lake Toba (1:2.3), Lake Sevan (1:3.0, after major diversion) and Lake Victoria (1:2.8). Preliminary measurements at Lake Victoria indicate that over 65 percent of the phosphorus load and 50 percent of the nitrogen load entering the lake are transported through the atmosphere. Atmospheric nutrient deposition rates in the African Great Lakes region in general are greater than in many other parts of the world. These nutrients are believed to originate from the extensive burning of grasslands and from dust derived from poor land management practices. A GEF-funded study will quantify the loads reaching the lake via this pathway and help identify the sources. If the importance of the atmospheric pathway is confirmed, then this finding has considerable significance for the management of the lake. The lake briefs for the other lakes with small surface ratios do not describe whether atmospheric deposition is believed to be a significant source of nutrients or not, although both Lakes Malawi/Nyasa and Naivasha briefs report evidence of atmospheric phosphorus deposition.

Climate Change

There is, as yet, only limited evidence of the impact of climate change on lake basins. The lake briefs record different ways in which climate change is believed to be affecting lakes: lake water temperatures have risen since the 1960s at Lake Tanganyika and since 1939 at Lake Malawi/Nyasa; the volume of glaciers feeding Issyk-Kul has been reduced; inflows have decreased in the last 20 years at the Kariba Reservoir and Lake Chad (although that is partly due to upstream abstractions); inflows to Lake Baringo from snowmelt on Mt. Kenya have decreased; and the volume of cold, oxygenated snowmelt has decreased at Lake Biwa, leading to an increase in deoxygenated bottom waters.

The Intergovernmental Panel on Climate Change (IPCC) forecasts significant changes in precipitation, evaporation, and temperature as a result of global warming. These changes are likely to affect many of the world's lakes (IPCC 2001). The effects are likely to be complex. First-order effects could include either increases or decreases in the volume of water entering lakes, changes in the seasonality of these inflows, increased temperatures of lakes, and increased evaporation from lake surfaces. There are also likely to be significant second-order effects, such as changes in lake stratification affecting biological and chemical process, changes in aquatic vegetation, changes in land uses within lake basins, and an increase or decrease in the demand for water in lake basins as a result of the migration of people.

Although the above changes have yet to have major impacts on human uses of lakes, changes of the magnitude expected from climate change will have very significant impacts. Some idea of the size of these effects can be gained from the effect of climate variability on the water balance of Lake Malawi/Nyasa. This water balance is dominated by direct atmospheric exchange; only a relatively small river, the Shire River, drains the lake. Malawi depends on electricity generated from hydropower plants on the river. Between 1915 and 1935, the outlet from the lake to the Shire River was completely closed, with no outflow. More recently, as a result of low lake levels in 1997, electrical power was being rationed at the end of the dry season in October and November. A long term loss of connection between the lake and the river due to climate change would clearly have very severe environmental, economic, and social impacts.

Shrinking Lake Size

Because they are effective sediment traps, lakes fill in and become wetlands over time periods ranging from decades to millennia. However, for a number of lakes in this study, this natural process has been accelerated by human activities. The causes vary. The Aral Sea and Lakes Chad and Baringo are shrinking (at least partly) because of excessive water withdrawal for upstream irrigation. In the case of Lake Sevan, it was because of augmentation of the river outlet for downstream hydropower and irrigation. At Lake Naivasha, the water has been extracted from the lake, both directly and from the closely connected aquifer. Climate change, leading to reduced inflows from upstream glaciers, is believed to be leading to a drop in lake levels at Issyk-Kul; climate change in Central Africa may have played a role in the reduction in size of Lake Chad. The dramatic decrease in the depth of Lake Baringo has been exacerbated by large loads of sediments coming from overgrazing near the lake; the Bhoj Wetland is also known to have infilled because of sediments contaminated with urban wastes.

Lake shrinkage has economic, social, and ecological effects. The dramatic shrinkage of Lake Chad has led to a reduction in fish catches, forced migration of populations leading to territorial disputes, and the loss of fish species and resting areas for migratory birds. Lakes are likely to continue to shrink until the demands that people place on them are related to the lakes' capacities based on an understanding of their long-term water balance.

Globalization

Globalization describes the trend toward an increased flow of goods, services, money, and ideas across national borders and the consequent integration of the global economy. There are a number of examples in the lake briefs where globalization is already affecting the resources and economies of lake basins. The rapid expansion of flower growing at Lake Naivasha is driven by the demand from Europe for cut flowers; the commercial fishery at Lake Victoria is dependent on the worldwide demand for Nile perch; and industrialization around Laguna de Bay satisfies a global market for manufactured goods. Globalization also helps the development of these regions by transferring technologies, standards, and capital to developing countries. Thus, European Union (EU) standards for pesticide residues in agricultural goods have led to controls on chemical use at Lake Naivasha and have led to improvements in the hygiene of fish landing sites at Lake Victoria.

The decline of centrally-planned economies and the spread of market economies are also affecting lakes and their basins. There has been a reduction in pollution entering Lakes Xinghai/Khanka and Baikal because factories have had to close, and phosphorus loads have been reduced at Lake Peipsi/Chudskoe because of the removal of fertilizer subsidies to agriculture in the Russian Federation. On the other hand, there is increasing pressure to open up the shoreline of Lake Baikal to private ownership in conjunction with the shift toward a market economy in the Russian Federation.

Environmental Flows

At the time the large reservoirs included in this study (the Kariba and Tucurui Reservoirs) were constructed, the provision of flows for downstream environments was not recognized as an important issue. However, the need to provide for the timing and size of flows to maintain downstream ecosystems when dams and barrages are constructed is now becoming increasingly recognized by a variety of parties.

Developments other than dams can also lead to changes in flows with consequences for downstream water users, but these have yet to receive the same level of recognition. The Aral Sea, Lake Chad, and Lake Baringo briefs provide examples where upstream irrigation developments have had serious impacts on downstream lakes. But other developments in the lake basin, such as deforestation, urban growth, and

Box 3.4 Common-Pool Resources, Common Property, and the Commons

The table below shows the characteristics of common-pool and other types of resources along the axes of 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; for example, 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; that is, one person's enjoyment of the climate-moderating or aesthetic benefits of a lake does not diminish another person's enjoyment. Excludability refers to the cost of controlling someone's access to a resource. Non-excludable goods have a positive cost for restricting access; that is, it is difficult to prevent people from accessing them.

	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; examples include fish, water for extraction, and the use of the lake as a sink for pollutants. Some uses like flood control are public goods. There are few private and club goods since, for almost all uses, it is difficult to exclude users, except in the case of private lakes or private ownership of certain parts of a lake, such as lakeshore property.

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 a case of a riparian group (the 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 term "commons" is often used as shorthand for either common-pool resources or for common property, often leading to confusion about what is being discussed—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. 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.

water transfer canals, can also change flows into lakes and reservoirs.

As a first step toward ensuring environmental flows, the environmental water needs of lakes and reservoirs and the services they provide to humans need to be accepted by a broad spectrum of stakeholders. National policies and laws need to recognize the importance of providing for these flows and procedures need to be drawn up for establishing and enforcing flow requirements. This process will place great demands on science: ecosystem requirements for water, as well as knowledge of the socioeconomic impacts of different flow regimes on water users will need to be assessed in each case. At this stage, few countries have undertaken the studies needed for establishing these environmental flows.

Proposals for loans from the World Bank are subject to stringent assessments on their potential environmental and social impacts, including their likely effects on river flows and the human and ecological uses dependent on those flows. India, the recipient of a World Bank loan for the Orissa Water Resource Consolidation Project, is in the process of establishing flow requirements that will be built into the operating rules for the Naraj Barrage to protect Chilika Lagoon. As part of the GEF-supported Water Utilization Program, the Mekong River Commission is preparing to carry out an environmental flow assessment that will guide future regulation and development of the Mekong River's water resources and the protection of the Tonle Sap. As more countries invest in water resources infrastructure such as dams, barrages, and canals, there will be an increasing need to assess the water requirements of lakes to ensure that they continue to provide resources for human use. It is important to design new infrastructure for environmental flows—multi-level outlets may be needed and the outlet sizes have to be capable of delivering the necessary volumes of water.

Response to the Problems: Management Interventions

Managers of lake basin resources can both prevent potential problems and overcome existing problems through either structural measures (such as construction of a water intake structure or sewerage system) or nonstructural measures (such as introduction of new fishing technology or a new regulatory provision for the control of effluent discharge).

The characteristics of lakes have an influence on the management of lake basin problems. The integrating nature of lakes, and the consequent difficulty of excluding users from accessing many of the lake's resources, has many management implications. Common-pool resources (Box 3.4), such as fish, can be overexploited 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 overharvesting, 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. Unlike common-pool resources, these rules are needed to protect the quality of the good rather than to allocate the goods among competing users. For example, prohibitions may need to be introduced on dumping rubbish to protect the visual amenity of the lake, or rules may be needed to ensure that all beneficiaries from flood protection contribute toward the costs.

The integrating nature of water also means that management needs to be coordinated across the different sectors that use the basin's resources. This does not necessarily mean that a single basin management authority needs to be established. Sometimes it is more efficient to establish mechanisms for the sectoral agencies to work together in a coordinated manner for the common good of the lake basin.

The long retention time of lakes—particularly for larger and deeper lakes—means that their management should be anticipatory, committed, and well-planned over the long term. At the same time, it should be flexible enough to adapt to changing values and new knowledge. In fact, the long time-scales involved in lake basin management argue for the existence of institutions in order to give permanence to management beyond the shorter time-scales of individuals. One other implication is the need for secure financing to make sure that structural and nonstructural interventions are effective over the long term.

The complex response dynamics of lakes argues for application of the best available scientific knowledge and, if necessary, the conduct of applied research programs to obtain additional knowledge for management. It is important to emphasize that research into these biophysical processes should be focused on the critical needs for management.

The Components of Lake Basin Management

From the preceding discussion, it is apparent that, given the characteristics of lakes and their basins, there are a number of inter-related components to managing a lake basin so that its resources are accessed equitably and efficiently. These components are described in Box 3.5.

These six components of lake basin management form the structure for Section II of this report, where the case studies and other material collected during this project provide lessons drawn from the practical experience of lake basin management.

Box 3.5 Components of Lake Basin Management

Good lake basin management requires the following six components to be well-integrated:

Institutions to manage the lake and its basin for the benefit of all lake basin resource users. They are sanctioned by society to give them the necessary authority and longevity to operate effectively. They can operate at the local level (such as local councils), at the regional level (such as a lake basin authority), at the national level (such as sectoral government departments), or at the international level (such as international commissions for transboundary lakes). Institutions require leadership from committed and visionary individuals, as shown in some of the case studies.

Policies to govern people's use of lake resources and their impacts on lakes. At the national level, they can be encoded in formal laws, statutes, and regulations and implemented by formal institutions. They can also be informal, often being developed and accepted among traditional groups of people living in the lake basin and at the lake. At the local level, policies are implemented through rules of behavior, incentives and disincentives, and education to change people's behaviors.

Involvement of people is central to lake basin management. They decide the uses for, and values to be obtained from, the lake's resources; they provide knowledge and experience for management; 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. They can demand accountability for the decisions made and resources used in managing lake basins.

Technology is not always essential for management. However, investments in technical responses can sometimes 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, while sewage treatment plants can be very effective at removing contaminants from point sources of pollution.

Information, both traditional knowledge and scientifically acquired knowledge, promotes efficient management. The more that reliable and demonstrable knowledge is identified and used in management, the more likely it is that the goals of those groups using a lake's resources will be met efficiently. 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.

Finance is necessary to fund the operations of management institutions and the implementation of technological solutions, the involvement of stakeholder groups, and the collection and application of monitoring information. However, access to finance is often the weakest point of lake basin management in developing countries.

Section II

Meeting the Governance Challenge

This section presents the lessons learned from the 28 lakes basins regarding institutions (Chapter 4), policies (Chapter 5), involvement of people (Chapter 6), technology (Chapter 7), information (Chapter 8), and financing (Chapter 9). While each chapter in Section II can be read as a stand-alone description of one component of lake basin management, the case studies show that sustainable lake basin management requires all components to be implemented together.

Chapter 4

Institutions for Lake Basin Management:

Developing Organizations for Action

Key Lessons Learned about Institutions

- Development of strong institutional links promoting effective participation, and development of strong local government capacity are among the important institutional considerations for lake basin management. Successful lake basin institutions develop good pathways to communities dependent on lake basin resources.
- Lake basin management institutions are most effective when they build on existing structures at local government, sectoral, and community levels. Existing sectoral institutional arrangements may be improved and facilitated through coordinating mechanisms without establishing a new lake basin management organization.
- Links to other institutions, particularly sectoral agencies, are vital to success. Formal links can be costly to develop and maintain and should be supplemented by informal links.
- Decentralization can help improve lake basin management if there is adequate administrative and technical capacity. It can place greater stresses on management capacity, however, particularly if they are distant from government centers.
- NGOs and CBOs often play critical catalytic roles in facilitating institutional linkages, particularly with regard to enhancement of community participation in collaboration with the government.
- The success of transboundary lake basin management depends on the member states' political will, commitment, and fulfillment of obligations, rather than the particular form of institution or its legal status. Nonriparian basin countries of a lake that may be reluctant to join a formal lake basin management authority may be successfully engaged through informal mechanisms.
- Transboundary collaboration without a plan can be successful, but it is likely to be more successful when guided by an agreed plan of action. GEF-IW projects promote such plans by requiring countries to produce a Transboundary Diagnostic Analysis followed by a Strategic Action Program.
- Lake basin management institutions need time to become effective. They also need to adapt to emerging problems and the development needs of the lake basin communities.

Introduction

Institutions are at the core of lake basin management. They administer the laws (and sometimes establish the policies and rules and incentives) for management of the resources (Chapter 5); they provide a forum for involving those affected by lake basin management, and for resolving conflicts (Chapter 6); they collect and store knowledge for action (Chapter 8); and they are sustained by finances (Chapter 9) obtained from local, national, and international sources.

Institutions for Lake Basin Management

Types of Institutions

Institutions include traditional organizations, such as village committees or fisheries groups; nongovernmental organizations; private sector organizations, such as industry associations; as well as formal, government-sanctioned organizations such as departments of fisheries and environmental protection agencies. This chapter will concentrate on the role of formal organizations and the lessons that have been learned from the case studies about their effectiveness.

Formal lake basin management institutions can have different functions:

- Resource development—to exploit the resources offered by a lake such as fisheries organizations and irrigation groups. This includes tasks such as allocating lake basin resources like water or fish licenses;
- Service delivery—to promote development in a lake basin by providing basic, underlying services such as water supply, sewage collection and disposal, and transportation links;

- Regulation—to ensure that the lake's resources are shared equitably or protected from externalities. They are usually sectoral and can be formed specifically for a lake—such as the Lake Victoria Fisheries Organization—or be national regulatory organizations (such as the Kenyan National Environmental Management Authority) with responsibility for regulating pollution control in all waterbodies, including lake basin resources. The rules that these organizations enforce are described in Chapter 5;

- Advisory—to recommend courses of action to governments at a variety of levels; and,

- Coordination—to promote coherent action across the diverse sectors and jurisdictions involved in lake basin management. They have a special role with transboundary lake basins, where there is no overarching authority, and they need to coordinate across nations as well as across sectors.

Table 4.1 provides a summary of the major institutions partly or wholly involved in the management of a lake and its basin for the 28 cases in this study, including some proposed transboundary coordinating institutions. The table does not include the service delivery (such as local government agencies) and resource development agencies (such as departments of agriculture) responsible for each lake basin; the former because of their ubiquity and the latter because they are usually national or transnational institutions whose focus is not solely on the lake's resources.

Judicial institutions are not normally directly involved in lake basin management. However, India provides an example where the courts have taken an active interest in the interpretation and enforcement of the law (Box 4.1).

Coordination between Institutions

One of the strongest messages to emerge from the lake briefs is the need for coordinated action between sectors and levels of governance (including between countries for transboundary lake basins). This applies to national policy, institutions and representative sectoral groups, including the coordination of the actions of upstream, downstream and lake user groups.

However, the lake briefs show that there is poor coordination between institutions at many of the lakes. The Lake Sevan brief provides a good example of the reasons: "Many institutions are engaged in different aspects of Lake Sevan management: elected and appointed administrative authorities, scientific research institutes, conservancy organizations, consumers, etc. Among them, Sevan National Park, under the Government of the Republic of Armenia and direct governance of the Ministry of Nature Protection, should take a leading role with overall responsibility for coordination of Lake Sevan management. Regrettably, this is far from the present reality for the following reasons: absence of legal grounds; weak human resources; weak material resources; poor scientific and technical equipment; lack of support of local inhabitants; and lack of self-dependence in operational decisionmaking."

Typically, either the water resources or the environment institutions are expected to take the lead in coordination because other institutions are focused on specific resource development and management responsibilities. However, water resources and environment institutions are weak institutions in many countries, particularly when the lake or reservoir basin possess important national economic values, such as water for hydropower and irrigation as in the case of Lake Sevan. This dominance of sectoral development institutions at the expense of those with potential coordinating responsibilities is one reason for the "absence of legal grounds" above in the case of Lake Sevan. This sectoral dominance is most pronounced in the case of reservoirs which are usually developed specifically for a high-value resource use. Unless there is a direct threat to the generation of hydropower, the supply of water for irrigation or urban/industrial use or for flood control, there is little likelihood that the coordinating activities of an environmental or water resource institution will be given priority.

A confounding problem is that the water resources and environment management institutions often do not understand the complementary nature of their responsibilities and do not work together. Unless environment concerns in the lake basin are properly managed, the value of the lake basin's water resources will decline. This is apparent at many lake basins in this study:

- At Lake Victoria, increasing nutrient loads have led to eutrophication of the lake;

Box 4.1 Public Interest Litigation in India

A major development in controlling the continuing degradation of lakes in India has been the involvement of the judiciary, sometimes at the highest level of 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.

Source: Reddy, M.S. and N.V.V. Char, Management of Lakes in India, Thematic Paper, Lake Basin Management Initiative.

- At Lakes Malawi/Nyasa and Tanganyika, soil erosion is causing loss of fish breeding habitat in the lake's littoral zone; and,

- At Lakes Ohrid and Victoria, limited controls over pollution from mining is leading to localized zones of heavy metal concentration in the lakes with the potential for entering the foodchain.

It often takes a crisis for environment and water resources institutions (and sometimes resource development institutions) to realize that they need to work together to ensure that lake basin resources are utilized sustainably. At Lake Biwa, it took many years of strenuous effort by the Shiga Prefecture Government before the environmental consequences of the Lake Biwa Comprehensive Development Project were understood and mitigated through payment for the use of the lake's water and subsequently through a special law for the lake's conservation. At Chilika Lagoon, the successful coordination of not only the environment and water resources institutions, but also a wide range of resource development institutions only became possible after the lagoon's connection with the ocean silted up, with severe consequences for the lagoon's fisheries as well as for its environmental values. Aquatic weeds proliferated and there was a decline in the numbers of migratory birds nesting on islands in the lagoon, presumably because of the decline in fish numbers following the closure of the lagoon's connection with the ocean. The success of the Chilika Development Agency is partly due to its ability to work with the Department of Water Resources which has responsibility for flood control and irrigation infrastructure.

These examples make it clear how important it is for environmental and water resources institutions (and preferably all institutions involved in use of the lake basin resources) to develop a common understanding of the limits on and problems arising from resource use (see Chapter 8), and to develop a joint vision of their management (discussed further below).

Informal Links to other Organizations

Institutional infrastructure is costly to create and maintain. In the case of the North American Great Lakes, the laws, treaties, conventions, compacts, and formal agreements have taken many years of effort to formulate and there is considerable bureaucratic overhead in servicing them. The infrastructure to support these agreements may not be available in many national or transboundary lakes. In addition to formal institutional arrangements, it is important to recognize that informal mechanisms, e.g., the conferences, workshops and taskforces are vital to the operation of communications between institutions (Great Lakes Brief). For example, researchers call meetings, outside of the formal institutional arrangements to address new issues, e.g., in the case of zebra mussel invasion in the 1980s into the North American Great Lakes system.

The building of both personal and institutional relationships with key stakeholders, including funders, is greatly facilitated by the continuity of key staff. A key individual, particularly if he or she is charismatic, can play a catalytic role in building links between institutions. The importance of having a dynamic person leading a lake basin institution is not directly discussed in any of the briefs, although it appears to have been an important factor in the success of the Chilika Development Authority and the Laguna Lake Development Authority. Such leaders have a vision of what is required, inspire their staff and are able to persuade other agencies and senior decision makers to coordinate their actions so that mutually beneficial outcomes are achieved.

Management of Transboundary Lake Basins

With few exceptions, the riparian and watershed lands of the lakes selected for this study lie within more than one political jurisdiction. Some political boundaries, such as local government or county government boundaries, lie within one country; others lie between countries. In keeping with common usage, we will refer to the latter—lake basins lying in more than one country—as transboundary lake basins, although it should be noted that many of the inter-jurisdictional issues are common between these basins and those lying within one country. In the case of transboundary lake basins, the differences in political environments, economic development, social norms, and administrative settings can readily lead to different approaches to lake basin management, with detrimental effects on the environmental and development status of lake basins.

Longevity of Transboundary Institutions

The briefs suggest that there are specific factors that affect the success of transboundary lake basin management, including the perception of common problems faced by the lake basin countries; the kind and nature of cooperative agreements among the countries; and their political will, commitment, and fulfillment of obligations. The institutional arrangements between countries are affected by the evolution of such arrangements, the relationship between the sector agencies and the coordinating body, the coordination and collaboration mechanisms, and participatory mechanisms and experiences of stakeholders.

In cases where there has been a history of cooperation between countries, establishing a transboundary coordinating arrangement can be rather straightforward, since each of the sectors often has its own set of transboundary relationships that have evolved over many years (for example, in the case of Lake Constance and the North American Great Lakes). As the institutional history grows longer, the relationship between the sectoral agencies and the transboundary coordinating body usually becomes clearer.

In the case of the North American Great Lakes, the International Joint Commission (IJC) was established in the Boundary Waters Treaty of 1909 and the U.S. Great Lakes Commission (GLC) (with eight states as members) was established in 1955. The IJC makes binding decisions regarding water uses that affect the lakes' water level and flow on either side of the two-nation border. Through various agreements, it also investigates issues of water quality and quantity and encourages cooperation among different government jurisdictions. In the case of Lake Constance (Box 4.2), the International Commission for the Protection of Lake Constance (IGKB) was founded in 1959 by the three riparian countries (Austria, Germany, and Switzerland) to preserve the lake ecosystem from further degradation. The International Bodensee Conference (IBK)— an intergovernmental organization consisting of seven Swiss cantons, two German states, an Austrian state, and the Principality of Liechtenstein—was founded in 1972 to deal with all major political decisions involving the lake basin. In most cases covered in the lake briefs, however, formal transboundary relationships on lake basin management do not date back more than several decades.

Among the lakes in the developing world in this study, the Lake Chad Basin Commission is the longest established transboundary lake basin management authority. It was established in 1964, with responsibilities "to regulate and control the utilization of water and other natural resources in the basin; initiate, promote, and coordinate natural resources development projects and research within the basin area; examine complaints; and promote the settlement of disputes, thereby promoting regional cooperation." The Lake Chad Brief states that: "Until recently, evidence of the commission's presence has been virtually invisible in the conventional basin apart from some scattered infrastructure. Member states need to vest the commission with more power to enable it to resolve water and land disputes and conflicts. A basic weakness in all river basin organizations and regional economic communities in Africa is lack of strong evidence of supernationality." This experience illustrates that, even for long-established transboundary institutions, political support is essential for success.

Forms of Transboundary Cooperation

It is not necessary that all basin governments are included in formal institutions for successful management. For example, Rwanda (and to a lesser extent Burundi), although not members of the East African Community, discuss management issues in the Lake Victoria Basin with the EAC. In another example, China is an active member of discussions on regional

Box 4.2 Transboundary Institutional Arrangement at Lake Constance

Two transboundary institutions have responsibility for the coordinated management of Lake Constance.

International Bodensee Conference (IBK)
The International Bodensee Conference, an intergovernmental organization of the lake-side federal states and cantons, was founded in 1972. Today the IBK has ten members—the Swiss cantons of St.Gallen, Thurgau, Schaffhausen, Appenzell Innerrhoden, Appenzell Ausserrhoden and Zürich; the German states of Baden-Württemberg and Bayern: the Austrian state of Vorarlberg; and the Principality of Liechtenstein. All important IBK decisions are taken by consensus. IBK is organized in a Permanent Committee and seven Commissions. Every year a conference with all prime ministers of the member states takes place in one of the member states. In 1999, the Environment Commission published a report entitled *Measures in the Fields of Agriculture and Water Protection in the Lake Constance Region*, which summarized the problems, the legal and administrative framework, and necessary activities and measures to be taken, especially cross-border cooperation among the administrations.

The common activities are financed by the members. The percentage of financing of each member is fixed according to the extent of the territory.

International Commission for the Protection of Lake Constance (IGKB)
Lake Constance has a peculiar legal and administrative feature. Clearly defined national frontiers between Switzerland and Germany exist in the lower lake. In the upper lake, only the shallow water area from the shoreline to 25 m water depth is national territory of the bordering countries. The major part of Upper Lake Constance is considered as common property, a so-called "condominium." The IGKB was founded in 1959 by the three bordering countries (Austria, Germany, and Switzerland) in order to preserve the lake ecosystem from further degradation. In 1960, the members concluded an Agreement on the Protection of Lake Constance from Pollution (signed into law November 1961). In 1987, the IGBK created a Memorandum, "The Future of a Clean Lake Constance: Long and Short Term Measures."

The main duties of the IGKB are the observation of the lake, confirmation of the causes of its pollution, recommendations for coordinated preventive measures, and discussion of the planned uses of the lake. The commission meets at least once a year and is composed of delegates from member governments and a limited number of high officers of those governments. As an advisory agency, the commission cannot decide on rules and actions connected with environmental protection, but by agreement the regional governments are obliged to transform the recommendations of the IGKB into national law. A technical and scientific board of experts serves as official consultants to the commission. They elaborate the research program and prepare reports on the research sanctioned by the commission. The board of experts has three working groups for studying special problems concerning the topics "Lake", "Catchment Area", and "Accident defense". The working results are summarized and published in green reports (annual investigation of the lake monitoring data) and blue reports (case studies and special topics).

To maintain communications between the organizations, one member of the IGKB is represented in the permanent committee of IBK. However, cooperation between IBK and other commissions and institutions is not regularly organized.

Source: Lake Constance Brief.

Table 4.1 Major Institutions Mentioned in Each of the Lake Briefs as Playing a Critical Role in Lake Basin Management.

Lake Basin	Trans-boundary	Key Institutions	Legal Mechanism	Function
Aral Sea	Y	Interstate Commission for Water Coordination	International Agreement	Resource Development
		Interstate Council on the Aral Sea Problems/ International Fund for the Aral Sea	International Agreement	Advisory
Baikal	Y	Lake Baikal Commission (now ceased)	National Act	Coordination (national)
		Federal Environmental Protection Agency for Baikal	National Act	Coordination (national) and Transboundary Negotiation
Baringo	N	No specific lake basin institution		
Bhoj Wetland	N	No specific lake basin institution		
Biwa	N	Shiga Prefecture (Department of Lake Biwa and the Environment)	National Act, Prefecture Law	Coordination
Chad	Y	Lake Chad Basin Commission	International Treaty	Resource Development, Coordination
Champlain	Y	Lake Champlain Basin Program	National Act (USA)	Coordination
		Lake Champlain Steering Committee	MoU	Advisory
		International Joint Commission	International Treaty	Resource Development
		Lake Champlain Fish and Wildlife Management Cooperative (USA)	Federal-state Agreement	Resource Development
Chilika Lagoon	N	Chilika Development Authority	National Law, Provincial Act	Coordination
Cocibolca/Nicaragua	Y	No specific lake basin institution		
Constance	Y	International Commission for Protection of Lake Constance	International Convention	Advisory
		International Bodensee Conference (IBK)	International Agreement	Advisory
		International Commission for Boating on Lake Constance	International Agreement	
Dianchi	N	Lake Dianchi Protection Committee and Bureau	Municipal Ordinance	Coordination
Great Lakes (North American)	Y	International Joint Commission (IJC)	International Treaty	Resource Development
		Great Lakes Commission (GLC)	Multi-state Compact (USA)	Resource Development, Advisory
		Great Lakes Fisheries Commission	International Convention	Advisory
		Great Lakes National Program Office – USA	National Law	Advisory
Issyk-Kul	N	Issyk-Kul Environmental Protection Authority	National Law	Regulation
Kariba Reservoir	Y	Zambezi River Authority	International Agreement	Resource Development, Coordination
		Zambezi Watercourse Commission (ZAMCOM)	International Agreement	Advisory
Laguna de Bay	N	Laguna Lake Development Authority	National Law	Coordination, Regulation, Resource Development
Malawi/Nyasa	Y	Lake Malawi/Nyasa Basin Commission (proposed)	International Convention	Coordination
		Lake Nyasa Basin Water Office – Tanzania	National Law	Regulation
Naivasha	N	Lake Naivasha Riparian Association	No legal status	Protection
		Lake Naivasha Growers Group	No legal status	Resource Development
Nakuru	N	No specific lake basin institution		
Ohrid	Y	Lake Ohrid Management Board	MoU	Coordination
Peipsi/Chudskoe	Y	Estonian-Russian Transboundary Water Commission	International Agreement	Advisory
		Intergovernmental Estonian-Russian Commission on Fisheries	International Agreement	Coordination, Regulation
Sevan	N	No specific lake basin institution		
Tanganyika	Y	Lake Tanganyika Management Authority (to be formed)	International Convention	Coordination
		Lake Tanganyika Basin Water Office – Tanzania	National Law	Regulation
Titicaca	Y	Lake Titicaca Binational Authority	International Agreement	Coordination
Toba	N	Coordinating Board for Lake Toba Basin Ecosystem Conservation	State Letter of Decision	Advisory
Tonle Sap	Y	Mekong River Commission	International Treaty	Coordination
Tucurui Reservoir	N	No specific lake basin institution		
Victoria	Y	Lake Victoria Fisheries Organization	International Agreement	Regulation
		Lake Victoria Basin Water Office – Tanzania	National Law	Regulation
		Lake Basin Development Authority – Kenya	National Law	Resource Development
		Lake Victoria Basin Organization (proposed)	International Agreement	Coordination
Xingkai/Khanka	Y	International Ussuli Commission (proposed)	MoU	Advisory

Note: The numerous sectoral and local institutions involved in lake basin management have not been listed if their primary purpose is other than lake basin management.

economic development of the Mekong River basin region, particularly in relation to initiatives from the regional funding institutions, although China is not a member of the Mekong River Commission.

It is often not possible or practical to develop a powerful super-national agency to form management policies and implement programs for a transboundary lake basin. The sectoral institutions of the member states typically have their own plans and programs, and harmonization of these plans and programs may be quite problematic. Under such circumstances, the lake basin nations may rely on the facilitating functions of coordinating institution, such as the IBK and IGKB of Lake Constance and IJC and GLC of the North American Great Lakes. A coordinating institution is one alternative for the joint management of transboundary lake basins in which the member states face issues that are technically complicated or politically disputed. The joint bodies should have a wide representation from many governmental and nongovernmental stakeholder organizations, including ministries and local authorities, so that the results produced by international/national projects would be broadly sustained. Box 4.3 provides more information on institutional forms based on the types of agreements.

Transboundary Cooperation Agreements

Transboundary institutions can be formed under a variety of mechanisms:

- A vision describes broad goals and principles for future actions, usually without binding provisions for resource mobilization or for the failure of mutual pursuit;

- Memorandums of understanding (MOUs) are documents of record, formal or informal, that serve as a basis for future actions of the parties. MOUs specify roles and responsibilities and usually have some provisions for resource mobilization and a clause for termination of the mutual collaboration;

- An agreement for joint management of a transboundary lake basin usually constitutes a legally binding document for formal international exchange through a diplomatic channel. It stipulates the needed joint actions for achieving certain shared goals. Some have provisions for penalties in case of failure of a party to fulfill the agreed objectives; and,

- A convention is a special type of agreement that involves sovereign states as signatories.

Box 4.3 provides examples from the lake briefs.

Political and Legal Considerations and Constraints

The briefs suggest that the success of transboundary lake basin management depends on the member states' political will, commitment, and fulfillment of obligations rather than the particular form of institution or its legal status. Thus, while the IJC has been successful, the Lake Chad Basin Commission has failed to control upstream water use in spite of being assigned authority in the Fort Lamy Convention and Statutes that established the Commission to "regulate and control the utilization of water and other natural resources in the basin." The two governments riparian to the Kariba Reservoir—Zambia and Zimbabwe—have a history of weak inter-agency cooperation. Departmental authorities often proceed with activities directed by their respective authorities, sometimes in contradiction to ZACPLAN, the overall basin plan agreed to by their respective governments.

Resource Mobilization for Planning and Project Implementation

If lake basin countries have adequate financial and human resources to fulfill transboundary commitments, then there may be no need for a comprehensive transboundary action plan covering multiple sectors and all lake basins. For example, the riparian and catchment countries of such transboundary lake basins as the North American Great Lakes, Lake Constance, and Lake Champlain have had decades of institutional collaboration without having a comprehensive plan. At the North American Great Lakes, managers have focused on developing remedial action plans for specific areas of concern, and conducted region-wide efforts under institutions and agreements such as the Great Lakes Water Quality Agreement (IJC), Great Lakes Fisheries Commission, and Great Lakes Commission. They are now in the process of developing action plans for each of the five lakes. While a comprehensive plan was not required, the relevant federal agencies developed a shared vision for the Great Lakes in an effort to better coordinate their efforts. At Lake Champlain, a comprehensive plan was completed in 1996 and updated in 2002. Although there had been collaboration for decades prior to the plan, key actions were not completely successful until the comprehensive plan was prepared using a participatory process to involve stakeholders. Collaboration without a plan can be successful, but this example shows that it is likely to be more successful when guided by an agreed plan of action.

Most transboundary lake basins are situated in regions where the riparian and catchment countries do not have adequate financial and human resources, the enabling environment is weak, and the record of transboundary collaboration is at an early stage or has been marginal. The GEF supports the management of some of these lake basins where there is a global public benefit. A Strategic Action Program is developed as part of assistance under the current guideline for the GEF International Waters Operational area. Such transboundary lake basin management programs should support existing programs, plans and institutions developed by the national governments. The Lake Malawi/Nyasa Brief states, "Internationally funded projects must use existing, agreed regional and national plans and not start afresh. This will minimize disruption to established programs and workloads."

Building Trust with the Public

Whether at a transboundary lake or a national lake, it is vital that any lake basin management institution secure the trust of sectoral institutions and the public (Chilika Lagoon and Laguna de Bay briefs). It is particularly important for transboundary institutions. The Lake Peipsi/Chudskoe brief makes the point that trust across national borders has to be built on the back of effective communications, a common set of data and analysis protocols, and transparent decision making across boundaries. Ethnic affiliations across borders can be used to facilitate this communication (African Lakes Workshop).

Contributions from Different Levels of Government

In keeping with the principle of subsidiarity, lake basin problems should be tackled at the lowest appropriate scale. Some problems need to be tackled at the basin or even larger scale. For example, the atmospherically-borne industrial pollution affecting Lake Baikal originates from a number of oblasts (provinces) in the Russian Federation and needs to be tackled regionally. However, other problems are quite local and can be dealt with locally. For example, hot spots can be identified at a number of the lakes in the study, including Missisquoi Bay in Lake Champlain, Akanoi Bay in Lake Biwa, Winam Gulf in Lake Victoria, and numerous islands in Lake Malawi/Nyasa. National governments (or their agencies) will be needed to tackle regional problems, but local governments may be capable of managing more local problems.

Given the numerous problems experienced in each study lake (Table 3.2), the implication is that institutions need to be functioning at all levels—national/international, regional and local—for effective lake basin management. For example, Lake Peipsi/Chudskoe experiences local problems (shoreline effluent discharge), regional problems (weed infestations) and international problems (unsustainable fishing practices and diffuse source nutrients). Although, according to the Principle of Subsidiarity, these problems need to be tackled at

Box 4.3 Examples of Agreement Types

Vision

Lake Chad. A Strategic Action Plan with long-term vision (20 years) for the Chad Basin has been prepared with the assistance of the Global Environment Facility (GEF). It was adopted by the member states in 1998. The Lake Chad Vision for 2025 highlights a number of important issues needing to be addressed in the basin.

Memorandum of understanding

Lake Champlain. The Memorandum of Understanding on Lake Champlain of 1988 and the Water Quality Agreement of 1993 signed by the states of Vermont and New York in the United States, and the province of Quebec in Canada are examples of nonbinding transboundary covenants. The MOU created a mechanism for the exchange of scientific information and encouraged cooperative planning for watershed protection. It established the Lake Champlain Steering Committee with diverse representation among the three jurisdictions, and established a role for three citizens' advisory committees. The MOU is a five-year renewable agreement and sets the stage for the passage of national legislation and the development of a comprehensive plan for the lake basin. This comprehensive plan is still under way.

Agreements

Lake Peipsi/Chudskoe. The Agreement between the Government of the Republic of Estonia and the Government of the Russian Federation on Cooperation in Protection and Use of the Fish Resources of Lake Peipsi/Chudskoe, Lake Pihkva, and Lake Lämmijärv was signed in Moscow on May 4, 1994. The goal of the agreement is to develop cooperation in protection and joint use of fish resources in Lake Peipsi/Chudskoe, Lake Pihkva, and Lake Lämmijärv. The agreement included the establishment of the Intergovernmental Commission on Fishery in Lake Peipsi/Chudskoe, Lake Pihkva, and Lake Lämmijärv.

The Great Lakes of North America. In 1972, the United States and Canada signed the Great Lakes Water Quality Agreement. Signed by President Nixon and Prime Minister Trudeau, the agreement does not have treaty status, but is a binational executive agreement that commits Canada and the United States to specific actions to protect and enhance water quality. The Great Lakes Water Quality Agreement not only addressed water quality issues, but perhaps equally importantly, the issue of multiple fragmented jurisdictions. To this end, the agreement established the International Joint Commission (IJC) Great Lakes regional office (the only IJC Regional Office), which has specific responsibilities for providing technical support, coordinating programs, and monitoring implementation of the two federal governments under the agreement. The IJC has established a Great Lakes Water Quality Board and a Science Advisory Board to carry out its mandate.

Conventions

Lake Tanganyika. The Convention for the Management of Lake Tanganyika is a government-government agreement setting out the rights and duties of the four riparian countries—Tanzania, Burundi, the Democratic Republic of Congo, and Zambia—surrounding the lake. It establishes institutional structures for cooperative management, management principles, a Strategic Action Program (SAP), and related matters. The convention was developed through a series of regional workshops bringing together senior lawyers and policy makers from each of the four riparian countries. The final draft of the convention was adopted by the steering committee (July 2000) at the completion of the GEF-funded UNDP Lake Tanganyika Biodiversity Project (LTBP). The convention was signed by the four riparian states on June 12, 2003, and is now being ratified by the various parliaments. Once it enters into force (after ratification by at least two countries), the convention will provide the legal authority to implement the SAP and regularly revise it.

Sources: Lakes Chad, Champlain, North American Great Lakes, Peipsi/Chudskoe, and Tanganyika Briefs.

the appropriate level, there is usually a need for support from organizations at all levels. Thus, unless national governments (and sometimes international assistance agencies) provide the funds the local urban effluent discharges at Lake Peipsi/ Chudskoe are unlikely to be mitigated using just local resources.

National-Level Governments

In almost all lake basins described in the briefs, national governments are directly or indirectly involved in the management of the respective lake basins. While some transboundary lake basins have transboundary management institutions established or about to be established (North American Great Lakes, Aral Sea, Lakes Champlain, Constance, Chad, Tanganyika, Victoria), the national governments retain considerable influence over management activities. National lake basins that are under direct or significant managerial responsibility of the national government include Lakes Nakuru, Tonle Sap, Laguna de Bay, Issyk-Kul, and Sevan, as well as the Tucurui Reservoir.

In general, the involvement of national governments in lake basin management takes place through sectoral ministries and their agencies. For example, agencies in charge of management of water resources would control the yield as well as allocation of water from the lake, and the forestry department would manage the use of plantation and forests within the basin. In many of the lakes studied in this project, the national sectoral institutions work through regional offices (Box 4.4). In most cases, these management regions are not based on the lake basin boundaries, even for water resources management agencies.

Local Governments

Local governments (municipal, district, and regional authorities) can play a central role in improved lake basin management. They are the bodies closest to the users of the resources of lake basins; they have responsibility for many resource management activities; and they also use lake basin resources. They are often best placed for facilitating a dialogue directly with lake basin resource users. Their decisions on land use zoning, transportation, construction, public health, ecological zoning, solid and liquid waste management, and industrial incentives all affect water resources.

Few of the 28 lakes in this study are managed entirely by a local government. The Bhoj Wetland falls under the jurisdiction of the Bhopal Municipal Corporation (BMC). While the state government retains responsibility for many resource use activities, the singularity of local authority and the importance of the lake to the local area means that BMC carries particular responsibility for lake basin management. Lake Biwa, the basin

Box 4.4 Sectoral Involvement at Lake Nakuru

Lake Nakuru in the Rift Valley of Kenya is a popular tourist destination with major wildlife attractions. The town of Nakuru is a rapidly growing industrial center and the forests in the lake's basin have been largely cleared for smallholder agriculture in the last 40 years. The town has experienced a growth rate of about 10 percent for the last three decades, putting tremendous strain on water supply and the environmentally safe disposal of wastewater. A number of government agencies have jurisdiction over different resources within the basin, illustrating the complexity of managing the basin:

- The Kenya Wildlife Service is mandated to conserve and manage Lake Nakuru under the Wildlife Act. It developed the Lake Nakuru Ecosystem Integrated Management Plan 2002–2012 to address poverty and reduce the threats facing the lake.
- The Municipal Council of Nakuru is in charge of urban development, setting trade effluent standards, and monitoring water quality. The council has a well-equipped water quality laboratory within Lake Nakuru National Park, although it often lacks funds to process samples or maintain the equipment.
- The Ministry of Water Resources Development operates within the lake basin under the Water Act, and is responsible for conserving the water catchment, water allocation, pollution control and monitoring, and resource mobilization for water resources development. Under recent legislation, operational responsibility will be devolved to a Catchment Area Advisory Committee with increased stakeholder involvement.
- The Forest Department operates in the lake's catchment under the Forest Act, and is responsible for forest resource development, extension services, and resource mobilization. Large areas of forests in the lake's catchment have been cleared under controversial government policies; these activities are in direct conflict with good management of the lake basin's resources.
- The Ministry of Agriculture is responsible for development of agricultural activities in the catchment under the Agriculture Act.
- The Provincial Administration is responsible for policy enforcement and creating an enabling environment for sustainable lake environment management.
- The Department of Occupational Health and Safety has taken the lead in the implementation of Pollution Release and Transfer Registers in Nakuru. They have sensitized the industrial community to initiate waste reduction programs, and developed a database that contains all the information collected from participating industries.

Source: Lake Nakuru Brief.

of which lies entirely within Shiga Prefecture and where the lake is central to the prefecture, provides another example.

Laguna de Bay, on the other hand, is managed by a special authority—the Laguna Lake Development Authority—whose boundaries include the basin as well as some local government areas outside the watershed. Some conflicts between the LLDA and the local government units illustrate the importance of having clearly coordinated actions between the different levels of government. Although the LLDA has been given the mandate to manage the lake's shoreline areas, it did not exercise this responsibility for many years. The delayed action also made it difficult for the local government authorities to understand why the parts of the lake within their municipality that remain dry at certain times of the year are not under their jurisdiction. In spite of the dissemination of the Laguna de Bay Shoreland Policy, the local governments continue giving permits for shoreland use which, by law, is the LLDA's responsibility. The confusion extends to other national agencies too. Agencies in charge of land management, surveys, and land titling classify these shoreland areas as alienable and disposable lands, in spite of the Administrative Order that was specifically approved to prevent this situation from occurring. Resolution of this situation will require action and political will by the top executives of the involved agencies.

In most cases, problems affect a wider area than just one local government jurisdiction because of the integrating nature of lakes. In addition, local governments often lack jurisdictional authority and resources to address complex issues, including the ability to bring other sectors and 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 many instances, local governments can be major source of lake degradation if they are responsible for the disposal of urban sewage and solid wastes. At Lake Ohrid, the discharge of untreated effluent from urban municipalities in both FYR Macedonia and Albania has been a major source of lake pollution. Solid wastes are disposed of in unlined pits and are believed to be a source of lake contamination. These pollution sources are currently being controlled with assistance from the German and Swiss governments and the GEF.

Institutions and Stakeholder Participation

Many lake briefs (Lakes Ohrid, Peipsi/Chudskoe, Laguna de Bay, and the Bhoj Wetland) state that successful lake basin institutions need good pathways to communities dependent on lake basin resources. In some cases, this may involve having community representatives on a management agency. Additionally, a report on Lake George presented at the African Regional Workshop says that these institutional links provide conduits for information to pass upwards from communities to planning and decision making at all levels, as well as providing opportunities for communities to feel part of management and responsible for protecting the lake basin's resources: "Benefits are already being felt by stakeholders, such as women and the poor feeling no longer excluded and being able to speak up at meetings." Representation by stakeholder groups will be discussed further in Chapter 6.

The breadth of representation (and the consequent range of communication channels) was identified as an important criterion for success in the Lakes Peipsi/Chudskoe and Titicaca briefs, along with the flexibility of the institutional design.

Decentralization

Several of the lake briefs describe the evolution of lake basin management institutions as part of government decentralization policies. At Tonle Sap in Cambodia, for example, concerns were expressed about the need to adopt decentralization policies that recognized the hierarchical system of governance within the basin management framework, from the Mekong River Commission to national and provincial authorities and all the way down to the poorest and most isolated communities within the lake basin. At Lake Toba in Indonesia, lake basin management has been developed within the context of government decentralization policies. In this case, the provincial government and five jurisdictions around the lake extend beyond the relatively small basin boundary of the lake itself. The need to coordinate among the local jurisdictions (kabupatens) and to resolve resource management conflicts (such as fish pen developments) within the province is evident, but has not been addressed to date. In addition, this brief points to the need for promoting community-based approaches, which had not been possible under the previous highly centralized governmental regime.

To support implementation of its national water policy, the Government of Tanzania established five river basin water offices and four lake basin water offices (for Lakes Victoria, Tanganyika, Malawi/Nyasa and Rukwa) by the end of 2004 as institutions responsible for managing the country's water resources (although this recent development was not captured in the briefs for Lakes Victoria, Tanganyika, and Malawi/Nyasa, which covered earlier periods). This basin-focused approach replaces the previous regionally-based administration of water resources. However, decentralization can increase the isolation of a lake basin from the national government; this has been a problem at Lake Tanganyika. The Lake Xingkai/Khanka drainage basin is also remote from the capitals of both China and the Russian Federation. As a result, the region does not have the economic or political visibility needed to receive significant attention from the central government of either country. Yet national-level attention is important to ensure the lake and its drainage basin receive sufficient economic and other resources to tackle the problems.

Capacity Building

Many of the briefs described the need to build capacity within local and regional institutions. The most commonly cited needs included stakeholder involvement and participatory management techniques, monitoring and evaluation, and administrative aspects of project management (particularly where GEF-funded projects have been implemented). Decentralization throws a considerable burden on local authorities, and in many cases local authorites are not well-equipped to handle such burdens. The Lake Malawi/Nyasa brief makes the point that decentralization has been proceeding only slowly in each of the lake's three riparian countries (Malawi, Mozambique, Tanzania) because it is not always welcomed by officials at regional or district levels who may be unwilling or unable to assume increased responsibilities. The cost of operating an environmental monitoring program and maintaining it over the long term presents a tremendous challenge, given the current capacity of many of the lake basin management institutions. However, there are opportunities to involve citizens in monitoring programs in developing countries to keep costs down, as well as build improved capacity among stakeholder groups.

At Lakes Baringo, Nakuru, and Toba, lake basin managers successfully made use of a tool developed by the World Bank for participatory rural appraisal (PRA) and conducted training among staff, environmental cadres, and/or local citizens in order to build capacity for community-based lake basin management programs. At Lake Ohrid, local coordinators, working with Watershed Management Committees, successfully built capacity for stakeholder involvement in the GEF-funded Lake Ohrid Conservation Project. At Tonle Sap, however, strengthening institutional capability for community-based approaches was identified as an urgent need that had not been adequately addressed.

One important lesson in the briefs relates to increasing the capacity of local NGOs and CBOs through training programs and small grants programs (Lakes Nakuru, Ohrid, Peipsi/Chudskoe). The GEF-funded Lake Ohrid Conservation Project provided small grants for NGOs in both FYR Macedonia and Albania to carry out a variety of activities, including summer eco-camps, education in the schools, cleanups along the shoreline of Lake Ohrid, reforestation on tributary streams in the watershed, the production and distribution of public education materials, and hosting roundtable discussions and workshops. However, these grants were only moderately successful in involving a wide cross-section of the public in their activities and depend on continuing access to international funds.

Institutional Evolution

Lake basin management institutions are most effective when they build on existing structures at local government, sectoral, and community levels. This capitalizes on the accrued knowledge and linkages of these organizations and accesses their legal powers. This is emphasized in a number of briefs and other reports. For example, one of the lessons from Lake George in Uganda is that "appropriate and effective institutional structures at national and local level should not duplicate existing systems, but be integrated into, and supplement, government structures."

The briefs show that it can take considerable time to establish effective institutions, particularly ones with a coordinating function since they have to rely on persuasive power and often have limited finances to achieve their aims. For example, one of the most successful institutions included in the briefs, the Chilika Development Authority, had few successes following its establishment in the early 1990s. Yet by the late 1990s it facilitated the biophysical recovery of the lake and the reestablishment of a sustainable income for fishing communities dependent on the lake, partly because it had invested in developing good relationships with the sectoral agencies that would be needed to implement the restoration effort, partly because it had invested in acquiring a relaible knowledge base about the lake basin problems, and partly because the urgency of the situation provided it with the necessary authority.

Even though they need to persist over the long term, effective institutions are not static. They have to evolve to match their activities with emerging problems and the development needs of the lake basin communities. The North American Great Lakes brief shows how an institution needs to be flexible enough to respond to emerging environmental issues—in that case from aquatic nuisance species, to climate change, to water export, to energy transmission infrastructure, or the assertion of stewardship by Indigenous Peoples in Canada and the United States through "First Nations" and tribal authorities.

Both Lake Naivasha and Laguna de Bay provide good examples of responding to changing development needs. In the former case, the institution has changed over 75 years from a lakeshore protection organization, to a lake conservation body, to (in recent years) part of a semi-autonomous lake basin management authority. It is notable that this evolution has brought increasing numbers of stakeholders into the management of the lake, most recently expanding the membership to include those in the lake's basin. However, some stakeholders, such as those in the upper catchment of the Malewa River, have yet to be effectively included.

In the latter case, the LLDA was established in 1966 to cultivate the potential of the lake and its environs for further development and control its environmental degradation. As early as 1983, the LLDA was authorized to undertake a thorough corporate reorganization, although little was accomplished. Over the last 15 years, because of the rapid increase in population, settlements, industrial establishments, and other economic activities in the basin with increasing pressure on the lake, there has been an increase in its role to protect the lake environment. The LLDA reengineering study has led to the authority being restructured as an integrated water resources management and development agency. This will include an expansion of its development activities through the proposed Laguna de Bay Development Corporation.

Three of the lake briefs described the use of formal institutional reviews to assess the effectiveness of the institutions in the face of changes in socioeconomic and political situations in the region, including regular evaluation of the effectiveness of the institutional design (Lakes Peipsi/Chudskoe, Titicaca and Laguna de Bay).

Chapter 5

Identifying Effective Actions:

National and Local Policies

Key Lessons Learned about Policy

- National-level policies are essential for establishing the foundation of good lake basin governance. However, there was little discussion of national-level policy in the lake briefs.
- Policies affecting lake basins need to support poverty reduction and development policies, because poverty itself contributes to lake basin degradation and also because affected stakeholder groups are more likely to become involved in lake basin management if they benefit.
- National policies are implemented at the local level through either command-and-control (CAC) policies, incentives/ disincentives (economic instruments), or public awareness. Each has advantages and disadvantages. These instruments are often used together.
- CAC policies are effective when there is a clear outcome being sought; there are relatively few affected stakeholders; and there is social acceptance of government decisions.
- Economic instruments have the advantages of being flexible; relatively cheap to implement; and able to include the cost of externalities. However, they can be difficult to introduce, especially when they involve charging for use of a resource previously accepted as being free.
- Overall, successful local policies build political will; involve the stakeholders; ensure administrative sustainability; are equitable; and actively work toward policy integration.

National Policy

A national policy describes a government's intentions for the use of a resource. The policy establishes the foundation for the other components of management—development of the principles of lake basin management, institutions, legislation, rules and incentives, community and private sector participation, and finance. If there are differences in the policies of different sectors that affect lake basin resources, or between different countries (in the case of transboundary lakes), then there will be inefficiencies and potentially conflicts in the use of the resources. Thus, an agricultural sector policy to expand agriculture in the headwaters of a lake basin may lead to increased sedimentation of spawning areas for fish in the littoral zone of a lake and thus come into direct conflict with the policy of the fisheries sector to protect sensitive fish breeding areas.

The Chilika Lagoon provides an example where the absence of a strong policy on involvement of stakeholder groups led to a unilateral decision by the state treasury to issue fishing licenses to commercial interests that compromised the incomes of local fishermen. When those affected by the decision were not listened to, there were riots resulting in deaths. The management program since 1999–2000 has emphasized stakeholder participation in major decision making; this has helped lead to the recovery of the lagoon. Thus, good national policy is central to good lake basin management.

Given the sectoral organization of governments, it is rare to find a national policy specifically on lake basin management. Instead, the government's intentions for managing lake basins are contained in water resources policies (encompassing both surface waters and groundwaters) and the policies of water-dependent sectors such as fisheries, irrigation, water supply, and environment. However, where the lake is of considerable importance, there may be a separate policy developed for that lake that coordinates the activities being carried out by sectoral agencies and, in the case of transboundary lakes, by riparian and basin countries. This is recognized in the Lake Victoria brief: "National policies and programs will need to include specific components to echo lake management policy, and the establishment of lake management policy will have to take into account existing policies and strategies of the riparian and catchment countries."

It is very difficult in most countries, whether developed or developing, to get consistency of action across sectors. The consequence is that actions by one sector can undermine or compromise actions by another sector. The problem is exacerbated in transboundary lakes. For example, water withdrawals by the irrigation sectors of upstream countries have added to the pressures on Lake Chad and affected fishing communities dependent on the resources of the lake.

The increasing acceptance of IWRM offers an opportunity for coordinating sectoral policies that affect lakes. An increasing number of countries are introducing water resources policies that require this coordination at the national and river basin level. Where river basin boundaries are coincident with or contain lake basins, these river basin initiatives will improve the ability of lake basin managers to coordinate actions.

The need to link lake basin management policy to social and development policy was widely understood within the lake basin briefs. The Aral Sea brief stated that "Water management issues are linked to economic and political issues. Cooperation on water issues should be an important part of the discussion on economic development and broader policy integration processes in the region." The Lake Sevan brief made a similar comment, and the Lake Baikal brief stated that policy makers should show the economic and social benefits of proposed environmental conservation legislation, projects, and policies. The Lake Toba brief identified the necessity of linking lake basin management to poverty alleviation because the poor often contribute to environmental degradation when pushed to the margins in order to survive.

One of the most pressing needs in many international lake basins is to harmonize national regulations in areas such as fishery and pollution control (e.g. Lakes Victoria, Ohrid, Peipsi/Chudskoe, and the Kariba Reservoir). Harmonization is not necessarily the same as uniformity. Harmonization ensures that there are no conflicts between the laws and regulations across national borders; it does not require laws to be identical.

Laws are usually formulated for the entire nation, and may not be appropriate for a particular lake. This jurisdictional scale problem is exacerbated in the case of transboundary lakes and reservoirs. Thus, Nigeria is important to the Lake Chad basin, but the basin is not dominant in Nigerian policy thinking. National laws are customized for the circumstances of specific lake basins through regulations and by-laws; these can also be used to help harmonize management across international borders.

However, harmonization of institutional and legal frameworks must reflect the sovereignty and subsidiary aspects of the transboundary states. For example, the beach management units established commonly across the riparian states around Lake Victoria need to be in keeping with each country's particular social characteristics, which reflect their own unique local situation and the history of community development. On the other hand, the historical ethnic attachment that transcends national borders may facilitate cooperation across state boundaries.

Local Policies

At a more local level, where there is competition between users of the resources of a lake basin, national policies need to be translated into mechanisms to ensure that access to these resources is allocated fairly and efficiently. This means managing people and their actions in order to change undesirable behavior and to reinforce desirable ones. This can be done through three basic mechanisms:

- Enforceable rules;
- Incentives/disincentives; and,
- Education and public involvement.

The last of these, educating the users into understanding the mutual benefits of sharing access to the lake basin resources, will be discussed in Chapter 6. However, all three mechanisms have complementary characteristics and are often used together. The only other intervention commonly used in lake basin management is a technological response such as sewage treatment, dredging, and the use of biological agents to control weed growth. These technical responses, which are an important part of the management package, are essentially responses to the consequences of people's actions; they are not mechanisms to change people's behavior. They are discussed in Chapter 7.

Enforceable Rules

Rules state, with the force of law, how the resources are to be used and shared. Consequently, they are referred to as command-and-control (CAC) policies. They can apply within a single sector (such as restriction on the use of a certain type of fishing gear) or can apply between sectors when different sectors draw on an underlying resource such as water. For example, rules have been recently established to allocate water from the barrages in the Mahanadi River upstream of the Chilika Lagoon to ensure that water is available for both downstream irrigation communities and for lake fishermen dependent on the upstream migration of fish, prawns, and crabs.

CAC policies are a common approach because they directly specify a desired outcome. However, to be effective, rules need to be enforced. Many briefs noted that this is a problem in countries where government capacity is low due to lack of financial resources or lack of political will. As the Lake Cocibolca brief stated, "the existing constitutional mandates, institutional mandates, laws, and international agreements suggest that there is a sufficient regulatory framework to direct environmental management actions, biodiversity preservation, and sustainable development. The major limitations are associated with the institutional, technical, and organizational capacity to enforce compliance with this regulatory framework and the lack of public awareness which facilitates legal action in every country."

CAC policies have been very successful for some problems in the high-income lake basins in our survey (Biwa, Champlain, Constance, and the North American Great Lakes). For example, phosphorus loading to Lake Constance was dramatically curtailed by the adoption of direct regulation on domestic and industrial dischargers. In developing countries with good enforcement capacity (such as Lake Dianchi in China), pollution standards have proven to be an effective method of reducing pollution loads.

A mixture of CAC policies is often used. For example, to help manage fish stocks in a lake, a number of restrictions may be enforced to control different aspects of the fishery, such as:

- Specifying fishing boat size;
- Specifying "closed seasons" when certain species may not be caught (Lakes Baringo and Naivasha);
- Technical regulations on fishing equipment such as gill-net size restrictions (Lake Victoria) and gear standards (Lake Peipsi/Chudskoe); and,
- Designating fishing zones for different categories of fishermen or different fisheries (Laguna de Bay).

Zoning regulations, such as the designation of certain areas as "protected" or national parks, are another example of CAC policies. Many countries designate the area around lakes or in parts of their basins as protected areas, particularly when they include Ramsar sites. However, protected areas often go unprotected if resources for enforcement are inadequate. For example, the Issyk-Kul, Sevan, Tonle Sap, and Xingkai/Khanka briefs all describe how poaching and other activities (such as industrial development) continue to occur in areas officially zoned for protection.

The administrative burden in enforcing a CAC policy becomes greater when the policy is more finely tuned (e.g. different standards for different users), when more people are affected, and when there is lower social acceptance of government-set standards. For example, it is possible to enforce fisheries regulations on larger commercial operations in Lake Victoria, but much more costly to enforce regulations for thousands of artisanal or near-shore fishermen through traditional CAC methods.

The importance of the social acceptance of CAC policies is illustrated by the fishing moratorium at Lake Naivasha. When the moratorium was lifted, it was decided in a public meeting that the number of fishing boats on the lake had to be reduced to a total of 43 boats. The difficult task of deciding who should have a license was ultimately determined on the basis of how a fisherman had behaved in the past. Those who had obeyed the rules got a license. Several fishermen subsequently were caught using small net sizes and were banned; their place was taken by other fishermen on the waiting list.

Incentives and Disincentives

Economic instruments—levies and subsidies—constitute a second method of controlling behavior. While not mandatory, they influence behavior by providing incentives and disincentives. Markets are a special type of economic instrument where the incentive is provided by a price signal set by other users of the lake basin's resources rather than by institutions. However, there are few instances of markets being established to guide people's behavior in the case studies; most prices are set by institutions.

Using prices to create incentives and disincentives has a number of advantages:

- Prices affect most people and normally do not require direct government intervention once the price has been set (except for the collection of revenues);
- People respond to changes in prices;
- Prices can be changed quite quickly and hence are a fairly responsive policy tool;
- They can be used to both reward good behavior (such as a subsidy for use of environmentally friendly equipment), or to punish undesirable behavior (such as a tax to discourage polluters); and,
- They can be used to "internalize environmental externalities", and thus encourage more efficient resource use. A higher price for pesticides, for example, helps sensitize farmers to the costs of pesticide pollution of water, and encourages them to use less pesticide.

Pollution charges are used at Lake Dianchi and at Laguna de Bay to discourage the discharge of harmful wastes into the lakes. The higher the level of discharge, the greater the charge. Other lakes provide examples where fees are levied on the use of the lake's resources. In the Tanzanian portion of Lake Victoria, fishermen paid a levy based on the fish catch on a trial basis. The removal of a fertilizer subsidy in the basin of Lake Peipsi/Chudskoe is an example where a previous incentive had distorted the behavior of farmers and encouraged them to use fertilizer excessively, to the detriment of the lake.

Although these economic instruments can be effective, it is usually not a simple political process to introduce them. There will always be pressures to resist changes by those who will lose something due to changes in prices. Their introduction usually has to be accompanied by an extensive education program to explain the overall benefits, and be backed up by strong political will. However, if the user group sees that they are in danger of losing all in the future, they may be more willing to accept some charges to control use of the resource. 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 resource and their industry.

There are examples in the briefs where economic instruments could be used to control use of lake basin resources. For example, the drawdown of Lake Naivasha has been caused, at least in part, by water consumption for horticulture. Although a water use permit had long been required, many water users were abstracting water without a permit or at levels well above the permit. More recently a water use charge has been established under the 2002 Kenyan Water Act, but this has yet to be operationalized. Enforcement of the user charges would help support management of the lake and help to limit the amount of water used.

One case where economic instruments are relatively easy to introduce occurs when there is a new or expanding use. For example, the sport fishery at the Kariba Reservoir was created by the filling of the reservoir. There were no previous sports fishermen to object to the issuing of licenses that were used to control the extent of the catch.

Just as with CAC policies, there is a need to monitor the implementation of economic instruments and impose sanctions if necessary. For an overfished lake fishery, for example, a fee on fish landings to discourage overfishing would still require monitoring of catches and the possibility of imposing fines on those who try to avoid the fee. Furthermore, with an economic-based system the other permit holders (the other stakeholders) now have an increased private interest in seeing that no one reduces their costs by avoiding the fee.

The Local Policy Mix

Successful policy implementation depends on many factors—sociocultural factors, institutional dimensions, public confidence in the administrative system, and "social capital" (See Box 5.1). It is not possible to be prescriptive about which policy is best for each problem. What works in one situation may not necessarily work, or work as well, in another.

Successful policy making is almost always a combination of several different policy instruments. Because of their complementary strengths, it is common to combine CAC policies with economic instruments (Box 5.2). Public information and consultation is usually essential to gain acceptance of (and compliance with) the new approaches, even when CAC approaches are chosen to address a problem. Table 5.1 shows the mix of instruments described in the briefs for the study lakes. The briefs do not describe the full range

Box 5.1 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 cooperative 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 cooperative 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.

Box 5.2 Lake Dianchi, China—A Mix of Policies to Improve Lake Water Quality

Water pollution was a major problem in Lake Dianchi, which is 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 stormwater runoff. The municipal government responded with large engineering investments in sewers and wastewater treatment facilities, and policies to control industrial polluters.

A pollution levy system had previously been introduced into China and was being applied in the basin along with discharge standards under which industries were charged a penalty if their discharges exceeded the discharge standards. The penalties 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 combined discharge standards, pollution charges, and loans for pollution-reducing investments.

In Lake Dianchi basin, progress has been reported in reducing pollution in the lake. By the year 2000, industrial wastewater discharged was reduced by 60 percent compared with 1995, COD was reduced by 80 percent, 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 of Lake Dianchi illustrates the application of a number of different policy tools working together toward the longer-term goal of improved lake water quality.

Source: Lake Dianchi Brief.

of controls over uses; it is probable that a wider range of instruments are actually in use at many of these lakes.

The mix of approaches can change over time too, in response to both experience and changes in external pressures. In the case of Laguna de Bay, for example, the government's management approach has evolved as the management authorities have had to both respond to new challenges—such as expansion of fish pen operations and shoreline industrial development—as well as search for new sources of funding (Box 5.3).

Lessons from Experience

Five broad lessons emerge from the lake briefs about what makes a successful local policy package.

Build "Political Will"

Without the support of the political establishment, it is usually impossible to implement effective management. Whether this is done by grassroots-level efforts, by carefully developed and implemented public consultation and information campaigns, or by direct contacts with decision makers, the creation of high-level commitment to the introduction and application of controls over resource use is an essential component of lake basin management. Often referred to as "political will," this merely means that governments and management authorities are committed, and therefore adequately resourced and empowered, to take actions and enforce the local policies. For example, the lack of political backing for the Lake Chad Basin Commission is identified in the brief as being the major impediment to the introduction of rules for allocating the waters of the Lake Chad basin.

Involve the Stakeholders

Some of the most successful examples of enforcement of rules occur when the affected community is involved with government agencies in setting and implementing the rules. Involvement of communities helps make the benefits of the rules clearer to those affected, draws upon the accepted authority of local leadership, uses their local knowledge for better design and enforcement, and reduces the cost to the central government. Involvement of communities in drafting, monitoring, and enforcing the agreed-upon regulations was advocated in the thematic paper on basin problems in Africa.

Fisheries management provides an example where the benefits of enforcing the rules are readily apparent to the stakeholders and where there were existing informal institutions governing fishing behavior. This is illustrated in the case of Laguna de Bay where, to augment the manpower needed to monitor the lake, the LLDA organized fisherfolk groups and deputized them as wardens. Later the Fisheries and Aquatic Resource Management Councils were formed and became one of the partners of the LLDA in resource management. These groups clearly have a direct stake in successful management of the lake and enforce the regulations on the allowable extent of fish pens, since "they stand to lose if the capacity of the lake to sustain fisheries is surpassed." There are other examples in Lake Victoria and Lake Malawi/Nyasa and at Lake George, although their efficiency has yet to be established.

The voluntary moratoriums on fishing in Lakes Baringo and Naivasha are powerful examples of stakeholder involvement in enforcing rules. The moratorium in 2001 at Lake Baringo was instituted after a monitoring report by the Kenya Marine and Fisheries Research Institute was presented to the fisherfolk. Based on these data, it was agreed to impose the moratorium and help the Fisheries Department enforce it. After two years, the size of tilapia has increased by 100 percent; this success has strengthened local support for the fishing rules.

Box 5.3 The Laguna Lake Development Authority, Philippines

When the LLDA assumed full responsibility in 1975 for regulating the use of the surface of the lake and in regulating effluent discharge quality, it used a traditional CAC approach. Over time, the LLDA has evolved in its response and more recently has tried to blend economic instruments with CAC policies.

Implementation of an environmental user fee system (EUFS) began in 1997. It combined a fixed fee and a variable fee to attack the problem of BOD discharges from lakeshore industries. 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 effluent BOD standard of 50 mg/l. These two components act as an incentive for polluters to reduce both the total load of effluent discharged and improve its quality. The EUFS was initially focused on a small set of industrial polluters and is being gradually expanded to cover other firms, residential areas, and commercial establishments. A CAC component is also needed since all industrial firms have to be registered and the effluent needs to be monitored.

The EUFS has been very successful: annual BOD loading to the lake dropped from 5,400 metric tons in 1997 to 790 metric tons in 2002 for the initial batch of 222 firms. The number of firms rose to 914 by 2002. Industries have introduced waste minimization, increased wastewater recycling, and improved treatment processes. In spite of this successful reduction in BOD loading, other problems in the lake (Table 3.2) remain to be resolved.

The CAC approach at Laguna de Bay is illustrated by the use of a zoning scheme for controlling the spread of fish pens. Within the zoned area, a fish pen permit (basically a licensing fee) has been introduced. The fee is currently about $120 per hectare per year and so is directly related to the extent to which the lake's waters are used for fish raising.

Source: Laguna de Bay Brief.

The European Union (EU) imposed sanction on the export of Nile perch in 1999 from Lake Victoria provides an example where an external shock galvanized stakeholder involvement. The sanctions were imposed because of the poor hygiene conditions at landing sites and during fish processing. The industry responded quickly and, with external funding assistance, improved the handling of the fish so that exports were resumed to the EU the following year.

There are fewer examples in the lake briefs of the successful involvement of more distant stakeholders—where the rules have less obvious benefits to those on whom they are imposed—in setting and enforcing rules in lake basins. For example, the Lake Baringo brief makes a point of contrasting the willingness of the fisherfolk community to support the fishing moratorium with the failure of attempts to control erosion on grazing lands. The brief attributes this difference to the acceptance, on the one hand, that fish are a common-pool

Table 5.1 Command and Control (CAC) and Economic Instruments Described in the 28 Lake Briefs.

Lake Basin	Command and Control			Economic Instruments			
	Standards	Bans/Quotas	Zoning	Licences to access resources	Subsidies	Effluent Charge	Fees for use of natural resources
Aral Sea		Fixed quotas of water allocation between countries					
Baikal	Lake water level standards	Timber harvesting banned within ecological zone	Zoning under "Baikal law" controlling permitted activities				
Baringo	Standards for fishing gear; Controls over tree cutting	Fishing moratorium		Fishing licenses; Licenses for water extraction			Fees for water use[1]
Bhoj Wetland	Water quality standards	Ban on motorboats; Ban on recreation activities	Foreshore zoning; Buffer zone between settlements and plantations		Subsidy to washermen to move out of lower lake catchment		
Biwa	Water quality standards for industrial, urban and agricultural discharges; Voluntary pollution control agreements by factories	Detergent phosphorus ban; Ban on persistent organic pollutants; Ban on invasive fish	National park with controls over land use; Lake zones for recreation boating; Zoned protection of reed beds		Preferential national government subsidy rates for major prefectural environmental infrastructure development; Compensation to fishermen for loss of fishery; Subsidy for catching invasive fish		Direct and indirect payments from the downstream water users
Chad	Water quality standards			Fisheries licenses			Water use charges (Nigeria)
Champlain	Water quality standards for effluent and industrial discharges	Detergent phosphorus bans; Restriction on emissions of atmospheric pollutants (U.S. Clean Air Act)	Buffer zones for wetland protection	Fishing licenses	Agricultural subsidies for riparian protection, etc.		
Chilika Lagoon		Allocation of water for environmental flows (to be approved)	Shoreline zoning (1 km) of restricted activities	Licensing of fisheries and prawns			
Cocibolca/ Nicaragua			Buffer zones; Biological corridors				
Constance	Emission controls on boats; Regulations on agriculture in catchment; Regulations on water sports and hunting	Prohibition on atrazine; Bans on toxic anti-fouling paints	Sensitive shoreline areas closed				Fee for water consumption
Dianchi	Water quality standards		Land use controls		Reforestation support; Industrial effluent control grants	Industrial pollutants levies	

resource where the rules protect the resource for all fisherfolk, and on the other hand to the individual ownership of the grazing lands where the benefits to the landowners from reducing erosion are less apparent. Some recent demonstrations of land conservation measures have successfully shown that they can result in improved productivity, which may assist in the adoption of erosion control measures.

Ensure Administrative Sustainability

The administrative requirements of any local policies need to lie within the capacities and resources of the management institution. CAC polices (regulations) may be particularly demanding on institutions—both for monitoring compliance and imposing sanctions. There are many instances in the lake briefs where it was stated that existing regulations were fine in principle but were not enforceable (African Lakes Workshop, Lakes Malawi/Nyasa, Nakuru, Naivasha, Chad, Cocibolca

Table 5.1 Command and Control (CAC) and Economic Instruments Described in the 28 Lake Briefs (cont'd.).

Lake Basin	Command and Control			Economic Instruments			
	Standards	Bans/Quotas	Zoning	Licences to access resources	Subsidies	Effluent Charge	Fees for use of natural resources
Great Lakes (North American)	Water quality standards; Regulations on discharge of nutrients from livestock operations	Prohibition on further water diversions					
Issyk-Kul		Ban on grazing and hunting in mining lease	Land use controls in Biosphere zones				Rents for grazing land use
Kariba Reservoir	Guidelines for resource use on Zimbabwe foreshores	Fishing quotas; Closed fishing seasons in Zambia					Charges for water use for hydropower production
Laguna de Bay	Water quality standards		Fish pen zones	Fish pen fee		Industrial pollutants levies	
Malawi/Nyasa	Standards for fishing gear; Regulations on forestry activities			Water use permits in Tanzania			Water resources use charges in Tanzania[2]
Naivasha		Fishing moratorium; Quota on number of fishing licenses	Zoning over shoreline use	Water use permits			Water resources use charges[1]
Nakuru	Industry and effluent standards (local council)		National Park zoning; Forestry zoning (degazetted)	Water use permits			Water resources use charges[1]
Ohrid	Water quality discharge standards; Fishing regulations; Regulations on use of agro-chemicals	Prohibition on non-native fish	National Park and other protected areas; Littoral zone protection (FYR Macedonia)				Fish levy at 10% of catch value (FYR Macedonia)
Peipsi/Chudskoe	Fishing gear standards and catch limits; Water quality standards	Quotas on fish catches (exchangeable between Estonia and Russian Fed.)			Removal of fertilizer subsidy (Russian Fed.)		
Sevan			National Park and other protected areas	Licenses for traditional fishing			Payment for use of fishing resources
Tanganyika	Fishing regulations						Water resources use charges in Tanzania[2]
Toba	Regulations on lake level		Land use controls; Prohibition on constructions within 10 m of shoreline	Permits issued for forestry			Environmental management fee set at 1% net revenue from chemical factory
Tonle Sap		Ban on fishing in fish sanctuaries	Land use controls in Biosphere zones				
Victoria	Fishing regulation		Wetland protection zones (Uganda)				Fish catch levy trial (Tanzania)
Xingkai/Khanka	Water quality standards		Ecosystem protection zones (China); Nature reserves (Russian Fed.)				

Note: No information provided in briefs on Lake Titicaca and the Tucurui Reservoir.
1. Kenya has legislated for water resources user fees but has yet to introduce them.
2. Tanzania has legislated water resources use charges.

Briefs and in a mid-term evaluation report on Lake Titicaca). The thematic paper on lake basin problems in Africa claims that there is a lack of enforcement of laws governing pollution of water, environment, farming practices, and waste discharge in all countries in Africa, while the Lake Nakuru brief lists the range of lake basin problems that are poorly regulated as including "uncontrolled sand harvesting and quarrying along river channels, illegal diversion and damming of streams and rivers, dumping of industrial wastes in unapproved areas, cultivation along river bank buffers, and illegal conversion of public utility land for private use."

Weak enforcement arises primarily from three underlying problems:

- Lack of equipment, knowledge, and training; for example, at Lake Baringo the Fisheries Department could not carry out regular surveillance because they lacked motorized boats;

- Lack of political and administrative leadership for enforcing the rules; for example, the Eastern Mau forest in the Lake Nakuru basin, originally over 65,000 ha, has been progressively de-gazetted over the last 10 years to make way for human settlement, even though it is central to the protection of the lake. What forest remains now is restricted to the crest of the escarpment, and consists of thickets of bamboo interspersed with stands of trees; and,

- Resistance from stakeholders in the lake basins; this can be overcome with improved understanding of the benefits of the policies and by ensuring that the affected communities have a real role in formulating and implementing them. Thus, the extensive involvement of fisherfolk in management of the Lake George fishery has resulted in a high degree of acceptance of new fisheries regulations.

Experience in the 28 cases illustrates the difficulty in building institutions that are effective and sustainable. This is increasingly difficult when the scale of the institutional responsibility increases. Localized institutions may be easier to set up and maintain than regional or international institutions.

Overcoming the hindrances in administrative sustainability is not easy for any institution. But identification as well as removal of inadvertently introduced obstacles, creation of conducive environments for collective pursuit of a common goal, introduction of innovative but informal means of sharing of information and data, and institutional adjustments to the long-term needs for sustainable use of lake basin resources need to be continually explored.

Be Equitable

One important requirement of good local policies is that they are fair and protect those who are underrepresented, poor, or from marginalized communities. This is closely connected with widespread community representation on the institutions that establish and implement the rules.

There are clear examples in the briefs where rules have been introduced that do not protect the powerless. Lake Naivasha provides an example where there has been a progressive involvement of those who use the lake's resources, although some—such as the Maasai pastoralists—are still poorly represented in decisions about water allocation. Perhaps the most dramatic example occurred with the displacement of local, disadvantaged persons living in the area flooded during the construction of the two large reservoirs in this study, the Kariba and Tucurui Reservoirs. At the Kariba Reservoir in the 1950s, the Tonga people were displaced to make way for the new reservoir and neither adequately compensated nor able to reap benefits from the dam. This is described more fully in the next chapter.

Actively Work toward Policy Integration

Different policies in different sectors of the economy should be coordinated to help obtain the desired benefits from the lake basin. It requires that analysts, planners, 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 that results in reduced water quality.

Policy integration is especially difficult for transboundary lake basins. The Great Lakes Commission of the United States and Canada illustrates the many decades required for the evolution of a successful international management regime. For example, the numerous difficulties in implementing improved management in Lake Victoria illustrate the great challenges in tackling diverse problems in a developing country context with a weak enabling environment within a much shorter period of time. Strengthening national and international collaboration mechanisms is one way in which common difficulties can be shared and possible ways to overcome these difficulties can be discussed. In many cases these difficulties are created simply because of a lack of information.

Chapter 6

Involving People and Stakeholders: An Essential Element of Effective Lake Basin Management

Key Lessons Learned about Involving People

- Public participation and active stakeholder involvement is essential to managing lakes and their basins for sustainable use. There are numerous benefits, including a greater acceptance of rules for allocating lake basin resources if stakeholders are involved in their formation and implementation.
- All affected stakeholders, both powerful and marginalized, need to be included in the decision making process. Historically disenfranchised stakeholders, including Indigenous Peoples, must be included if they and the lake basin are to benefit.
- Not only does stakeholder involvement potentially improve lake basin outcomes, but the omission of stakeholder groups from key decisions can lead to serious problems if their livelihoods are affected. Examples in the briefs show there is still some way to go in involving necessary groups in some lake basins.
- Creating linkages to the improvement of livelihoods of the local communities is a key to promoting participation in lake basin management and moving toward sustainable use of lake basin resources in many developing countries.
- Without proper understanding and appreciation of the local cultural beliefs, values, and norms, a lake basin management plan will not be accepted and properly implemented by the community.
- Women play a central role in the provision, management and safeguarding of water. Their participation in a full civil society, using a participatory approach and using culturally sensitive methods, will enhance efforts to achieve effective lake basin management.
- NGOs and CBOs play key roles in agenda-setting and the policy development process. Their roles include operational functions, networking, collaboration, and mediation among government agencies and local communities, and transferring skills to local institutions and community groups.
- Any effort that depends upon a change in behavior or compliance with new legislation must rely on CEPA (Communication, Education and Public Awareness) if change is to occur.

Throughout this report reference has been made to the need to manage lakes and their basins together for sustainable use. Of all the elements of this shift, none is more difficult and controversial than the movement from a citizenry that "receives governance" to one that is organized and participates actively in the governance process. The briefs are replete with examples of engineering solutions, some of which have led to major improvements in the environmental status of lake basins. However, even when engineering solutions are successful, behavioral change at the individual, household, and community levels is essential for sustainability, and involving people is the only means to that end.

Management plans or programs will be difficult to fund and implement without the involvement of people who are directly or indirectly dependent on a lake basin's resources, since stakeholders will have little sense of ownership or commitment. The number of stakeholder groups competing for the limited resource base can be quite large, making public participation and stakeholder involvement particularly important. The briefs show that some lake basins have gone through many decades of struggle to improve their management, and in the process have devised ways to involve people in the development and implementation of their management plans and programs.

How deeply people are involved in lake basin management varies from one lake basin to another. For example, fisheries are a major resource in many lakes, and the development and implementation of various fishery management schemes requires strong involvement of the fishing community. The mode of involvement, however, varies depending on the type of fishery. In the case of a community-based subsistence fishery, the mode of involvement has to be adjusted to the traditions, culture, and life style of the fishing community, while in the case of an export-oriented fishing industry, the socioeconomic implications of the industry to the lakeshore communities have a strong influence on the mode of involvement. Again, the involvement of people in lake basin management activities has been the major driving force in promoting environmental protection, pollution controls, ecosystem management, and biodiversity preservation in many countries in the industrialized world, including countries in Asia-Pacific, North America, and Europe.

This chapter discusses this subject from two perspectives. First, it summarizes the discussion in the lake briefs and thematic papers on public participation and stakeholder involvement, including how the process of developing and implementing lake basin management plans and projects can be better facilitated with the involvement of people. Second, based on the findings from the briefs, it explores ways to improve community participation and stakeholder involvement, particularly in areas such as communication, education, and public awareness (CEPA). It also discusses gender equity and women's participation, involvement of Indigenous Peoples, and the special issue of displaced peoples. Emphasis is given to the role of NGOs and CBOs in management and communication. In addition, the chapter briefly introduces the international context of participation and involvement, as well as the role of international NGOs.

Benefits of Stakeholder Involvement

Participants at all three regional workshops agreed emphatically that public participation and stakeholder involvement in lake basin management are essential, including relevant groups upstream, downstream and even outside of the basin if they are stakeholders. The briefs also stressed the benefits of stakeholder involvement in lake basin management, including the following examples.

- The public's interest in the implementation of a management plan is generally longer than the time span of the government officials and so participation can promote sustainability. "The long-term viability of many project outputs would depend heavily on local populations because of their residence as opposed to the government staff (African Lakes Workshop)."

- The local community would be able to provide the local knowledge useful for developing and implementing the management plan (the Lakes Victoria and Tanganyika and Chilika Lagoon briefs and the African Lakes Workshop all identified this advantage) as exemplified by the observation, "the existing practices reflect not only the interests of local communities but also their informal management methods (Chilika Lagoon brief)." It also implies that local cultural beliefs, values, and norms need to be fully understood and appreciated by the developer of the management plan for it to be accepted and properly implemented by the community.

- Community-based activities using a participatory approach could bring into the policy development process the voices of usually excluded stakeholder groups so "policy makers can draw insight into what works and why, and use that knowledge to create strategies to bridge the gap between national or regional policy and local practice (Lake Toba brief)." Not only does their involvement confer the above benefits, but it can assist with improving social equity and poverty reduction.

- There is a greater acceptance of rules for allocating lake basin resources if stakeholders are involved in their formation and implementation. As the Lake Champlain brief says "Because stakeholders have been involved from the beginning of the planning process, they have shown a greater acceptance of the policies and actions developed, and a greater willingness to form partnerships to work toward implementation." There is also a reduced cost of enforcing the rules if the stakeholders have been involved in formulating them since the communities are more willing to become

Box 6.1 Participation and Involvement: Defining Key Terms

The terms "participation" and "involvement" are used interchangeably in this report. There are four levels, or types, of participation, in ascending order from least influence to most influence: (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). The four levels are not indicators of scale; they indicate distinctly different types of participation. It should not be assumed, however, that all participation is good or that a higher level of participation is automatically better; the type and extent of participation depends on the situation.

The terms "public", "community", "citizen", and "stakeholder" are used with loose distinctions. Public participation is often distinguished from stakeholder involvement, with the latter processes being more inclusive and targeted. Stakeholders are defined as individuals or groups who make use of, have an impact on, or are impacted by, decisions regarding the use and management of lake basin resources. There is no blueprint for stakeholder participation. In many situations, it is useful to get an overview of all the stakeholders relevant to the issue of concern using "stakeholder analysis". Such an analysis can help refine issues that are strongly felt but often poorly articulated.

The term community designates both communities-of-place and communities-of-interest. Communities-of-place include members of the public who may be affected by, or interested in, management decisions and actions by the nature of their residency within or near management activities. Communities-of-interest include groups with a focused interest in (often accompanied by organized efforts to influence) management of resources unrelated to their member residence (Kusel 1996). Some communities may be both of place and interest, such as villages highly dependent on fisheries, forestry, or agriculture.

involved in implementation activities (Chilika Lagoon and Lakes Baringo, Naivasha and Toba briefs).

- Public involvement can help get politicians interested in supporting lake basin management. The protests of fisherfolk at Chilika Lagoon, and public understanding of the implications of losses of public assets at Lake Cocibolca all contributed to building government support.

- Public participation, particularly through skilled NGOs and CBOs, can also augment the skills of management institutions (Lakes Toba and Champlain briefs).

Overall, the briefs stressed that community participation needs to be properly designed (Lake Victoria brief, African Lakes Workshop); the roles of communities and government institutions need to be well defined (African Lakes Workshop, Lake George report); existing traditional structures should be involved where feasible (Lake Malawi/Nyasa brief, African Lakes Workshop); and local and international knowledge institutions should be involved (Lake Naivasha brief).

Identifying and Involving Stakeholders

The management of a lake basin involves a broad spectrum of stakeholder groups concerned with both land and water management. The Lake Naivasha brief provides an example of the limitations on lake basin management when some important groups in the basin have not been involved. Although there has been a history of growing involvement by groups around the lakeshores, the communities in the upper basin have little interest or involvement in the lake. The loads of pesticides, nutrients, and sediments entering the lake from the intensive horticulture practiced around the lakeshores is believed to be low, partly because groundwater flows away from the lake and partly because of stringent self-regulation. Rather, these pollutants are believed to originate from poor agricultural practices in the upper catchment, and this circumstance is unlikely to change while these groups are not fully included in the lake basin management process.

While some of the stakeholder groups have a vested interest in lake basin resources themselves, others, like politicians, play catalytic roles. For example, during the African Lakes Workshop it was noted that legislators and their staff may themselves be important stakeholders, but they represent the constituent stakeholder groups. Depending on specific lake basin management cases, other kinds of catalytic stakeholder groups may be identified. For example, the Lake Champlain brief identifies watershed associations as catalysts for "non-regulatory protection programs." The experience of most of the developing countries also suggests that international actors constitute an important group of stakeholders. They play a unique and critical role in the translation of global institutional agendas and local grassroots agendas into a common policy for sustainable lake basin management. Often, it is international actors that provide critical technical and financial assistance for developing and establishing participatory lake basin management in the developing countries.

If possible, it is best for stakeholder groups "to be involved from the beginning of the planning process so that they may have a greater acceptance of the policies and actions developed, and a greater willingness to form partnerships to work toward implementation (Lake Champlain brief)." The Lake Toba brief also emphasized that stakeholders should be involved from the outset of the planning process. However, this is not always possible because of the different levels of experience, capacities, and vision of the groups and the closeness of the issues to their concerns. The Laguna de Bay brief took a more organic view, seeing lake basin management as "a work in progress with different stakeholders. Understanding a lake and its environs takes time, and, along the way, knowledge is gained and mistakes are committed."

A number of the lake basin briefs stated that the power of community-level participation is evident when the outcomes of participation are clearly and directly linked to an improvement in the livelihoods of participating communities. The Lakes Champlain, Baikal, Baringo, Malawi/Nyasa, and Nakuru briefs all stated that local people would support interventions that will improve their livelihood security, while the Lake Toba brief stated that people will not change their behavior until they realize or experience the benefits (Also, to note, while it was not mentioned in the lake briefs, there is also good evidence from research into procedural justice (Syme and others 1999) that stakeholders who have been involved in decisions show increased acceptance of rules, even when the rules do not favor their interests.) The use of small-grants programs and a focus on poverty reduction activities, including in GEF-funded projects, is an important aid to promoting stakeholder involvement and contributing to sustainable lake basin management. At Lake Nakuru, the biggest hindrance to undertaking catchment restoration activities was that many communities could not immediately identify the potential benefits of the activities. Overall, the experiences with rural water supply, sanitation, and reforestation projects in the briefs indicate that participation of citizens and local communities greatly improves the likelihood that project assets will be fully used and properly operated and maintained.

The participation and involvement of an individual is strongly influenced by that of the group he or she belongs to, or more broadly, by the political and/or cultural environment he or she is in. For example, one brief points out that people are more easily convinced by their neighbors' experiences and tend to trust those they live with rather than outsiders. In this connection, one of the briefs states, "Behavioral change does not happen until people realize or experience the benefit resulting from the change. Behavior can be said to have changed only when newer behavior patterns replace older ones consistently and are sustained thereafter. Measuring the change of behavior as a result of environmental education of schoolchildren would certainly take a very long time, but the results can be far more effective and sustainable" (Lake Toba brief).

The briefs describe a range of techniques for improving community involvement. For example, the Bhoj Wetland brief states, "Community participation may be made more effective if they are combined with awareness campaigns and other eco-friendly activities"; the Lake Ohrid brief describes "a pilot project and catalytic measures designed to test and demonstrate affordable and cost-effective measures for improving the environmental conditions in the watershed." The thematic paper on basin problems in Africa mentions involving stakeholders in "drafting of regulations and in monitoring and enforcing." At Lake Toba, a coordinating board of stakeholders has been established "to build synergism, coordination, and sustainable development of the drainage basin, including regular monitoring to allow timely corrective measures." Other approaches are described in the following sections on awareness raising and education, gender equity and women's roles, and NGOs and CBOs.

Some successful examples of capacity building in community groups include the fire-fly monitoring (including by school children) program at Lake Biwa; an awareness-building program that was linked to the establishment of four wildlife sanctuaries managed by local communities at Lake Baringo, and the involvement of fishing communities in helping enforce a fishing moratorium; the training of fishing communities at Lake Victoria in raising and releasing weevils for water hyacinth control; and the involvement of citizens and stakeholders in developing a comprehensive plan for the Lake Champlain basin.

Women, Indigenous Peoples and Displaced People

In many briefs and at the regional workshops, specific reference was made to the important role of women, Indigenous Peoples and displaced people in lake basin management. Key lessons for these three major groups of stakeholders are summarized below.

Gender Equity and Women's Participation

The nature of gender issues in lake basin management is not much different from that in other environmental and natural resources management settings. The experiences in the lake basin briefs, however, reinforce the notion that without full and persistent attention directed to gender issues, it will be more difficult to achieve successful and sustainable implementation of lake basin management. Some comments from the briefs include:

- Women's roles have been and will remain important in lake basin management (Box 6.2), although there are numerous obstacles to recognizing and promoting their roles. Deliberate efforts have to be made to remove obstacles and to provide opportunities for women to participate;
- Better governance, institutions, and policies will arise from an empowered and gender-sensitive community (thematic paper on Basin Problems in Africa); and,
- Particularly in rural areas, where women's energy and competence are well-developed, the integration of women into the development and decision making process is of great importance (Lake Constance brief).

Box 6.2 The Important Role of Women

The importance of women's participation in the water sector was raised at the International Conference on Water and Environment (Dublin 1992) and at the United Nations Conference on Environment and Development (Rio de Janeiro 1992). In particular, the third of the Dublin Principles relates specifically to the issue of women's participation, stating that "Women play a central role in the provision, management, and safeguarding of water." Increasingly, government officials of institutions related to water management are aware of the need to recognize women's participation in the hydrological sector.

Women play an increasingly important economic role in developing countries, particularly in countries where the economic crisis has pushed men to migrate to cities or to other countries in search of increasingly important cash incomes. In the wake of this massive migration, many rural women have become the head of their household. In addition, women have become more active in their community's administration, such as the management of their water and sanitation systems, community services, and other economic responsibilities. In most of the poor agricultural economies of Africa, Asia, the Middle East, and Latin America, women are working in the fields, managing the transportation of their products, and offering their products in the marketplace. Nevertheless, as a result of gender bias, this work is generally unrecognized and their economic role is invisible.

Women also have active roles in the non-economic sector. Urban and peri-urban water use related to health relies mostly on women as housekeepers, where they are in charge of the washing, cooking, and other hygienic activities within the family. The lack of access to safe water and sanitation, especially in rural areas, and the exposure to contaminated water are linked to pregnancy failures, infant illnesses, and deaths, as well as all sorts of water-related diseases that affect the community and family health. A greater part of government budgets goes to "curative" health programs, instead of "preventive" health programs that could be managed by women. In many rural areas, women are in charge of watering and washing cattle, irrigating homestead crops, and other tasks. They have to spend hours every day collecting water, sifting it, or taking care of their children affected by water-related diseases. If women had more access to training for more efficient use of water and the care of waterbodies such as lakes, they could prevent many health problems and have more time to spend on other economically productive activities with their families.

Several examples of targeted efforts to promote the participation of women emerged from the lake briefs. For example, a three-month gender sensitivity training course was instituted at Lake Nakuru; at Lake Toba, participatory rural appraisal (PRA) was a successful technique in which women were invited to participate in community meetings; in the upper watershed of Chilika Lagoon, a pilot project was conducted to create women's forums geared to enhance their participation; at Lake Biwa, women organized the "Soap Movement" to reduce use of a detergent that was causing pollution and contamination in their lake; and at Lake Baringo, eight women's groups were funded to start microenterprises, including purchase of zero-grazing animals, poultry-keeping, merchandise kiosks and market-day trading, and food crop production.

Promoting the role of women does not always mean that they should contribute jointly with men. In some cultures, it is not appropriate for a woman to attend a meeting with men and it is more appropriate to organize separate activities. "Men organize the men's activities, women organize theirs," one workshop participant said of a case at his lake basin. For Lakes Nakuru, George, and Toba, a community-based process was used where women could attend meetings or participate in activities with other women.

Indigenous Peoples

Indigenous Peoples have a wealth of traditional knowledge and experience and a key stake in the sustainable use of lake basin resources. However, Indigenous Peoples are often among the historically disenfranchised stakeholders. The experience in the lake basin briefs shows the importance of engaging all basin stakeholders, especially Indigenous Peoples.

In many cases, Indigenous Peoples may have been forced, due to displacement by other groups and/or restrictions of access to traditional grazing lands, to use unsustainable livestock practices. As reported in the lake briefs, the indigenous communities that live in the Lake Baringo basin keep large numbers of cattle which overgraze the basin leading to increased soil erosion, sedimentation in streams and the lake itself, and intensification of frequent flash floods. The large herds of cattle also invade the lakeshore where they destroy the habitats of various plants and animal species. Reducing the number of animals in the herds is a practice which is not acceptable to the pastoralists. As an alternative, a participatory range management plan that regulates access to grazing lands and movement of herds could be developed with involvement of pastoralists and enforced by elders. However, this has yet to be developed. Issues of limited access to lake waters by indigenous pastoral communities were also reported in the Lake Naivasha brief. It should be noted that traditional pastoralists may not understand the effects that their individual activities have on the lakes and their resources.

In other cases, such as Laguna de Bay, indigenous communities are located in the near shore area and depend directly on lake resources for their livelihoods. At Laguna de Bay, a National Commission on Indigenous Peoples that was created at the country level to protect the welfare and interests of Indigenous Peoples played a useful role in involving these communities in lake management. Other examples have been less successful. Although overcoming extreme poverty situations and paying attention to the rights of indigenous communities were identified as important issues for lake basin management efforts in several lake briefs, there remains a need to significantly increase the engagement of these communities. Careful study of pre-existing resource use rights,

Box 6.3 Indigenous Peoples: Key Lessons from Lake Titicaca

Located in the Andes Mountains on the border of Bolivia and Peru, Lake Titicaca is, volumetrically, the largest high altitude lake in the world. Although year-round air temperatures on the high altitude plateau are cool at night (8-10 degrees C) and moderate during the day, the lake has a moderating effect on the local climate, which has led to the development of unique plant and animal species and also the establishment of indigenous communities. With the exception of mixed populations found in cities and large towns, the general population of the Titicaca basin is comprised almost entirely of Indigenous Peoples: the Quechua zone in the north, the Aymara zone in the center, and another Quechua zone in the south. In addition, the Uro population is located in some areas near the lake, including the Puno area in Peru, in the Desaguadero River basin in Bolivia, and around Poopo Lake in Bolivia.

With the change from Spanish colonial rule to national rule, large tracts of land were taken from indigenous communities to form properties controlled by new landlords. This system of large haciendas remained until the application of agrarian reform laws in Bolivia in 1953 and Peru in 1969. This history, spanning centuries, created hostility and distrust among the indigenous population that remains to this day. Later policies to create an open market resulted in the reduction of prices for agricultural products. Added to this, government investments in infrastructure and services in cities had a negative impact on rural areas. Nevertheless, the local population possesses a great desire to improve livelihoods in the Lake Titicaca basin, which if properly directed could produce positive results for the people and the lake.

The introduction of exotic species in the Lake Titicaca basin, such as the Trout (*Salmo truta*) during the 1940s, and the Pejerrey (*Basilichtys bonaerensis*) to Lake Poopo in 1969, led to the extinction of native fish species and infestation of a protozoan parasite that affected 70 percent of the annual native fish harvesting in 1988. These fish introductions had negative impacts on the socioeconomic conditions of the Aymaras and the Urus whose indigenous communities and livelihood patterns depend on native fish.

Source: Lake Titicaca Brief.

traditional management methods or potential impacts to the environment or local communities is especially important in areas with indigenous communities. Mechanisms should also be developed to protect the rights of Indigenous Peoples and resolve conflicts that may arise.

Lake Titicaca, where the rural population is almost entirely made up of Indigenous Peoples, provides another example where there is a need to increase the participation of indigenous communities in lake basin development (Box 6.3). In this context, agreements between Bolivia and Peru led to the establishment of a binational authority and the creation of a Master Plan for Flood Prevention and Resource Management in the Lake Titicaca basin. The binational authority has recognized a special role for indigenous communities and other key stakeholders in the implementation of the Master Plan.

Experience shows that lake basin management is more cost-effective if stewardship of lakes and their basins is built upon the customs and cultures of the community. Furthermore, the disruption of traditional uses of a lake and basin resources can negatively impact the daily activities, food sources and ability of the lake basin environment to support life. It is important to recognize that direct engagement with indigenous leaders and indigenous communities has proven to be the most effective way to foster their participation in lake basin planning and management activities.

Displaced People

A special case arises with reservoir construction or when management interventions at lakes (especially those involving infrastructure such as regulation dams/weirs, flood control structures and drainage programs) affect the livelihoods of local people. It is becoming widely accepted that local people affected by these investment decisions must be involved from the beginning and compensated when they suffer losses. Increasingly, development projects recognize the need to focus on restoration of livelihoods rather than solely on compensation, and the importance of making communities the beneficiaries of projects. However, this has not always been the case. For example, the Kariba Reservoir brief describes how, in the 1950s, prior to the use of resettlement action plans and other instruments used today, 80,000 Tonga people were displaced from their traditional lands to make way for the dam. They were neither involved in the decisions about the dam, adequately compensated for their losses, nor able to share in the benefits from the dam and reservoir.

There can be secondary and tertiary impacts beyond the direct impacts of dams and similar large infrastructure on local people. Typically, infrastructure projects in developing countries attract both formal and informal populations during the construction period, who in many cases become permanently settled in the project area. Although addressed in many contemporary projects, these impacts have historically received little or no attention in project planning and implementation, despite the often significant ecological and social consequences. In the case of the Tucurui Reservoir, which commenced operation in 1984, 4,300 families were displaced but the reservoir construction attracted over 20,000 workers to the dam site. These increased populations bring further social changes. At the Kariba Reservoir, the construction workforce attracted prostitutes to the area with a concomitant rise in sexually transmitted diseases. Not all changes are detrimental. At the Tucurui Reservoir, traditional small-scale navigation was replaced with road transportation; there was also a change in the macro economy, including large-scale industrial, forestry, and agribusiness projects. Small businesses derived from the rapid increase in the worker's population also developed rapidly. The important point is that public decision makers (at a variety of levels of government) and stakeholders need to be adequately informed of the scope of the proposed project, have access to information on the positive and negative impacts of the construction and operational phases of the investment, and have the opportunity to participate in public consultations and receive compensation for losses in a transparent manner.

The Role of NGOs and CBOs

The briefs illustrated the diversity of roles played by NGOs and CBOs in lake basin management.

Agenda Setting and Policy Development

NGOs and CBOs have the advantage of being more independent of political pressures than formal management agencies, and so are often well positioned to play an important and frequently leading role in the agenda-setting and policy development processes. For example, in the Lake Baikal and Lake Biwa basins, consumer and environmental movements have played key roles in some of the major changes in environmental management.

In many other cases, NGOs have had an active role in promoting issues within institutions for lake basin management (Lakes Champlain, Naivasha, Nakuru, Ohrid, Peipsi/Chudskoe, and the North American Great Lakes). For example, the Peipsi/Chudskoe Center for Transboundary Cooperation is a regional NGO that works to promote sustainable development and transboundary cooperation in the border areas of the Baltic States and the New Independent States. It cooperates with the local authorities and stakeholders on regional development projects, as well as on educational, research, and social projects in the region, and is also actively involved in the work of the Estonian-Russian Transboundary Water Commission.

International NGOs not only play a unique and critical role in the translation of global institutional agendas and local grassroots agendas into a common policy for sustainable lake basin management, but they also lead many new initiatives that are supplementary and/or complementary to the activities of the international funding organizations and national governments. Increasingly, the environmental threats to lakes have a regional or global dimension. For example, the World Wildlife Fund for Nature (WWF) brought international attention to the threat to the internationally recognized flocks of flamingos at

Lake Nakuru from urban and rural pollution. IUCN has played a pivotal role in supporting the Ramsar Convention, which has provided the basis for defining a number of threatened lakes as Ramsar sites. They can also assist in linking lake basin management programs with global initiatives and sister lake programs; for example, the Tahoe-Baikal Institute is a registered nonprofit organization that organizes education, research, training, and exchange programs between these sister lakes in the United States and the Russian Federation.

Operational Functions

There are examples in the lake basin briefs where NGOs perform operational functions. In other cases, NGOs act as implementing agencies for lake basin management. Lake Naivasha is the outstanding example where a lakeshore protection organization has evolved to play a major role in lake planning and management. In still other cases, NGOs have implemented projects through small grants provided by governments or international donor organizations. NGOs and CBOs can become very experienced and effective in such work because of their closeness to communities and their needs, their flexibility in operations, and their low cost structures.

Networking, Collaboration, and Mediation

NGOs are often active in networking, collaboration, and mediation among government agencies and local communities. Examples from the lake briefs include:

- The network of NGOs and CBOs that has promoted an outreach program around Chilika Lagoon. The stakeholders have also formed a federation of NGOs and CBOs called the "Campaign for Conservation of Chilika Lagoon" that is working closely with the Chilika Development Authority;

- A network of community groups has been used to undertake conservation activities at Lake Nakuru;

- With a wide area of jurisdiction and with limited staff to carry out its mandate, the Laguna Lake Development Authority has developed strategic alliances with local government, CBOs, and NGOs to help gain wide support in the implementation of its plans and programs; and,

- "NGO roles can become even more significant when there has been past political instability" (Tonle Sap brief).

Although NGOs also often play an important role in mobilizing funds for lake basin management, maintaining a steady flow of funds has always been challenging for lakes in the industrialized countries (Lakes Biwa, Champlain, Constance, and the North American Great Lakes briefs) as well as in countries in economic transition (Lakes Baikal, Peipsi/ Chudskoe and Ohrid briefs) and in developing countries (Lake Naivasha brief).

Communication/Facilitation Role

NGOs have played an important role in the collection, dissemination, and analysis of information in the Aral Sea basin, North American Great Lakes, and Lakes Baikal, Champlain, Nakuru, and Naivasha. In other cases, NGOs have played the role of information brokers, facilitating the exchange of information across national borders (for example, the Peipsi/Chudskoe CTC). NGOs often are active in public awareness raising and environmental education; illustrative examples of public awareness campaigns include those from the Aral Sea and Lakes Baikal, Ohrid and Peipsi/Chudskoe. A lake basin program may form an outreach partnership with a network television affiliated in the basin. The features, specials, and promotional material aired for the project may reach millions of viewers in the basin, with the costs shared among partners (Lake Champlain brief).

Whether through governments or NGOs, effective communication strategies are matters of critical importance in lake basin management because of the need for the stakeholders to understand the complexities of biophysical phenomena and the complexities and subtleties associated with socioeconomic, cultural, and political dimensions of management. As indicated in the Lake Malawi/Nyasa brief, researcher-policy maker communication problems need to be overcome for every lake.

Training

International NGOs often have specialist technical skills within their organizations and can transfer some of these skills to local communities and institution staff through training programs and other capacity building exercises. For example, the Wildlife Conservation Society has been able to train counterpart staff from Cambodian government agencies in techniques of biodiversity survey and assessment, report preparation, and environmental education and awareness. Other NGOs such as WWF-Cambodia have undertaken similar projects. Training needs analyses have been undertaken as part of donor-supported natural resources management projects in Cambodia.

Funding NGOs and CBOs

Funding is needed to sustain the above NGO and CBO activities over the long term. In both developed and developing countries, NGOs proliferated through specific projects and programs for lake basin management. In particular, international aid programs and donor agencies, but also international NGOs, have played an important role in the development of the NGO sector in countries in economic transition and in developing countries. The Chilika Lagoon and Lakes Ohrid, Peipsi/ Chudskoe, and Baikal briefs provide examples. Yet many of them currently face difficult organizational and financial challenges because of the short-term nature of these funding sources. In both the developed countries (such as Lakes Biwa, Champlain, Constance, and the North American Great Lakes) and countries in economic transition and developing countries (e.g. Lakes Baikal, Naivasha, and Ohrid), NGOs have problems to consistently maintain even part-time staff.

Communication, Education and Public Awareness (CEPA)

Effective participation of local communities in lake basin management means that local communities need access to technical, social, and economic information. Consequently, public awareness and information campaigns are a vital part of the participation process. In fact, any effort that depends upon a change in behavior or compliance with new legislation needs to rely on CEPA (Box 6.4) if change is to occur. The lake basin briefs provide a wide range of experiences with regard to CEPA.

Designing CEPA Programs

Integrated approaches should be considered in designing and implementing CEPA programs. Awareness-raising or community education alone will not stop unsustainable resource exploitation by community members; several factors need to act concurrently, such as changed community values, availability of alternative behaviors, and disincentives for unsustainable activities. Lake Ohrid is an example where increasing community awareness through community-based organizations, coupled with changes in legislative frameworks, is slowly helping to improve the conservation of the lake system.

Situation analysis and problem identification should be undertaken before designing the CEPA program. A basic principle of intervention in community affairs is that root causes of problems must be understood and agreed upon before actions are developed and implemented. A period of research is necessary for gaining an understanding of the situation and helping the community to understand the root causes of the problems, and also to analyze their relationship to government, other communities, and middlemen.

Indicators of success, monitoring, and evaluation are essential to assess the effectiveness of CEPA programs. As with other aspects of conservation, it is extremely valuable to assess the success of CEPA actions in relation to the measurable objectives, including changes in the community's attitude to the need for resource conservation and co-management initiatives.

The Scope of CEPA Programs

CEPA is often slow-acting and is best understood as a series of investments for significant future returns with each investment strategically linked to ensure direction, continuity, and effectiveness. Strategic thinking and coordination between activities and programs should be important components of CEPA action planning, which should also be realistic about time-scales. CEPA activities take time to be effective. For example, at Lake Biwa, long-term efforts on changing values and empowerment have paid off after many years; at Lake Nakuru, the 10-year CEPA program has not yet reached a threshold level.

CEPA programs should be sustained and sustainable, with innovative arrangements and capacity building. It is thus sensible to link with institutions that will provide long-term funding. At Lake Constance, networking, campaigning, and public relations required sustainable finance; at Lake Champlain, the program employed a full-time education and outreach coordinator and a communications and publications coordinator; at Lakes Biwa, Tanganyika, and Toba, mainstreaming environmental education was a means to ensure sustainability; and at Lake Chad, local user associations were provided with loans to establish institutions for management of water resources, with the fees used for maintenance of the equipment but also for implementation of environmental projects. The Lake Ohrid experience highlights the importance of using early successes to leverage investment in, and broad support for, sustaining CEPA programs. At Lake

Box 6.4 Communication, Education, and Public Awareness

The components of CEPA—as described by the Ramsar Convention on Wetlands based on UNESCO, the Convention on Biological Diversity, and the World Conservation Union-IUCN publication—are defined as:

- Communication is the two-way exchange of information leading to mutual and enhanced understanding. It can be used to gain the involvement of actors and stakeholders and is a means to gain cooperation of groups in society by listening to them first and clarifying why and how decisions are made;
- Education is a process that can inform, motivate, and empower people to support wetland conservation, not only by inducing lifestyle changes, but also by fostering changes in the way that individuals, institutions, businesses, and governments operate; and,
- Awareness brings the issues relating to wetlands to the attention of individuals and key groups who have the power to influence outcomes. Awareness is an agenda setting and advocacy exercise, which helps people to know what and why this is an important issue, the aspirations for the targets, and what is or can be done to achieve these targets.

The five common objectives of a conservation-based CEPA program are (1) to encourage a general interest in conservation, (2) to generate greater awareness of conservation issues, (3) to bring about a specific change in opinion, (4) to disseminate specific information, and (5) to build capacity (Sutherland 2000).

Source: UNESCO (2002).

Toba, the approach was to train environmental cadres from within local communities. This proved to be a very successful way of garnering trust and support; however, the brief notes that small incentives to compensate cadres for their time and energy would help to sustain the initiative.

CEPA actions must be placed within the larger economic and social context. CEPA solutions that are not socially and economically acceptable cannot hope to achieve their goals. For example, at Lakes Baikal and Cocibolca, watershed management policies and actions needed to be linked with regional economic development priorities. The lack of awareness about social and economic benefits was a limitation to successful implementation of lake basin management efforts at Lakes Dianchi, Laguna de Bay, Malawi/Nyasa, Nakuru, Toba, and Victoria. At Laguna de Bay and Lake Malawi/Nyasa, awareness-raising and poverty alleviation actions were linked to reduce pressure on the lakes' resources, while at Lakes Baringo, Champlain, Toba, and Nakuru, environmental education and awareness programs were coupled with economic incentives and improvement of the livelihood of the local communities. At the Bhoj Wetland, the shifting of the idol immersion venue to reduce stress on the upper lake was only made possible because of an extensive public awareness campaign that was designed to work within the existing cultural and religious context.

Making CEPA Effective

Involvement of all stakeholders in identifying issues and their solutions, and providing them with sufficient technical and local knowledge of the issues, will improve the effectiveness and efficiency with which CEPA can effect change. For example, at Lake Cocibolca, increased awareness among local officials has led to an increased call for national action; at Lake Baringo, a moratorium on fishing was instituted to improve fish stocks once fisherfolk had been informed of data on catches and brought into the management process; and at Chilika Lagoon, local fisherfolk helped disseminate information about the importance of using the right mesh size nets, and imposed a ban on juvenile catch, resulting in a significantly higher yield.

Dissemination of information and data to stakeholders is important. The information and data gained from lake basin management programs and experiences should be disseminated to national and local governments, lake basin management practitioners, NGOs and other stakeholders, and should be easily accessible. At Lakes Champlain, Chilika, Biwa, Ohrid, Nakuru, Sevan, and the Bhoj Wetland, CEPA programs established resource, education, or exhibition centers; at Lakes Baringo and Toba, they established participatory rural appraisal (PRA) programs.

A variety of CEPA methods may be needed within one CEPA program. At Lake Toba, a variety of small-scale, grassroots-level CEPA programs produced tangible results; at Lakes Toba, Peipsi/Chudskoe, Laguna de Bay, Dianchi, Tanganyika, and the Chilika Lagoon, CEPA programs used IT technologies; at Laguna de Bay, water quality data was presented in a simple schematic diagram called "the Water Mondriaan"; at the Bhoj Wetland, there were competitions, rallies, and street theatre performances with a conservation message; at Lake Biwa, a "floating school" offered 5th-graders the opportunity to have fun while learning; at Lake Peipsi/Chudskoe, there was an annual international children's creative works competition; at Lake Baringo, environmental awareness packages incorporated incentives; and the GEF-funded Lake Malawi/Nyasa Biodiversity Conservation Project used an innovative environmental theatre (staffed by actors from the three riparian countries) that reached over 100,000 people.

Identification of the target group(s) is an important first step in designing an effective CEPA program. A common problem with awareness-raising activities at the community level is that they are not targeted at the groups who are most important in resource utilization and management and in forming community opinion. There is a tendency to focus on the easy parts of awareness-raising, such as education in schools, or on general presentations through posters. Better results tend to follow targeting of specific groups, following an analysis of influence patterns. For example, at Lake Cocibolca, students and the younger generation were identified as primary targets: at Lakes Nakuru, Chilika, Toba and Tanganyika, women were identified as a specific target group; at Lakes Tanganyika, Nakuru, and Tonle Sap, political leaders and decision makers were singled out as the primary target for awareness efforts; and at Lake Constance, consumers were targeted.

There may be significant benefits to be gained from involving the private sector (industry) in CEPA efforts. The "Shiga Environment Conservation Association", a private-sector initiative at Lake Biwa comprising more than 400 relevant local companies, actively contributes to and supports lake basin management activities, allowing it to operate over the long term. At Issyk-Kul, three pilot projects have been initiated for the development of green industry and tourism. The Lake Champlain Basin Program has formed an outreach partnership called Champlain 2000 with a network television affiliate and a bank in the basin. Conservation of Laguna de Bay Environment and Resources (CLEAR) is a tripartite partnership—including the LLDA, Unilever Philippines, and the Society for Conservation of Philippine Wetlands (SCPW)—to ensure the continuity of efforts to conserve the lake's resources and empower and educate the communities within the watershed. In some cases, private-sector support has come about in response to public pressure, such as the case of PT Toba Pulp Lestari (PT TPL), a private industry operator in the Lake Toba region, which agreed to set aside 1 percent of its net revenue for environmental management.

Chapter 7

Responding with Technology: Opportunities and Limitations

Key Lessons Learned about Technology

- Justifying the introduction of technological interventions strictly for the purpose of lake environment protection is generally quite difficult unless the long-term resource values of the protected environment are properly accounted for in decision making. The long-term view in policy making is critical in appropriately introducing protective technological interventions.
- Exploration of lower-cost technological options, combined with source control of pollutants, should be a priority consideration for lake basin management. A long-term objective should be to reduce, reuse, and recycle land-based sources of possible pollution through on-site control technologies with involvement of representatives from the polluting facilities and local communities.
- Nonpoint-source problems, particularly sediments, nutrients and agro-chemicals from agricultural and forestry land uses, can be tackled through community-based reforestation and afforestation, and catchment protection activities. These approaches need to be sustained for decades or even tens of decades to have visible impacts on the receiving water body. Institutional sustainability is strongly linked with successful technological interventions involving collective efforts by people and communities. In spite of the long-term benefits of retaining tree cover in lake basins, for example, there were a number of examples in the study lakes where forest clearance was practiced for short-term economic gains because of lack of awareness as well as lack of institutional strength.
- Wetlands act as efficient traps for contaminants as well as providing other valuable services. Rehabilitating degraded wetlands, and even constructing artificial wetlands, is seen as a cost-effective method of protecting lake environments because removing contaminants after they have entered lakes is very expensive. Protection of existing wetlands should be a priority.
- There is a need for concerted scientific research into technological development and application for better lake basin management. For example, the introduction of biological methods based on scientific studies has been successful at a number of study lakes to control nuisance flora and fauna. Scientific research is also needed also to ensure that the introduced biological agents will not have unexpected effects.
- A shift to a long-term view of sustainable lake basin resources use requires new conceptual approaches and innovative technological designs for lake basin management. For example, making appropriate provisions for environmental flows to maintain the ecological health and resource uses of lakes is a growing concern as more dams and weirs are constructed for water storage and regulation.

Investments in technologies that support lake basin management come in several forms. Some technological interventions such as primary or secondary sewage treatment or on-site sanitation (such as pit latrines, soakaways and septic tanks) are constructed for public health purposes for communities along the shoreline or in the basin but may have significant supplementary environmental benefits. Other technologies such as tertiary treatment for removing nutrients from sewage or other interventions including flood control works may be designed specifically to improve the lake water environment. This chapter deals with the use of both these incidental and deliberate conservation or remediation technologies; it does not deal with the much wider range of technologies intended for development purposes, such as dams or fish pens.

The term "technology" has been interpreted broadly here to include:

- Engineered infrastructure (such as sewage treatment plants and flood control dykes) as well as restoration of "natural infrastructure" (such as wetlands);
- Techniques (such as biomanipulation of foodwebs) as well as physical infrastructure;
- Technologies that can be applied within the lake basin, as well as those applied within the lake itself; and,
- Technologies that are reactive to symptoms of the problem, as well as those intended to treat root causes

such as soil erosion from poorly managed agricultural or forest lands.

Changing people's behavior through rules, incentives/disincentives, or education to bring about improvements in the environmental status of a lake is not easy. For some problems and under particular circumstances, it is more effective to use a technological response. When well-designed and implemented, these technological responses can have profoundly positive effects on lakes. However, many problems are not amenable to technological solutions, and even for those problems that are amenable, technological responses are often not sufficient by themselves. The Lake Xingkai/Khanka brief shows how construction of flood diversion canals and sluice gates on the Muling River dramatically altered the hydrology of the Lake Xingkai/Khanka Basin, allowing part of the flood waters from a hydrologically-separate river basin to eventually enter the lake. Although this engineering effort was initiated to provide flood protection to the citizens in a different river basin, the river flows through a number of major cities and towns, receiving wastewaters from these cities along its journey. This has resulted in the canals potentially affecting both human health and the environmental quality of the lake.

The range of conservation and remediation technologies included here, as well as the lessons that can be extracted from the briefs (Table 7.1), is limited for two main reasons. First, the lakes studied in this project tend to be quite large, so many of the engineering techniques used at smaller lakes (such as water-level drawdown, deep water discharge, artificial circulation, or sediment oxidation) are not described. The Bhoj Wetland (one of the smallest lakes in the sample) is an exception that illustrates some of these techniques suited to smaller lakes. Second, the focus of the briefs is on non-technological responses to problems, and so many technological responses may be omitted from the briefs. Three of the 28 lake briefs (Lake Malawi/Nyasa, Tonle Sap and Issyk-Kul) did not describe any technological responses to lake basin management problems. A more complete description of conservation and remediation technologies is available from Holdren and others (2001) and National Research Council (1992).

At least one technological response has been applied to each of the problems affecting the lakes in this study (Table 3.2), with the exception of emerging problems such as climate change and atmospheric transport of nutrients that require long-term regional and global approaches for which the practical and significant provisions have been quite limited. In the following discussion, these technologies are divided into two groups: those that are applied within the lake basin and those that are applied directly in the lake.

Watershed-based Measures

Flow Control

The ecological functioning of downstream lakes can be severely affected when the flows of inflowing rivers are modified through either regulatory structures (such as dams and weirs) or through upstream water withdrawals. In the study lakes, this has occurred at the Aral Sea and Lakes Chad and Baringo, Chilika Lagoon, and Tonle Sap. Lake ecology is affected by changes in both the volume of water reaching the lakes as a result of these upstream changes, the timings of the flows, and in some instances the changes in water quality as a result of changes in river flows. For example, some fish species used spring floods as cues for breeding; if these floods are reduced by upstream structures, then breeding may not occur or may be disrupted.

It is only recently that the significance of maintaining these important components and patterns of natural flow regimes for the benefit of downstream ecological life has been realized. These environmental flows are now being increasingly accepted as a necessary part of water resources developments. For example, the World Commission on Dams identified environmental flows as being an important aspect of dam development with environmental flows being part of "Sustaining Rivers and Livelihoods", one of the seven strategic priorities identified in the report of the World Commission on Dams (2000). Also, the World Bank has begun including environmental flow assessment as part of the environmental assessment process when it is appraising project proposals.

At both Tonle Sap (as part of the Mekong River system) and at Chilika Lagoon, there are efforts under way to identify the operational procedures that will ensure that the most important components of natural flows are maintained for the benefit the lakes (and other parts of the river systems). Both these projects are being financially supported by the World Bank; GEF is supporting the Tonle Sap project.

As part of its Water Utilization Program, the Mekong River Commission is supporting the development of river flow rules that will include environmental flows to meet such requirements as minimum monthly natural flow during the months of the dry season, the reversal of the Tonle Sap flows in the wet season, and daily flood peaks at natural levels. While hydrological, hydraulic, and some simple water quality models have been developed for the lower Mekong River, there is a dearth of information on the impact of changes in flow on both the basin's environment and on the people's use of the basin's resources. Consequently, an approach involving expert judgment has been used to develop an initial set of flow rules that meet environmental and social goals. It is intended that these initial flow rules will be superseded in about 5 years when better information is available on the environmental and social assets to be protected and the links between flows and environmental and social outcomes.

A new barrage is being constructed, with World Bank support, to replace an old weir at Naraj on the Mahanadi River, which partly flows into the Chilika Lagoon. The operation of this barrage will affect the river flows into the lagoon, potentially with impacts on the entire ecosystem. The Orissa State Department of Water Resources has made a commitment to develop an environmentally sensitive operating rule for the Naraj Barrage, and an Environmental Flow Assessment has been undertaken as part of the process of determining the barrage operating rules.

The effects of four river flow scenarios on the spatial and temporal patterns of salinity, turbidity, water level, and sediment deposition within the Chilika Lagoon were modeled using a 2-D hydrodynamic model. These effects were, in turn, translated into direct and indirect social and economic impacts on the lagoon fisheries, tourism revenue from biodiversity, and economic impacts from waterlogging on the floodplain. An interim set of environmentally sensitive operating rules were developed during 2004 as a result of these investigations. However, they will need to be revised as monitoring continues in the lagoon and the understanding of the hydrological-ecological links and the social and economic impacts improves.

Flow Diversions

Out-of-Basin Diversions

The detrimental effects of wastewater on a lake can be avoided by diverting it outside of the basin. This technique has been used occasionally in a range of countries. Over 100 years ago, the wastewater of Chicago in the north central United States was diverted from discharging into Lake Michigan, which adjoins the city, to combat typhoid and cholera outbreaks, and channeled to the Illinois River/Mississippi River system. While this solution reduced the pathogen problem in Lake Michigan, it caused a deterioration in the water quality of the Illinois and Mississippi rivers.

Of the lakes in this study, diversions of sewage have been carried out only at the Bhoj Wetland to control nutrient inflow and to minimize microbial contamination of this drinking water source. Sewage may be diverted from the Lake Dianchi basin, but this will not occur until after another diversion project—to bring water from outside the Dianchi basin for use in Kunming City—is completed. The reason is that irrigation return flows and reuse of domestic sewage are important inputs to the water balance at the lake and, if sewage is exported, then these inputs will need to be replaced with other freshwater supplies.

Although there is little discussion in the briefs about sewage diversion, the key lesson from the Lake Michigan and other examples (such as diversions from Lake Washington and Lake Tahoe in the United States) is that it is critical to assess

Table 7.1. Summary of Technological Responses at the Study Lakes.

Lake Basin	Basin							In-lake					
	Point Source				Non-Point Source			Biolo-gical	Chem-ical	Physical			
	Wastewater diversion	Conventional wastewater treatment	Advanced wastewater treatment	Industrial wastewater treatment	Wetlands rehabilitation	Forestation	Catchment protection	Predation	Biocides	Aeration	Diversions	Dredging	Harvesting macrophytes
Aral Sea		✓			✓							✓	
Baikal		✓		✓		✓							
Baringo						✓	✓						
Bhoj Wetland	✓	✓				✓	✓	✓		✓		✓	✓
Biwa			✓	✓	✓	✓	✓					✓	✓
Chad					✓	✓	✓					✓	
Champlain			✓	✓	✓		✓						
Chilika Lagoon						✓	✓					✓	✓
Cocibolca/Nicaragua		✓											
Constance			✓										
Dianchi			✓		✓	✓	✓				✓	✓	
Great Lakes (N. America)	✓		✓	✓								✓	
Kariba Reservoir								✓	✓				
Laguna de Bay		✓		✓		✓	✓						✓
Naivasha		✓			✓			✓	✓				
Nakuru		✓				✓	✓						
Ohrid		✓			✓	✓					✓		
Peipsi/Chudskoe		✓											
Sevan					✓		✓				✓		
Tanganyika						✓							
Titicaca		✓										✓	
Toba		✓				✓	✓						✓
Tucurui Reservoir		✓											
Victoria		✓					✓	✓	✓				✓
Xingkai/Khanka		✓											

Note: The table lists the technologies described in the lake briefs or that were known to the editorial team. However, it is likely that many more technological responses have been applied at the study lakes and in their basins.

whether, on balance, the benefits to the lake from diverting the wastewater outweigh the costs of the diversion plus any costs imposed on the receiving waterbody. These costs can arise from water quality problems, changes in flows, and introduction of exotic organisms in the receiving waters, together with social issues such as the perception of being the recipients of other people's wastes.

Diversion into a Basin

In cases where water in a lake basin is in short supply or when a lake has been heavily polluted, additional water can be imported from outside the basin to alleviate a water shortage or dilute the polluted water. While bringing in more water does not address the root causes of any problems (inefficient water use, overuse, or pollution), it is used in cases where neighboring basins have surplus water and other solutions are expensive. There are a number of examples in the lake briefs:

- At Lake Ohrid, the Sateska River has been diverted to flow into the lake to increase the hydropower potential of the lake;
- A 49-km long tunnel was completed in 1981 to divert water from the Arpa River to stabilize the level of Lake Sevan, and a second tunnel was completed in 2004 and both are being used to raise the lake level;
- 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 is under construction to bring in about 245 million m^3 of water to augment Kunming City's water supply. One of the purposes of the diversion of freshwater into the Lake Dianchi basin, apart from overcoming a shortage of water for urban water supply, is to increase the flushing rate of the lake in order to reduce the lake's eutrophication;
- During the latter part of the Soviet period, there were proposals to divert massive amounts of water (between 30-60 km^3/year) from Siberian rivers to the Aral Sea region to be used for irrigation. This proposal did not proceed because of economic and scientific difficulties; and,
- There are proposals to transfer water to Lakes Chad and Issyk-Kul from outside their basins. However, the large costs associated with such projects and the complex potential environmental and social impacts make such schemes slow to be realized.

While these transfers may have a beneficial effect on the basin that receives water, they may also have adverse environmental and social impacts in the basin that provides the water. Detailed environmental and social studies need to be undertaken in each case to make sure that the costs and benefits and equity implications for all users of the water resources are weighed up carefully in each case before decisions are made on water transfers.

Control of Point-Source Pollution

On-site Effluent Disposal

Simple pit toilets sometimes connected to septic tanks for primary treatment are by far the most common method of disposing of human wastes in rural (and many urban) areas in the developing countries in this study. Unfortunately, only one lake basin brief provides data on the use of these on-site methods. The Lake Cocibolca brief shows that, in the Costa Rican part of the basin, 31 percent of people use pit latrines with no treatment method, while 68 percent of the population use latrines connected to septic tanks. A negligible number were connected to a sewerage system. This is also the case in other lakes such as Victoria, Tanganyika, and Malawi/Nyasa.

There is no information on the extent to which these effluents reach watercourses. Based on experiences in other countries, septic tanks and pit latrines commonly overflow during wet seasons, creating a local health hazard and washing effluent into streams, often into shallow groundwater aquifers and eventually into lakes.

Many development agencies are pursuing programs to improve access to both safe water and improved sanitation facilities (some form of treatment such as a septic tank) in urban and rural areas in developing countries. However, the World Bank (2000) states that only 35 percent of the rural population in developing countries had access to improved sanitation, and no more than 20 percent of developing countries (and less than 10 percent of the lowest-income countries) are increasing access at the rate needed to meet the Millennium Development Goal (MDG) for water supply and sanitation. While these programs are primarily pursued for health and development reasons, the low coverage of wastewater collection and treatment implies that individual household effluent disposal poses a considerable threat to water quality in developing countries, particularly those with periods of high rainfall.

There has been growing interest shown in the technological development of ecological sanitation systems that not only encourage resource conservation (such as dry toilets to save water and produce compost materials) but also in systems that employ resource recovery and reuse (such as urine and feces separation for collection and extraction of phosphorus as a useable resource). These technologies are drawing significant interest in both developing countries and developed countries. It is anticipated that over the next few years, the conventional low-cost sanitation projects promoted in many developing countries will increasingly make use of these technologies where appropriate.

Conventional Wastewater Treatment

Directly treating wastewater before it gets to a lake is another engineering response to lake problems that was widely practiced in the lakes studied in this project. Fourteen out of the 24 lake basin briefs that reported technological responses had primary and secondary wastewater treatment, at least in the densely populated urban areas of their basins. Even so, only a small fraction of the lake basin population usually has access to reticulated sewage and wastewater treatment.

Primary treatment removes larger material from sewage, while secondary treatment (which usually utilizes microorganisms to decompose organic material) 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, conventional wastewater treatment is costly to both develop and maintain. In most study lakes in developing countries, the funds were provided through external donor support (the Bhoj Wetland in India and Lake Dianchi in China are exceptions).

However, the continued functioning of these plants requires a reliable stream of finance for operations and maintenance costs. In a number of lake basin briefs, the projects were not completed or failed after completion because the national and/or municipal governments were unable to meet their commitments. For example, the Njoro sewage treatment plant at Lake Nakuru was never fully operational because of a lack of government finance to provide the necessary wastewater collection infrastructure to transport sewage to the plant for treatment. The Lake Naivasha sewage treatment plant ceased to function in the early 1990s when vital equipment was stolen. Untreated sewage has been discharged to the lake since then, threatening the lake's ecosystem and the people and industries dependent on lake water.

Together with the subject of runoff control from the upper watershed region, sewage treatment requires an all-out international effort to come up with more appropriate and practical technological and institutional solutions than are currently available. The importance of increasing the international effort to share information and experiences cannot be overstated.

Advanced Wastewater Treatment (Tertiary Treatment)

Advanced wastewater treatment involves enhanced nutrient (nitrogen and/or phosphorus) removal at conventional wastewater treatment plants to cut down on the load of nutrients reaching lakes. It can achieve up to 95 percent removal of nutrients. Advanced treatment is expensive to construct and operate and requires that a conventional wastewater treatment facility is already operating reliably. Consequently, it is usually carried out only in high-income countries (Box 7.1). In the 28 briefs, only Lakes Biwa, Champlain, Constance, Dianchi, and the North American Great Lakes have extensive advanced treatment facilities in place. In those cases, advanced treatment has profoundly reduced the load of phosphorus to the lakes, a root cause of eutrophication.

Box 7.1 Conventional and Advanced Wastewater Treatment in the 28 Study Lake Basins

The extent of sewage treatment in the 28 lake basins is related to 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.

GNI per capita \ Population Density	1) < 100 persons/km²	2) >= 100 persons/km²
I) Low-Income Economies < $765	**I-1) No provision** **Lakes:** Malawi/Nyasa, George, Tonle Sap, Issyk-Kul, Chad, Kariba Reservoir, Tanganyika, Baringo, Chilika Lagoon **Funding**: Not currently planned.	**I-2) Low to medium provision** **Lakes:** Victoria, Naivasha, Nakuru, Bhoj Wetland, Toba **Funding:** Mostly by international assistance.
II) Middle-Income Economies $765–$9,385	**II-1) Low to medium provision** **Lakes:** Aral Sea, Baikal, Titicaca, Ohrid, Xingkai/Khanka, Tucurui Reservoir, Peipsi/Chudskoe, Cocibolca **Funding:** Partly funded by international assistance.	**II-2) Low to high provision** **Lakes:** Dianchi, Laguna de Bay **Funding:** Mostly by international and/or central government assistance.
III) High-Income Economies > $9,385	**III-1) High provision** **Lakes:** Champlain, Great Lakes **Funding:** By central and local governments.	**III-2) High provision** **Lakes:** Constance, Biwa **Funding:** By central and local governments.

Note: Sewage treatment is provided at Laguna de Bay through a private sector initiative for new residential areas and industrial establishments.

Source: S. Ide, Possibilities and Limitations of Environmental Infrastructure Provisions for Lake Basin Management, Thematic Paper, Lake Basin Management Initiative.

None of the technologies described in the briefs addressed a more recent concern regarding the ecological effects of pharmaceutical wastes discharged into surface waters from domestic sources.

Industrial Wastewater Treatment

Industrial wastewater treatment can collectively remove not only organic matter and nutrients but also toxic contaminants. The coverage of industrial wastewater treatment is similar to advanced wastewater treatment (discussed in Box 7.1); extensive treatment with strict effluent standards is in place at Lakes Biwa, Champlain, Constance, Dianchi, and the North American Great Lakes. Treatment of industrial wastewaters can also be coupled with water conservation. Thus, at Lake Baikal, the only significant source of industrial wastewater to the lake—a pulp mill—has installed a closed wastewater treatment system to limit the release of organochloride compounds to the lake.

However, industrial wastewater treatment need not involve expensive centralized treatment plants. While not a lake basin, the control of tannery effluent streams in the Palar River Basin in Tamil Nadu State, India provides an example. This river basin is the center of India's leather tanning industry, providing 35 percent of the country's leather export earnings and employment to 50,000 workers. The tanneries discharge a wide range of pollutants, including large quantities of salt, BOD, acids, and heavy metals. Both surface and groundwater have become heavily polluted. Currently, 330 of the 594 tanneries in the river basin are connected to simple Common Effluent Treatment Plants (CETPs) that remove BOD and particulates. However, these simple treatment plants are not able to remove dissolved salts, which need to be reduced through changes in treatment in the tanneries.

The main lesson regarding industrial wastewater treatment comes from the study lakes where it was not carried out and toxic industrial contaminants have been released into a lake. The characteristics of lakes make cleanup very difficult and expensive: the integrating nature of lakes means that the problem cannot usually be contained within a small area; long retention time means that toxic chemicals in a lake stay in the system for a long time; and complex response dynamics means that the chemicals often biomagnify, creating both ecological damage and risk to humans.

A number of lakes in this study reported toxic industrial contamination. The North American Great Lakes are perhaps the best illustration of how long term and pervasive toxic contamination can become. By the early 1980s, decades worth of heavy metals and toxic organic chemicals had collected in the sediments of the rivers and harbors in the Great Lakes Basin to the point where the U.S. EPA's Great Lakes program identified polluted sediments as the largest major source of contaminants to the Great Lakes food chain. Over 2,000 miles (20 percent) of the Great Lakes shoreline were considered impaired. On the U.S. side of the border, over 1,000,000 m^3 of contaminated sediments have been remediated over the past 3 years. In 2002, the U.S. Congress authorized $270 million over five years from fiscal years 2004 to 2008 for cleanup activities.

This level of funding is generally not available for cleaning up industrial contaminants once it has reached lakes in the developing world. One exception is Lake Dianchi, where more than 4 million m^3 of contaminated sediment have been dredged up, removing 8,200 tons of total nitrogen, 1,900 tons of total phosphorus, and 4,400 tons of heavy metals.

Control of Nonpoint-Source Pollution

Even in cases where point-source controls have been successfully managed, 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 now that point sources have been controlled. The difficulty in controlling nonpoint sources, which include agriculture and urban runoff, is that sources cannot be readily identified or monitored, involve numerous stakeholders, and are episodic (usually arising after rainfall events) rather than continuous. Regional and national programs and projects for the control of nonpoint source pollution from agriculture, especially livestock, are being supported by the GEF and World Bank in the Baltic Sea Basin, Danube River Basin, and Black Sea Basin. These programs and projects involve the direct participation of rural communities and farm families and provide models that can be used for addressing this issue in lake basin management programs.

Nonpoint sources usually become more of a problem with increased development and changes in land use within the basin. Not only do the changes in land use in lake basins lead to increased generation of sediment, nutrients and agro-chemicals, but often the associated destruction of wetlands and riparian areas reduces the basin's ability to filter these pollutants before they reach lakes. For example, the partial destruction of the extensive wetlands in the Lake Xinghai/Khanka basin due to their reclamation for agriculture has compounded the effects of the land use change occurring in the basin. Over the years, one third of these unique wetlands has been destroyed.

Wetland Restoration and Construction

Eleven of the 28 lake briefs describe the loss of littoral wetlands (Table 3.2). Their destruction usually results from development of lakeshore areas (such as urban sprawl at Lake Champlain, construction of roads at Lake Biwa) or reclamation of wetlands for farming or grazing. Rehabilitating these wetlands can reduce nonpoint-source loads delivered to lakes, as well as help conserve and restore biodiversity. Some examples from the briefs include:

- The Lake Chad brief describes the rehabilitation of the Logone Wetland in Cameroon in 1993. 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, the project had conserved 4,000 acres of wetlands and surrounding areas in the basin;

- The Lake Naivasha brief shows how several of the larger horticultural enterprises in the basin have reduced their impact on the environment by using constructed wetlands to treat their wastewater. In addition, the protection of much of the lake's fringing wetlands over the years has helped reduce the impact of pollutants from surrounding urban and agricultural areas; and,

- The Aral Sea brief illustrates international efforts by the GEF and World Bank to restore wetlands on the lower Amu Darya delta, including Lake Sudochie, a Ramsar site.

The briefs show that destroyed wetlands will ultimately either need to be replaced or a technological solution (such as wastewater treatment) will need to be introduced if pollution loads to lakes are to be reduced. In many cases, it is more cost-effective to avoid destruction in the first place. However, the briefs still detail many lake basins where wetland destruction continues (Lakes Victoria, Xinghai/Khanka, Ohrid).

Reforestation and Afforestation

Loss of forest cover in a lake basin usually increases land erosion and sediment transport, resulting in reduced lake water quality. Many of the lake briefs describe efforts to develop forests in lake basins, either through reforestation (replacing destroyed forests) or afforestation (planting forest where it did not exist before). The former are discussed in the

Box 7.2 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), commonly known as the Ramsar Convention. The majority of lakes in this survey have Ramsar sites in their basins, which include, in some cases, both littoral areas and the lakes themselves.

The Ramsar Convention defines "wetlands" in its Article 1.1 as "...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." 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 includes 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.

For the convention, lakes can be fresh, brackish, saline, or alkaline. Importantly, the fact that the convention urges contracting parties to manage effectively and sustainably all wetlands, including lakes, within the 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 (in hectares) of the four categories is shown in the table below for each of the Ramsar regions.

	O	P	Q	R	All 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 Grant fund has supported management interventions at lakes in many regions of the world, including the following countries: Algeria, Argentina, Armenia, Bolivia, Bulgaria, Burkina Faso, China (3), Comoros, Ecuador (2), Former Republic of Yugoslavia, Georgia, Mongolia, Paraguay, Peru, Philippines, Russian Federation (3), Togo (2), and Uganda. The convention will continue to promote wise management of lake systems as part of its global approach to wetlands and water.

Source: Ramsar Secretariat.

Lakes Baikal, Chad, Laguna de Bay, Nakuru, Ohrid, Tanganyika, and Toba briefs; the latter are described in the Lakes Baringo and Dianchi, Bhoj Wetland, and Chilika Lagoon briefs.

In some of these cases, native tree species have been replaced by exotic species. While these replacement species usually have more rapid growth rates (leading to quicker soil stabilization) and greater marketability, they may not restore the biodiversity of the original forests. In addition, the hydrologic balance of the lake basin can be altered through reforestation and afforestation schemes. For example, in the Lake Toba basin native species have been replaced with quick-growing eucalypt species. Local people believe that these exotic species use more water than the pines they replaced, although forestry experts dispute this belief.

In addition to the intensive afforestation in the lake's basin, plantations have been used at the Bhoj Wetland to create a buffer zone around the western, southern, and northern fringes of the Upper Lake to prevent encroachment by human settlements, cultivation, and grazing within the lake area. The species selected either produce biomass or have medicinal properties, as well as being tolerant of both flooding and drought conditions. Such management of littoral zone forest stands, including active reforestation and afforestation, should also be extended beyond lakeshores to the riverbanks in the lake basin.

In addition to the efforts to restore or create forested land cover, several briefs indicate that forestry practices in terms of site selection, forest road design, harvesting rotations, and preservation of riparian forest stands can be improved to reduce sediment sources (Lake Nakuru, Lake Malawi/Nyasa, Issyk-Kul, and Lake Victoria). As the extent of erosion problems depends on local climate, geology, topography, and the intensity of human activities (highlighted in the briefs of Lake Nakuru, Kariba Reservoir, and Issyk-Kul), land use planning can be effective in minimizing the environmentally adverse effects of forestry activities. GIS-based databases are one tool that can identify areas that are unsuitable for forestry because of their natural characteristics.

Catchment Protection

Soil loss from poor land management in agricultural and pastoral areas was widely reported in the lake briefs. The causes included overgrazing, fallow cultivation, gully erosion, and unstabilized streambanks. Lake Tanganyika is a case where large-scale deforestation and farming practices in the smaller northern watersheds of the lake have caused a dramatic increase in the soil erosion rates and represent a threat to the integrity of one of the world's most biodiverse lakes. Sediment transport rates have been measured to be about 10 times greater in cleared and settled areas in the Tanzanian part of the lake basin than in comparable uncleared areas. The freshly eroded sediments entering the lake adversely affect its biodiversity by blanketing important breeding areas.

Economically, this problem represents a loss to the agriculturalist as well as a cost to the downstream water users, and therefore soil conservation activities are often welcomed by agricultural communities once their effectiveness is demonstrated. The sedimentation of Lake Baringo is partially due to soil loss from poor pasture and farming management in the lake's watershed. Soil conservation trials were funded as part of the GEF-funded Lake Baringo Conservation Project, including over 30 km of terraces to control sediment movement. One of the outcomes has been a successful harvest for farmers after previous years of crop failure. This success will act as an incentive for wider adoption of these conservation measures.

Control of Mining Wastes

Mining wastes are described as affecting a number of lakes in this study. For example:

- Mercury, believed to come from gold mining activities in Tanzania, has been detected in the sediments offshore from the Tanzanian part of Lake Victoria. This heavy metal is believed to originate from the large number of artisanal miners operating in this part of the basin. These miners have neither the training nor finances to operate mercury separation technologies safely;

- There are a number of old mines that used to produce chromium, nickel, iron, and coal near the Albanian part of Lake Ohrid. Many large piles of waste material remain and are a source of pollutants to the lake each time it rains. Concentrations of heavy metals in samples taken from the near shore lake water are very high;

- At Issyk-Kul, there are widespread mining operations, which have resulted in occasional illegal dumping of chemicals;

- Gold and other minerals are mined extensively in the Russian part of the Lake Baikal basin. There are almost no environmental controls, and the mines generate significant levels of iron, sulphur, chloride, mercury, and nitrogen in the rivers. Countless copper and gold mines also exist in the Mongolian part of the basin, which has little or no control efforts in place. For example, the regional government in Zaamar, Mongolia has an environmental inspection budget of roughly $1,200/year for a gold field that in 2001 produced almost $40 million in revenues; and,

- Phosphorus mining at the southern end of Lake Dianchi has caused serious erosion. Phosphorus-rich soils have been flushed into the lake, adding to the lake's high nutrient loads.

A number of simple technologies exist for controlling the loss of mercury from small-scale artisanal gold mines—such as modifications to sluice boxes to reduce their mercury losses to creeks, and the use of retorts to reduce the atmospheric loss of mercury—but the briefs report few, if any, attempts to introduce technologies. Even many of the commercial mines in the above examples appear to use few technologies to control the discharge of contaminants.

In-Lake Measures

Control of Water Levels

A number of lake briefs reported actual or potential reduction in lake size as a serious problem (the Aral Sea, Lakes Baringo, Bhoj, Biwa, Chad, Naivasha, Sevan, Toba), to the point where it has been identified as an emerging issue in Chapter 3. Dams or weirs have been installed at Lakes Sevan, Biwa, and Toba to control the lake levels. These structures have primarily been developed for production purposes—water supply at Lake Biwa, hydropower at Lake Toba, and both hydropower and water supply at Lake Sevan. While the dams at Lakes Toba and Sevan have had detrimental environmental consequences, the weir at Lake Biwa has helped the lake's fringing reed beds to survive, provided habitat for fish and water birds, and contributed to the recreational values of the lake.

A small dam is being constructed between the Northern Aral Sea in the north and the Large Aral Sea to help maintain water levels in the former. At present, water flows from the Northern Aral Sea to the Large Aral Sea, where it tends to be rapidly lost due to high evaporation. With this intervention, the Large Aral Sea will receive even less water, the Northern Aral Sea will likely stabilize, and a portion of the original biodiversity will be maintained. In this case, a technological response (construction of a small dam) is being used to mitigate problems from a previous technological intervention (upstream irrigation).

Control of Nuisance Species

Nuisance species include both plants and animals. Some have been introduced and multiplied uncontrollably in the absence of natural predators; others are native and have multiplied to nuisance levels because of changes in the lake environment. Water weeds, particularly water hyacinth, were widely reported in the lake briefs as being a nuisance. Excessive growth of aquatic weeds impedes boat traffic, promotes water loss through increased evapotranspiration, interferes with fishing, blocks irrigation channels, and interferes with hydropower generation and water treatment plants, as well as reducing the recreation uses of lakes. Infested areas can also foster vector-borne diseases. Algal blooms, particularly cyanobacterial blooms, were also widely reported. There are a number of biological, chemical, and physical options for controlling both water weeds and algae; however, these methods do not attack the underlying causes, which usually involve high nutrient levels and sometimes disturbances to the ecological structure of the lakes.

Biological methods

Known predators of the invasive water weeds can be introduced to control their rampant growth. In a well-known example, two species of weevils *(Neochetina eichhornia* and *Neochetina bruchi)* were used successfully at Lake Victoria to combat serious infestation of water hyacinth. The success was probably assisted by a period of high rainfall that disrupted the weed's habitat. Extensive research was conducted prior to the release of the weevils to show the weevils would be specific to the water hyacinth and would not result in another uncontrollable distortion of the ecosystem (as occurred after the introduction of the Nile perch in the 1950s). This biological method has been sustainable because it was accompanied by a community involvement program whereby traditional fishing communities, who were adversely affected by the explosive weed growth, were taught to raise and release the weevils.

Lake Naivasha, the Kariba Reservoir and the Bhoj Wetland provide examples of successful biological control of invasive weeds using different predators. At the Kariba Reservoir, grasshoppers *(Paulinia acuminata)* were used to control Kariba weed *(Salvinia molesta)*; at Lake Naivasha, a host-specific insect *(Cyrtobagus salviniae)* was introduced; while at the Bhoj Wetland, a herbivorous grass carp *(Ctenopharyngodon idella)* and Indian major carp were used to control submerged weeds such as Hydrilla, Najas, and Vallisnaria. Sterile triploid species were used to avoid problems from excess numbers of the grass carp.

Although the insect had effectively reduced the Kariba weed cover at Lake Naivasha to insignificant levels by the early 1990s, water hyacinth then spread rapidly. This was probably due to the lake's increasing nutrient levels and the lack of competition from Kariba weed. Water hyacinth is now being controlled by the *Neochetina* weevils. The key lesson learned is that even successful biological control may not be sustainable if root causes (such as high nutrient levels) are not tackled.

Biomanipulation is another biological approach to the control of nuisance species. It involves 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 is usually not sustainable in the long term because there are too many alternative food pathways and too many other influences on the spread of the algae. 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 largely confined to lakes in the developed world, and even there it is not in widespread use.

Chemical methods

Chemicals can be applied to a lake to control an algal bloom or to kill an invasive species. However, on all but the smallest lakes, the cost is usually prohibitive if the infestation is extensive. For example, herbicides were trialed at the Kariba Reservoir to control both water hyacinth and Kariba weed and at Lake Victoria to control water hyacinth, but—given the scale of these infestations—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 methods

Direct harvesting can be a relatively quick and direct way to remove nuisance weeds, but is not suited to controlling algae. Weed harvesting has been carried out at the Bhoj Wetland, Chilika Lagoon, and Lakes Biwa, Toba, and Victoria. The harvesting programs at Lakes Toba and Victoria relied heavily on community involvement. At Lake Victoria, the harvested weeds were turned to commercial gain—they were used for manufacturing handicrafts. However, like many technological interventions, harvesting does not address the root causes leading to excessive weed growth and is not sustainable in the long term.

The large commercial Nile perch fishery on Lake Victoria is an example of harvesting of introduced fish. While the Nile perch was initially seen as a nuisance species when it first dominated the lake, the value of the commercial fishery is now such that it is regarded as an important industry for the riparian countries. Whether a nuisance or a benefit, the harvesting of the fish has been so intensive in recent years as to raise concerns about overfishing.

Control of Water Quality

The integrative characteristic of lakes means that water quality problems are best controlled at source before they reach the lake. However, some technologies were reported in the lake briefs for controlling in-lake water quality issues.

Dredging

The removal of sediment from rivers and lakes by dredging is a common method for removing excess silt, nutrients, and toxic compounds. For example, changes in basin land use led to large increases in sediment loading to Chilika Lagoon. The high silt loads blocked the outlet of the lagoon and prevented normal exchange of sea water. The salinity levels dropped, leading to a sharp decline in the native fisheries as well as an increase in invasive macrophyte growth. When a new channel to the ocean was dredged, the salinity returned to normal conditions, leading to a dramatic recovery of the fishing and prawn industries and a decrease in the area covered by invasive weeds.

Dredging is sometimes used to remove nutrients from the bottom of shallow, eutrophic lakes. Dredging has been used to remove phosphorus-laden sediment from Lakes Biwa, Dianchi and the Bhoj Wetland. For the Bhoj Wetland, the deposition of the contaminated silt affected the water quality and obstructed the lake's outlet. Silt was removed from the upper and lower lakes by both hydraulic and dry excavation, increasing the capacity of the lake by 4 percent. The excavated materials were used to convert previously barren areas into productive agricultural land because of their high nutrient concentrations.

Dredging has also been used to remove toxic chemicals from lake sediments. For example, over 140,000 tons of PCB-contaminated sludge were removed from the sediment of Cumberland Bay in Lake Champlain at a cost of $35 million. Similar programs have been used to remove toxic contaminants from the North American Great Lakes and heavy metals from Lake Dianchi.

However, there are also potentially severe ecological effects arising from dredging. 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 and can potentially stir up toxic sediments, thereby putting them back into the water column. In addition, dredging is expensive to carry out and is not a long-term solution unless the sources of contamination are tackled.

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 depress dissolved oxygen levels (DO). Low DO, in turn, can lead to fish kills and the loss of benthic water habitat to commercially and ecologically important species.

One short-term way of dealing with the problem is to inject dissolved oxygen or compressed air directly into the low DO region, usually the bottom of the lake. To date, this approach has only been viable in the smallest lakes because of its cost. For example, among the lakes in this study aeration has only been used at the Bhoj Wetland, where a total of 15 aeration units have been installed to oxygenate the bottom water. This has not only led to improvement in water quality, but has increased the attractiveness of the lake for tourists. However, remediation technologies such as aeration do not attack the root cause of low DO levels. For sustainability they need to be accompanied by source control measures—in the case of Bhoj Wetland, reduction in the influx of nutrients and organic material from the surrounding urban region.

Chapter 8

Informing the Process:

The Role of Science

Key Lessons Learned about Information

- Both natural science information and social science information are needed for lake basin management. The latter includes socioeconomic and cultural information pertaining to and held by local communities and Indigenous Peoples. Sometimes the information on locally generated management approaches can be very useful when there are no long-term monitoring studies available to provide scientific data.
- Scientific information has been successfully used in the study lakes to show the limits of lake basin resources, enlighten hard-to-see connections, and provide innovative solutions to problems. However, the benefits from use of information have not been fully realized. The briefs described a number of problems where scientific information could have been used by decision makers, managers, and other stakeholders, but was not. Scientific information needs to be translated into the language of decision makers and stakeholders if it is to be fully applied in management.
- While there is need for more directed research with application in mind, having managers define the research needs, possibly through a formal needs analysis, was recognized as an effective way to have research results taken up and applied in management. There is a need for a collective, widely shared knowledge base of experiences in applying scientific information.
- The GEF-IW requirement to produce a diagnosis of transboundary lake basin problems (Transboundary Diagnostic Analysis) that is mutually agreed by riparian countries appears to be successful in promoting joint lake basin management programs.
- Two of the characteristics of lakes (long retention times and complex response dynamics) make long-term scientific commitment particularly valuable. Resident research institutions in developing countries can be assisted by international collaborators through training and technology transfer programs.
- Monitoring has been used to both develop a baseline for the lake basin and to assess the effectiveness of management interventions. Some difficult problems have been resolved through use of monitoring data.
- Scientific models had been used to help managers at a number of study lakes. However, the appropriate model has not always been used. The complexity of the model needs to be matched to the capacities of the users, the available data, and the demands of the task.

Information Needs for Lake Basin Management

Information that is reliable, widely understood, and accepted is central to decision making in lake basin management. Without it, institutions can be inefficient, rules can be ineffective, and technology can be misapplied leading to problems such as the desiccation of the Aral Sea or the drawdown of Lake Sevan. Knowledge can play a particularly important part in improving the management of transboundary lake basins; this chapter includes discussion on the promotion by the GEF of Transboundary Diagnostic Analysis (TDA) as a tool to promote discussion and agreement on joint management programs between lake basin countries.

Information includes both scientific information—such as the values of measured parameters like dissolved oxygen, nutrient concentrations, and biomass counts—as well as socioeconomic information, such as people's values and associated goals for their resources and social and cultural relationships that would improve resource use and control (Box 8.1).

Another valuable source of information resides in the communities, including indigenous communities, living along a lakeshore or in a lake basin. 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, 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 Congo. Nevertheless, where it is available, scientifically acquired knowledge is preferable because it is subject to quality control procedures.

The integrating nature of lakes, long retention time, and complex response dynamics 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. In the case of the Aral Sea, the very high costs from the decision by the former Soviet Union to divert large quantities of water from the two principal inflowing rivers might have been avoided if environmental, social, and economic studies had been carried out to predict the consequences of the decision. A similar outcome may have occurred in the case of Lake Sevan had Soviet planners examined more comprehensively the long-term environmental impacts of the decision to reduce the lake level for power generation and irrigated agriculture.

Use of Scientific Information

The case studies show that science is used in three main ways in decision making: to show the limits of the resource; to enlighten hard-to-see connections; and 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 study; unsustainable fishing practices, primarily overfishing, are one of the main problems (Table 3.2). Overfishing threatens lake ecosystems and livelihoods, especially in developing countries. Scientific studies have provided key information leading to temporary moratoriums on fishing (Lakes Baringo and Naivasha) and restrictions on allowable technologies (Lakes George, Ohrid, and Victoria). As a result of the rules based on this information, these fisheries have either recovered, or are in better shape than they would have been without the information.

Table 3.2 shows that eutrophication, caused by excessive nutrient load (usually phosphorus; occasionally nitrogen) generated from human activities in a lake's drainage basin (and sometimes beyond) is another common problem in lake basins. As illustrated in Figure 2.2, a lake can absorb a certain quantity of nutrient load without showing major changes. However, there comes a point at which the loading leads to a major, undesirable shift in the lake ecosystem. The extent of the shift, along with information on the nutrient load that 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. Even though this policy was successful in controlling much of the point-source load to the lakes, a more recent study has shown that nonpoint sources also must be controlled to fully meet the target loads. The Lake Baikal brief also demonstrates how scientific study can reveal that nonpoint sources of pollutants can be transported to a lake via both waterborne and atmospheric pathways and pose a major threat to a lake. Scientific studies at Lake Malawi/Nyasa showed the limits of different fish populations. Inshore artisanal fishing was overexploiting the available resource. The ornamental fish trade was threatening some of the highly localized cichlid species the lake was renowned for, but the pelagic fishery was largely unexploited and potentially available for providing much-needed protein for lake basin populations.

Box 8.1 The Information Bare Essentials: A Checklist for Decision Makers

- *Scientific/Technical Prospects and Options*. What is the current condition of a lake; that is, 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 drainage basin, for the observed problems? What are the lake basin 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 the lake and its resources? To what extent can the public and other stakeholders be mobilized to help identify and implement effective lake basin 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 basin 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 the lake and its resources, or are new or modified ones needed? Do different lake basin management institutions have overlapping or conflicting mandates? Are existing laws and regulations enforced in a consistent and 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 the lake and its 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 basin management interventions? Is the governance process transparent, equitable, and accessible to the public and other stakeholders?

Enlightening Hard-to-See Connections

The biophysical processes in lakes are complex. A key role of science is to shed light on the hard-to-see, indirect connections that are common in lake basin management. Some examples include:

- At 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 while the lake level fluctuated naturally due to climate variability, abstractions for horticulture were almost certainly responsible for the recent decline in the lake level (Box 8.2). As a result, there was widespread

Box 8.2 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. The phenomenon was eventually explained as being the result of the shallow bathymetry of the lake coupled with climate variability. Starting in 1982, much of the land around the lake was 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 overused by this new development. They also were concerned about pollution of the lake and aquifers from agro-chemicals used by the horticulture industry. Many horticulturalists did not believe that they were overusing the water resources 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 Kenyan Ministry of Water Development to study the water balance and the water-related environmental impacts. This study was carried out in close collaboration with International Institute for Geo-Information Science and Earth Observation (ITC) in the Netherlands. ITC developed a simple, spreadsheet-based water balance model of the lake and its basin. The model used data from a variety of sources—government and private sector—for a period from 1932 to the present day.

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 8.1). Over this period, 95 percent of all observed monthly lake levels differed from the modeled levels by 0.52 m or less. 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.

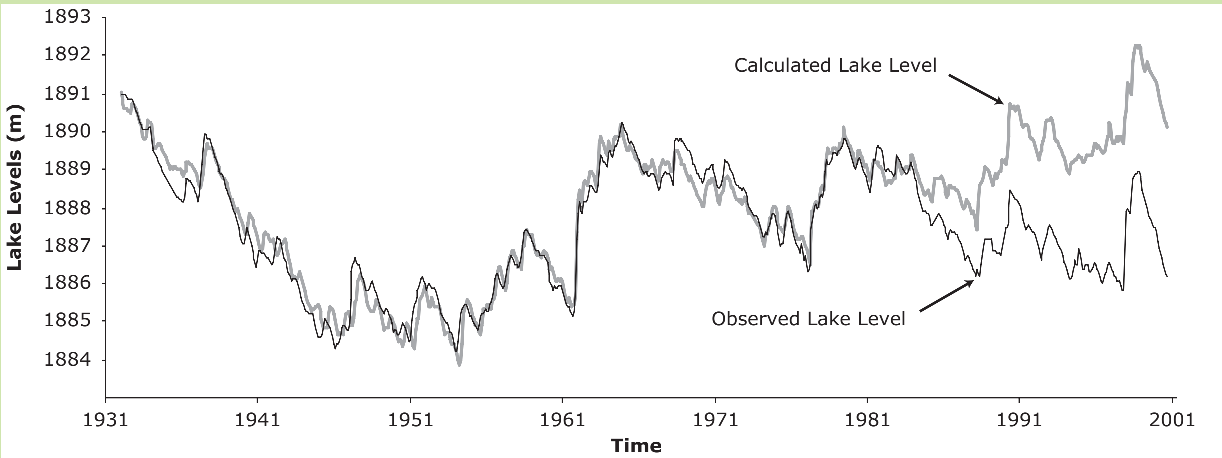

Figure 8.1. Long-term Water Level Change in Lake Naivasha.

The onset of this decline in water level coincided with the commencement of horticulture in the area in 1982, and there was a 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 stakeholders 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 among horticulturalists and to protect the lake's values.

Source: Becht and Harper 2002.

acceptance of this cause and an understanding that different interest groups needed to work together to use the lake's resources equitably;

- Scientific investigations showed that a proposed hydraulic control structure at Laguna de Bay (designed to stop saltwater intrusion from the ocean) would have a detrimental effect on the lake fisheries. Eventually, it was decided to cease operating the structure, allowing natural saltwater intrusion to occur again, resulting in a decrease in turbidity and improved conditions for fisheries;

- Detailed measurements and investigations at Lake Biwa showed that decreasing snowfall over the last few decades, along with a weakening of the overturn of the lake waters in spring (both possibly related to climate change), led to lower dissolved oxygen levels in the bottom waters of the lake every spring, providing the conditions for potentially large phosphorus release from sediments and a rapid worsening of eutrophic conditions;

- Research at the North American Great Lakes 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 are part of the airshed, and therefore not normally considered by decision makers; and,

- Recent studies at Lake Victoria (Hecky, R., H. Bootsma, and E. Odada, "African Lake Management Initiatives: The Global Connection" Thematic Paper, Lake Basin Management Initiative) suggest the role of atmospheric deposition of phosphorus to the lake has been greatly underestimated. If confirmed, this unexpected transport pathway could have major implications for managing the lake and its basin.

Providing Innovative Solutions

The understanding of the lake basin process developed through scientific studies can be used to develop innovative approaches to address a range of problems. Some of the major examples from the case studies include:

- For the Chilika Lagoon, modeling studies showed that dredging a channel between the lake and the ocean could improve salinity conditions and fishery production in the lake. The construction of the channel led to a dramatic recovery in the fishery and prawn catches. Apart from restoring livelihoods of fisherfolk, this action also helped alleviate a major source of conflict among the local communities;

- At the Kariba Reservoir, ecological studies showed how introduction of a fish (*Limnothrissa miodon*) into an ecological niche opened up by the formation of this reservoir would provide a commercially valuable fishery;

- In the Lake Chad basin, scientific field experiments showed that wet-season conditions could be simulated by water releases from the Tiga and Challawa dams. This demonstrated that artificial flooding of wetlands could be undertaken using existing infrastructure;

- High levels of heavy metals at the Bhoj Wetland were shown to result from immersion of idols during religious festivities, an unlikely but significant source. The research also showed a solution (moving the ceremony to another site) was possible; and,

- Scientific studies at the Aral Sea indicated that construction of a dam between the Northern and Large Aral Seas could maintain the current size of the Northern Aral given the reduced inflows, and with it, some of the lake's biodiversity and livelihoods for local people.

Opportunities for the Use of Scientific Information

There were a number of cases where scientific information was not used but where it could have made a major difference. Examples where the lake briefs cited the urgent need for scientific studies include the:

- Effects of climate change versus local water withdrawals on lake levels at Lake Chad;

- Limits of sustainable grazing in the Lake Baringo basin;

- Quantities of water available for irrigation at Lake Chad;

- Effects of aquaculture on Lake Toba on the lake's water quality;

- Effect of proposed upstream dams, forest clearance and land degradation on Tonle Sap; and,

- Effects of increasing sediment (and attached phosphorus) loads on the ecosystems of Lakes Malawi/Nyasa and Tanganyika.

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 cost-effective in the long term. Second, 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. Finally, it can be very difficult to get scientists from disciplines as diverse as sociology, biology, 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 socioeconomic; physical and ecological) interact. These difficulties affect scientific studies in the industrialized world as much as they affect the developing world.

The Use of Models

A wide range of models have been used for the lakes in this study, ranging from the simple to the complex. A complex hydrodynamic model of circulation patterns was used to assess the likely benefits from different lake openings in the Chilika Lagoon before the new opening was dredged to the ocean. Modeling five scenarios for Lake Peipsi/Chudskoe showed that nutrients from nonpoint sources were the principle issue to be tackled, and that they were likely to decrease as a result of reduced usage of fertilizers in the Russian Federation. 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. The issue of model complexity also was illustrated at the North American Great Lakes. Five different eutrophication models, ranging from the simple to the complex, were used to determine the phosphorus target loads for the North American Great Lakes (International Joint Commission 1978). Despite their range of complexity, they tended to converge on the same targets, implying that the simple models were sufficient. Lake Naivasha (Box 8.2) provides another example where a simple, spreadsheet model proved to be influential in aiding management.

It is noticeable how often simple models have proven successful. However, the lesson is not that simple models are best—it is doubtful if the Chilika Lagoon 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 available data, and the demands of the task.

It is essential that the model design be driven by lake basin managers and other stakeholders and not by the model developers. Initial brainstorming sessions between stakeholders and model developers can substantially facilitate this goal, along with the participation of local experts and officials in its development. A conceptual model developed at an early stage of a lake basin management project can help identify data needs and required sampling and monitoring efforts.

The Value of Monitoring

Monitoring of a lake and its basin can provide valuable insights into the lake basin's baseline condition and changes over time, including any changes from the effects of management actions.

Assessing Baseline Conditions

Baseline monitoring programs have been in place at all of the study lakes located in industrial countries and in some of those in developing countries. Two 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; and,

- 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 provides the best baseline picture of a lake basin, even short-term or even historical studies can prove valuable. For example, the classic research by Talling and Talling (1965) and Talling (1966) on Lake Victoria in 1961 has been used to show that the lake's zooplankton changed dramatically from being diatom-dominated to cyanobacterially dominated. In another example, studies on the endemic species of Lake Dianchi in the 1950s helped scientists understand past conditions in that lake as they attempt to conserve its biodiversity.

Long-term monitoring can have serendipitous effects. For example, the Lake Biwa brief describes how long-term records of snowmelt, together with lake water temperature and dissolved oxygen concentrations, provided indications on 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."

However, lake basin-wide monitoring programs in transboundary lake basins need to be consistent across national borders. If inconsistent data—different parameters, different sampling and analysis techniques, different locations and frequencies, and so on—are collected, then it can be very difficult to develop a reliable picture of the status of the lake basin. There are a number of examples in the lake briefs where the environmental status of transboundary lake basins has been difficult to access because of inconsistent monitoring programs. At Lakes Ohrid and Xingkai/Khanka, there have been recent efforts to harmonize monitoring programs with GEF assistance. The first lake-wide status reports have been produced for both lakes. Harmonizing monitoring procedures is not easy when the transboundary lake is only one out of many waterbodies in each country. The Xingkai/Khanka brief makes the additional point that research efforts also need to be coordinated across national boundaries. To date, lack of dialogue on research findings for the drainage basin has prevented harmonized, cost-effective management actions regarding transboundary environmental issues.

Assessing the Effects of Interventions

Monitoring can help managers assess the effectiveness of their interventions. The Lake Dianchi brief describes how monitoring has shown that the pollutant loads entering the lake have increased in recent years. It also shows that policies to reduce the loads from individual enterprises have been successful. The increased loads to the lake are the result of an increased the number of polluting enterprises and population in general. Without the monitoring information, the policies would probably have been declared failures. On the other hand, the Lake Chad brief noted that, because of the absence of transboundary monitoring and a lack of political will, past agreements on the conservation and development of basin resources could not be enforced, resulting in detrimental impacts on the lake ecosystem.

Sharing Information

For maximum effect, the results of scientific studies should be made available in language that decision makers and resource users can understand. This is an important point since it is a common experience for scientific information to be put aside because those who could potentially use it do not understand it. The following are some of the ways in which information at a study lake basin was made available to stakeholders.

Use of Indicators

The public and decision makers do not easily understand many scientific parameters. For example, while water transparency is a fairly easy concept to understand, chemical oxygen demand (COD) is more obscure. Therefore, many of the study lakes have developed "indicators" to provide easy-to-understand summaries of scientific monitoring results.

The development of indicators has been the subject of major biennial conferences in the North American Great Lakes basin (Box 8.3). At Laguna de Bay, water quality data are presented in a simple schematic diagram called the Water Mondrian. Inspired by the work of the Dutch painter, Piet Mondrian, it presents technical information in the form of simple lines and

Box 8.3 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 GLWQA's progress toward this goal, the U.S. 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. 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 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 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 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 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 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 can be found at: http://www.epa.gov/glnpo/solec/

Source: North American Great Lakes Brief.

colors in an easily understood format (see Laguna de Bay brief for a diagram).

The GEF has developed a framework consisting of three types of indicators (process indicators, stress reduction indicators, and environmental status indicators) that can be applied flexibly and allow easy evaluation of the progress of projects (Duda 2002). Process indicators measure the establishment of an institutional and political enabling environment for lake basin management. In the initial phases of projects, process indicators may be the only indicators of progress (for example, establishing country-specific inter-ministerial committees, documentation of stakeholder involvement in planning efforts, or country ratification of conventions or protocols pertinent to a lake basin project). Stress reduction indicators measure on-ground actions and investments implemented within the lake basin. Examples include implementation of nonpoint-source pollution programs, releases of water from dams for environmental purposes, or enforcement of specific fishing policies. Environmental status indicators are measures of improvements in the quality of lakes and lake basins. Examples include improved (measurable) chemical, physical, or biological parameters in a lake, improved recruitment classes of targeted fish species or diversity, or changes in local community income and social conditions as a result of improved environmental conditions.

The information collected in this project has been used to further develop the process indicators for assessing progress in good governance of lake basins (World Bank 2005). For example, the lake briefs show that good practice in the involvement of stakeholders in lake basin management is characterized by:

- Having all relevant stakeholders involved;

- Allowing sufficient time for stakeholders to develop the capacity to be engaged and to become familiar with issues;

- The use of existing representation structures such as local governments, NGOs, and traditional organizations;

- Having clearly defined roles for stakeholders, preferably defined in government policy; and,

- Having access to sufficient resources for stakeholders to be effectively engaged.

Similar characteristics have been identified for the other indicators of governance processes—clear national policy, effective institutions, efficient rules for allocating resources, scientific information, and sufficient finances for both operations and investments.

Museums and Information Centers

Lake-based museums and centers can also help disseminate scientific and other information. One example is the Lake Science Center established at Barkul at the Chilika Lagoon basin for hydrobiological and other studies during 1999–2002. The Lake Champlain brief highlighted the value of developing a lakefront laboratory and science museum as a means of fostering effective management within the drainage basin. The Lake Biwa Museum is a longstanding and very successful example of a lake science center devoted to dissemination of information and data about the lake basin and its problems. Based in part on these successes, museums and information centers are proposed or planned for the Bhoj Wetland and Lakes Sevan, Toba, Victoria and Issyk-Kul.

Involving People

Many of the case studies show the benefits of directly using people to gather and provide information. The benefits include building greater ownership among stakeholders for management actions and augmenting the monitoring efforts of scientific staff, particularly in developing countries. Examples include the following:

- Akanoi Bay basin, 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) have led to a decline in the number of fireflies. A local NGO implemented various restoration projects, with the indicator of success being an increase in the number of fireflies—a simple indicator of restoration progress;

- At Lake Victoria, water hyacinth control efforts are carried out and monitored by local fishing communities, who are best positioned to carry out such work;

- The Lake Tanganyika brief notes the importance of involving the local communities in data collection. However, it does suggest limitations on 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; and,

- The Lay Monitoring Program in Lake Champlain 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.

Undertaking Science and Monitoring

Resident Research Organizations

A number of the study lake basins had resident organizations to carry out both required and elective research, together with monitoring and coordinating information gathered by various sectors.

Lake Champlain (along with Lake Biwa and the North American Great Lakes) provides an example of how science and monitoring can play an important and effective role in lake basin management. Nearly two dozen representatives from the scientific community 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 Lake Champlain Basin Program's Steering Committee each year. The TAC also oversees research and implementation projects to ensure their scientific merit and application to lake basin problems. Links to management are further strengthened by the chairman of the TAC, a nongovernmental scientist who also holds a seat on the Lake Champlain Steering Committee. When scientific information is needed to guide a management decision, the Steering Committee allocates funds to support research or monitoring to address the knowledge gap.

Internationally Funded Programs

Internationally funded studies can assist when developing countries do not have resident scientific institutions able to carry out the necessary research. For example, Lakes Malawi/Nyasa, Victoria, and Tonle Sap have received much attention from foreign scientists, although the information has yet to have a major influence on decision making.

Carrying new knowledge forward into action is a common problem in many development projects. The scientific component of a project tends to last long enough to gather and analyze information, but not long enough to follow through with the implementation of results. This is partly because implementation is usually viewed as the responsibility of governments. Unless the project builds strong linkages between local researchers and international experts, there is seldom a mechanism for continuity. This problem can be exacerbated by the lack of interest or political will by government agencies to follow through on project recommendations.

Any collaboration with international groups should include a training component that transfers as much knowledge as possible to local institutions. Without it, there is a cycle where riparian states are forced to rely heavily on expatriates to undertake tasks that would otherwise have been undertaken by local experts. The LLDA provides an example, in which local ability is well supported and developed. Because of its limited staff numbers, LLDA has teamed with international and local academic and research institutions. The LLDA has taken on the role of commissioning the necessary research and ensuring it influences management. At present, it is an active partner of the University of the Philippines-Environmental Forestry Program in the implementation of the Philippine Millennium Ecosystem Sub-Global Assessment, with a focus on the Laguna de Bay ecosystem.

There were a number of cases in the lake briefs of successful collaboration between local and outside researchers. Lake Baikal has developed a sister lake relationship with Lake Tahoe in the United States. The Lake Ohrid Conservation Project had a scientific advisor from its sister lake, Lake Champlain, who advised on the monitoring component of the project and helped guide the development of the Lake Ohrid State of the Environment report. Lake Toba researchers have also benefited from an exchange program with staff from Lake Champlain, its sister lake.

Integrating Knowledge

The complexity of lake processes and the close links between lakes and their basins means that scientific studies need to be integrated across disciplines. Lack of integration was explicitly identified as a shortcoming in the Lakes Toba and Chad, the North American Great Lakes, the Tucurui Reservoir, and the Bhoj Wetland briefs. At Lake Toba, the agencies conducting various research projects 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 basin.

The North American Great Lakes brief states that the previous single-issue approach has proven valuable to a point, but now the need is for a multidisciplinary approach. The Lake Titicaca brief describes how the Binational Master Plan was based on an integrated study of the lake and its basin. The recent Lake Victoria stocktaking report (Hecky 2003) and the Lake Ohrid State of the Environment report (Watzin and others 2002) illustrate the value of an integrated approach, although the Lake Victoria research did not have a well-integrated research design at the beginning. However, none of these reports has a significant socioeconomic component.

GEF Transboundary Diagnostic Analysis

Generating consistent knowledge for transboundary lake basins is especially problematic because of different levels of development in riparian countries, different priorities, and different scientific standards. The Transboundary Diagnostic Analysis (TDA) process has been devised by the GEF-IW focal area to help overcome this problem (Mee and others, 2005). It identifies and analyzes the scientific, technical, and socioeconomic information relevant to determining the major problems hindering the sustainable use of lakes and their resources, as well as the transboundary nature, magnitude, and significance of the various elements as they pertain to water quality, quantity, biology, habitat degradation, and/or conflicts; identifies the root causes of the problems; and ideally provides information and understanding on the types and magnitude of the programs and activities needed to address the problems. A properly conducted TDA will serve as a comprehensive information and database for the subsequent development of a Strategic Action Program (SAP) comprised of activities, projects, and remedial measures needed to ensure the sustainable use of a transboundary waterbody and its resources to the overall benefit of all drainage basin inhabitants.

The joint development of a TDA provides riparian countries with a forum for cooperating and collaborating in the exchange of information, and for working together to develop common lake basin goals. It also contributes to transparency and accountability as part of the development of wider regional

Table 8.1 The Production of TDAs and SAPs for the Eight GEF-IW Lake Basins.

Lake Basin	TDA	SAP
Aral Sea[1]	No	Yes
Chad	Yes	Yes
Cocibolca	In progress	In progress
Ohrid[2]	Yes	Yes
Peipsi/Chudskoe	No	No
Tanganyika	Yes	Yes
Victoria[3]	In progress	In progress
Xingkai/Khanka	In progress	In progress

1. Although no TDA was carried out during the GEF-funded Aral Sea project, there was sufficient information available for a SAP to be produced.
2. The State of the Environment report for Lake Ohrid is equivalent to a TDA and led to a SAP being agreed.
3. The TDA and SAP for Lake Victoria are being produced as a separate, short-term project.

cooperation. This cooperative element is probably as valuable as the assemblage of scientific information. For this reason, the GEF recommends that the development of the TDA be overseen by a high-level (preferably inter-ministerial) committee from all lake basin countries to provide strong country ownership of the identified problems and preliminary actions.

Eight projects in this study were funded under the GEF-IW focal area; only three of these have produced TDAs and SAPs (Table 8.1). Although there was very little comment in these lake briefs about the production of TDAs and SAPs, it was clear that the signing of a Convention for Lake Tanganyika was assisted by the TDA process and the collaboration at Lake Ohrid in jointly assembling data and developing the state-of-the-environment report was central to the development of a comprehensive management plan for that lake system. The Lake Tanganyika TDA is described in Box 8.4. The Lake Xinghai/Khanka brief stated that there have been great benefits already from collating data and information across national boundaries. However, the Lake Cocibolca brief warned that, even though

Box 8.4 The Lake Tanganyika Transboundary Diagnostic Analysis

The Lake Tanganyika Biodiversity Project commenced in 1995. Its objective was to "...establish a regional long term management programme for pollution control, conservation and maintenance of biodiversity in Lake Tanganyika."

The main threats to Lake Tanganyika's biodiversity were identified by the country representatives at a workshop early in the project. These threats were:

- Unsustainable fisheries;
- Increasing pollution;
- Excessive sedimentation; and,
- Habitat destruction.

The representatives ranked the perceived threats in order of national priority. A preliminary TDA was developed based on this information as well as the outputs of a series of national review meetings. The preliminary TDA brings together the four national review exercises and adds the regional and transboundary perspective. The final TDA was undertaken following the completion of a special studies program and the preparation of reports directed at the specific information requirements of the TDA.

The TDA is structured as a three-level matrix with the four main threats to the lake, the transboundary implications, the institutional problems and the general action areas constituting the first level (Table 8.2).

Table 8.2 Level 1 of the Three-level Lake Tanganyika TDA.

Main Threat to Biodiversity and Sustainable Use	Cross-Cutting Transboundary Implications	Cross-Cutting Institutional Problems	General Action Areas
• Unsustainable Fisheries • Increasing Pollution • Excessive Sedimentation • Habitat Destruction	• Global Loss of Biodiversity • Loss of Shared Fisheries Resources • Decline in Water Quality	• Lack of Resources • Poor Enforcement of Existing Regulations • Lack of Appropriate Regulations for Lake Tanganyika • Lack of Institutional Coordination	• Reduce Impact of Fishing • Control Pollution • Control Sedimentation • Habitat Conservation

The second level has four parts, one for each of the four identified General Action Areas. Each part describes the problems that together form the threat that the General Action Area is addressing; the stakeholders that that will need to be involved; the uncertainties where further information is required; and a Programme of Actions which address the specific problem. The third level takes each specific problem and its Programme of Action and identifies its timing; the key agency that would lead a particular proposed Action; and the available human and material resources.

Source: Lake Tanganyika: The Transboundary Diagnostic Analysis. GEF, Washington, DC.

a TDA will be produced, the lack of reliable data will affect the quality of the SAP.

Although the evidence is limited, it appears that technical collaboration during the process of producing an agreed diagnosis of the problems affecting a transboundary lake basin, including the priority actions for managing the problems, does advance cooperation between riparian countries.

This lesson of the importance of developing a common understanding based on factual information can also be applied to sectoral institutions within countries. There is a greater likelihood of institutions cooperating when they have a common understanding of issues and potential management actions. This need is most acute in the case of environment and water resources institutions which are commonly responsible for taking the lead in lake basin management. Consequently, it is important that scientific information is both translated into language that staff from these institutions can understand and targeted at the management objectives of these institutions. In addition, this information should be made accessible to the public at large.

Chapter 9

Mobilizing Sustainable Financing:

Local, National and External Funds

Key Lessons Learned about Financing

- Locally generated funds, such as water user fees, fish levies and pollution charges, can provide a stable and important part of the financial base for lake basin management. However, unless there is a high value use extracted from the lake's resources, these funds are not usually sufficient for lake basin management.
- It is important that locally generated funds are largely retained locally and that there is involvement of resource users in establishing and administering the fees.
- Most funding for lake basin management comes from national and/or local sources. External funds should play a catalytic, rather than a primary role for implementing lake basin management activities and investments.
- 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.
- National funding, sometimes supplemented by external loans and grants from development organizations, is often used for large capital-intensive investments. In some countries, such as China and the Philippines, national funds constitute the major of capital funding; whereas in others, such as Kenya, Albania and FYR Macedonia, donor support constitutes a major source of capital financing.
- The GEF is a major source of funds for improving the management of transboundary and globally important lake basins. These funds are used to establish the enabling environment for successful ongoing lake basin management.
- To ensure global benefits from lake projects, particularly in the case of international lake basins, a programmatic approach from GEF and other funding bodies, would be better than a project-by-project approach. This approach would also require a longer-term commitment from lake basin countries to sustainable management.

Sustainable lake basin management depends on sustainable financing. Management expenditures are comprised of the salaries, facilities and operating costs of the management organizations, including support for implementation of regulations, monitoring, applied research and communication activities. These are complemented by expenditures for infrastructure investments, often undertaken by specialized agencies, including their operation, maintainence and replacement (OM & R costs).

According to the briefs, securing sufficient financial resources is a constant concern:

- "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 Nakuru 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." (Issyk-Kul brief); and,
- "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).

Expenditures are of two major types:

- Large, discrete capital investments, typically associated with investments in technological solutions such as sewage treatment or hydraulic works (Chapter 7); and,
- Day-to-day OM&R costs, largely salaries and operating costs.

In most countries in economic transition and in developing countries, neither cost is fully met from local resources. National governments and foreign donors typically provide funds for capital investments. This is likely to continue because of the size and infrequency of these investments. However, regular, ongoing expenses can be met, at least partially, from local funds, although in most lake basins these local funds need to be augmented with national sources.

In principle, all stakeholders using lake basin resources should contribute to the management of those resources so that their quality is maintained. 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. The administrative costs of collecting fees or charges can be substantial. Hence the focus of this chapter is on practical steps that can be taken to develop sustainable financing for improved lake basin management.

While obtaining sufficient funds will remain a problem for almost all lake basin managers, the lake briefs provide examples of how additional financing can be obtained. 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.

Most money for lake basin management has come (and will continue to come) from sources within each country. In this chapter, we use the case studies to examine the three principal sources of funds:

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

Locally Generated Funds

Locally generated revenues typically consist of payment for services provided by lake basins (such as charges for use of raw water or recreational or economic use of a lake) or for the use of the lake to dispose of wastes. Local revenue can also come from fines for not adhering to the conditions of a license or permit. These funds are collected from direct users (and beneficiaries) of lake resources such as fishermen; those who benefit from the lake as a source of ecosystem services (such as people who benefit from flood mitigation); and those groups whose activities pollute the lake (such as industries or municipal wastewater disposal systems).

Locally generated funds include those collected from people who benefit directly from the lake basin's resources. These include revenues from downstream users of a lake's resources. These funds are most valuable if the downstream uses have high value, such as drinking water or hydropower generation. For example, Lake Biwa has been very successful in attracting money from Osaka and Kyoto (which use the lake's water for domestic and industrial purposes) for investment and management costs to help protect the lake's resources. In fact, total public investment in the Lake Biwa region for lake basin management from 1972 to 1997 was $18 billion, most of which was paid by national and downstream sources. The Kariba Reservoir provides another example. The lake's water is used for hydropower generation. The operational costs of the Zambezi River Authority, which manages the lake basin, were funded from the revenues of the energy generating authorities in the riparian states of Zambia and Zimbabwe.

The Armenian community provides another example of a local community that benefits from the resources of a lake. Although not discussed in the Lake Sevan brief, a recent study (Laplante and others 2005) has estimated that Armenians living in Yerevan, the capital, are willing to pay around $18 per person for the continued existence of Lake Sevan at its present level. This is a substantial sum given the per capita GNI of $950 in Armenia (World Bank data, 2003, Atlas method). Additional research is looking at the willingness of expatriate Armenians to pay for the lake's existence. These numbers are expected to be much higher. The challenge, of course, will be to collect some of these potential contributions.

Private funding is a subset of locally generated funding and is usually only important when the number of stakeholders is small and the community is both relatively rich and socially cohesive. The stakeholders can band together to make needed investments and enforce certain management policies. For example, the LNRA is an example of a relatively wealthy interest group that has joined together to protect the lake's natural resources.

In many countries, the legal framework states that all money collected from user fees has to go to the national treasury. Local water resources managers are discouraged from collecting these fees if the funds are not to be retained for local purposes. Where these revenues can be retained for local use, collection rates are relatively high and have been applied successfully to meet local needs. Thus, the Tanzanian government has allowed water user fees to be retained for local use at all its nine river and lake basin water offices, including those for the three African Great Lakes included in this study. Under a separate policy, a trial of fish levies has been successfully tested in the Tanzanian part of Lake Victoria (although the water user fees and the fish levy are collected by separate agencies, their use is not complementary to each other, thus important opportunities for strengthening lake basin management are being lost). At Laguna de Bay, fees from fish-pen operators are split between the lake basin authority (LLDA) and local governments, with the latter component being applied locally to projects or activities related to environment, livelihood, river embankment and flood protection works, and watershed development.

User Fees

A user fee is a charge that is paid by those who derive a benefit from the direct, or indirect, use of the lake. In practice, however, user fees have been instituted for direct use of lake resources such as water and fish. These resource users have both an interest in 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. For example, user fees from fish-pen operators in Laguna de Bay in the Philippines (Box 9.1) have become an important source of funds for the LLDA. This example also illustrates the importance of agreeing on a distribution of the funds with responsible institutions, such as local government.

Tourism, both national and international, is another resource use where user fees (admission fees, daily use charges) can be used to produce revenue for improved lake basin management. For example, at Lake Nakuru, visitors to the national park to see the flamingos and other wildlife pay a user fee. This practice could be extended to other lakes, where there is a clearly defined lake basin-related tourism activity (such as birdlife at Lake Baringo). Tourism is an important source of income at the Kariba Reservoir, although it has yet to be accessed for helping fund lake basin management. Recreation is another use that can provide a source of local finance (for example, Lakes Constance and Ohrid, and the North American Great Lakes).

Healthy lake basins provide services and physical products to industries too. In Indonesia, for example, the management authority for Lake Toba has been working with various stakeholders to increase its funding base for improved lake basin management. In particular, a wood-pulp producer, PT Toba Pulp, is working with the local community to ensure its forestry activities are more "environmentally friendly." An important ingredient for success with resource user fees is the local retention of at least part of the fees collected. PT Toba Pulp also sets aside 1 percent of its net revenue (about $500,000) for the use of the local government for improved environmental management in the lake basin. The fish catch levies that have been trialed in the Tanzanian part of Lake Victoria provide another example of payment by industry for the services provided by a lake basin.

Half of the lake basins in this study have per capita GNI that falls in the "lower income" range (less than $765/yr). In the most extreme case, the Lake Malawi/Nyasa basin has a per capita GNI of only $217. While it is argued in some lake briefs, such as the Chilika Lagoon brief, that some beneficiaries are too poor to bear the costs of water resources management, it is equally clear that they bear significant costs if management of the resources is not funded. 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 or conservation. This helps create general public awareness and expectations about appropriate and effective management.

Introduced properly, resource user fees can be accepted by even the poorest communities. In some cases, a potential source of local revenue is through a fish levy. The fisherfolk at Lake George, among the poorest in the world, have agreed to pay an annual fee (about $1.50) to LAGBIMO, the lake basin coordinating body. This fee is acknowledged to be inadequate for funding management costs, but implementing even a partial user fee system—along with the necessary community involvement, accountability, and transparent management—is part of the larger reform of lake basin management and can begin to generate some revenues for improved management. In another example, the Chilika Development Authority has already initiated a process of self-financing through local beneficiaries, although the sources of these funds are not described in the lake brief.

Pollution Charges

Fees can also be levied on those whose actions potentially damage the lake and its sustainable use. Pollution charges serve a double purpose; they generate revenue to address the pollution issues or compensate those who are hurt by the pollution, and they serve as an incentive for polluters to decrease their pollution. These aspects of pollution charges are illustrated at Lake Dianchi (Box 9.2).

Box 9.1 User Fees at 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. They have adopted a flexible, responsive system to allow them to make revisions based on the results of monitoring.

Revenues from a 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 $120 per ha of fish pens, generates revenues for improved lake basin management and makes the lakeshore communities active stakeholders in lake basin management.

While the fee has successfully generated income for LLDA and local governments, it does not act to discourage undesirable impacts. The fee became an end in itself; as fish-pen numbers expanded, revenues rose. However, the expansion led to conflicts between pen operators and marginal fishermen who rely on access to open water fishing. In 1983, the conflict led to loss of lives and properties. Nor did the fees act to discourage the increase in nutrients lost from the pens as a result of overfeeding. (A different fee, the Environmental User Fee, was discussed in Box 5.3).

Source: Laguna de Bay Brief.

Box 9.2 User Fees in Lake Dianchi, China

Lake Dianchi, which is located 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 alone, they spent over RMB 340 million (about $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 basin.

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 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 authorities have begun to tackle the major problem of pollution of this important lake.

Source: Lake Dianchi Brief.

It can be important to set the pollution charge at a level that encourages a reduction in pollution loads but does not drive firms out of business. For example, pollution fees at Laguna de Bay were set iteratively. Regardless of how carefully charges are adjusted, there may well be cases where some firms will have to close, since the costs of either correcting the pollution or paying the charges are too high. This has been the case at Lake Dianchi, where 249 previously polluting industrial enterprises met the water discharge standards in response to the cleanup program and four enterprises closed down.

While locally generated funds—both water resource user fees and pollution charges—are probably still only a small share of lake-management funding at most lake basins, it is the part of the funding package that has the most potential for future growth. Few of the lake briefs provide details of local funding sources. However, the Laguna de Bay Brief shows that the percentage of income derived from water resource user fees (for fish pen) and permits to discharge wastes has risen in recent years (Table 9.1), while income from fines for noncompliance with permits has fallen.

The Laguna de Bay experience with pollution charges has been to start simple and fine tune as experience builds up. Their six recommendations are (1) select a simple, modest approach; (2) start with a sector-based pilot to help understand feasibility aspects, administrative convenience, institutional arrangements, and acceptability; (3) pick one or two controllable parameters; (4) revise charges based on results of monitoring; (5) create a strong and credible regulatory arm with multistakeholder orientation; and (6) set pollution charges at all levels from zero discharge and increasing above the effluent standards.

National Funding

Most lake basin management programs rely, entirely or in part, on financing from the national or provincial/state government, either through sectoral ministry budgets or special appropriations for integrated lake basin management. National-level funding is often insufficient in amount and may not be sustainable, particularly if the lake basin is remote or populated by a minority group, or when issues pertaining to that lake are competing with other priority concerns.

National funding is often essential for capital infrastructure investments. These large investments—for such things as wastewater treatment, major water supply projects, or flood control or dredging works—are rarely funded at the local level because of the size of these investments or because the benefits may be quite wide ranging and long term. For example, from 1991–2001, the state of Vermont spent over $20

Table 9.1 Contributions to Local Sources of Income at Laguna de Bay.

Funding Source	Percentage contribution					
	1997	1998	1999	2000	2001	2002
Fish-pen fees	24	24	25	34	26	40
Discharge permits	10	13	12	12	15	22
Pollution fines	23	28	24	18	23	14
Interest on securities	18	16	15	13	16	8
Miscellaneous	25	19	24	23	20	16
Total	100	100	100	100	100	100

million on reducing phosphorus discharges from municipal wastewater treatment plants in the Lake Champlain Basin, and New York spent over $10 million building and enhancing wastewater treatment plants. From 1991–98, Quebec invested over $13 million in construction of wastewater treatment for areas discharging to the Lake Champlain Basin and Richelieu River.

In lake basin activities that do not involve large capital investments, national government funding of lake basin management is usually delivered through the budgets of sectoral agencies, such as Forestry or Water Resources departments. For example, during the World Bank-supported Orissa Water Resource Consolidation Project, the Chilika lagoon basin remediation activities were implemented by the Agriculture Department, Soil Conservation Department, Forest Department, Fisheries Department, Department of Water Resources, Bhubaneshwar Development Authority, Orissa State Pollution Control Board, and the Tourism Department. The Chilika Development Authority coordinated these activities to ensure they contributed toward the lake basin's restoration.

External Funding

About two thirds of lakes in this study had some sort of external support. External funding is often used for infrastructure investments where it supplements national government funding. Supplemental funding can range from a marginal share of the total to the bulk of management funding. For these jointly funded investments to be fully effective, there needs to be a clear agreement between the government and the donor 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 sewage 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 the Kenyan government has not fully met its obligations to fund the necessary reticulation infrastructure.

External support can take the form of loans from the World Bank or regional development banks that have to be repaid. "Hard" loans carry near market-determined interest rates; "soft" loans or credits carry below-market, highly-subsidized interest rates and are generally only available to the poorest countries. Most bilateral assistance (such as from the European Union and individual donor countries) and GEF funding are in the form of grants. Some lake basin projects combine grants with loans. For example, the first phase of the Lake Victoria Environmental Management Program includes a GEF grant of about $36.8 million, a "soft" loan from the World Bank of about $35 million, and a $7 million contribution from the three national governments. A key issue is the inadequate integration of institutional and investment costs for lake basin management into the planning and budgeting system at the national and local level within countries, and the limited priority these activities are given in the allocation of loans and grants from international sources.

External funds are not necessarily essential for successful lake basin management in countries in economic transition or developing countries. Some lake basins in developing countries have no, or very limited, external funding. For example, the primary source of funds to control pollution of Lake Dianchi and restore its ecosystem comes from Chinese government sources. By the end of 2000, 2.1 billion yuan ($250 million), including part of a World Bank loan, was spent supporting the completion of 17 engineering projects. This lake basin program has achieved some success in controlling industrial point sources of pollution, treating effluent discharges, restoring forest cover in the lake basin, and removing contaminated lake and river sediments. The Chillika Lagoon and Laguna de Bay provide other examples of successful lake basin management programs that were primarily funded from national sources.

External funding has benefits and costs. It allows managers to implement more policy reforms and undertake more investments, but is usually not sustainable over time if efforts to develop local sources of revenues for lake basin management are not developed. For example, without this important provision, the average GEF project is a one-time investment over 3 to 5 years. Consequently, it is important that external funds are used to initiate management changes that are self-sustaining within the basin countries. The lake briefs reflect this requirement that external funds play a catalytic, rather than an implementing, role in lake basin management. Basic ongoing funding has to come from national and/or local sources if improved lake basin management is to be sustainable.

The Global Environment Facility

The GEF is a unique mechanism in that it is based solely on the fact that ecosystems, including lakes, have global environmental benefits and that the global community should provide assistance in meeting the management costs beyond what a country would normally provide to meet national benefits. Hence, GEF funding is designed to cover the "incremental costs" of an activity—those costs that produce international environmental benefits over and above national-level benefits.

The GEF has a specific focal area to assist countries manage transboundary waterbodies, including lakes. These funds supplement funds provided by the riparian countries and other donors. Thus, in the case of Lake Peipsi/Chudskoe, GEF funds have partially assisted the governments of Estonia and the Russian Federation set up the institutional environment for successful lake basin management, including transboundary cooperation and information exchange and the development of a transboundary water management program. The two governments have signed three agreements (fisheries, environment, and water use) and have set up a Transboundary Water Commission to improve the management of the lake basin. In another case, the development and protection of Lake

Victoria has been hampered for many years by the absence of a broad agreement among the three riparian countries (Tanzania, Kenya, and Uganda). However, with GEF, World Bank and other donor funding assistance, the three countries have collected an extensive database of information on the lake basin and are now drafting a transboundary diagnostic analysis and strategic action program for the lake. If successful, this initiative will lay the foundation for a joint approach to managing the lake and much of its basin.

In other cases, where the lake possesses some globally important values, the international community may need to assist riparian countries with lake basin management. For example, Lake Malawi/Nyasa, recognized to be one of the most biodiverse in the world, is central to the economy of Malawi but is of lesser importance to Tanzania and Mozambique. Malawi operates an aquarium fish trade that exploits some of the highly localized and rare fish species, while Tanzania and Mozambique are developing agriculture and tourism within the lake's catchment with the potential for adding sediment and nutrients to the lake. There is considerable international concern about the threat to the lake's biodiversity. Despite a preliminary GEF-financed biodiversity project and considerable preparation work for a major follow-up project, the Government of Malawi has decided not to give the conservation of the lake's biodiversity a high priority.

However, the lake briefs note that, while highly valuable, the short-term nature of these projects jeopardizes the long-term sustainability of management improvements. There was concern expressed at the African lakes workshop and in the Lake Malawi/Nyasa brief that, when GEF funding ceased, the activities being supported also ceased (The GEF-funded Lake Malawi/Nyasa Biodiversity Conservation Project was a small, early, pilot project). The brief on the Lake Baikal GEF-Biodiversity project echoed the same concern: "it is unclear how successful projects developed under the GEF project will continue to receive funding now that the project is over." While these comments may reveal a misunderstanding of the purpose of the GEF funds, they still indicate that there is a need to make the outcomes of GEF-funded projects more sustainable. While it was not explicitly noted in the lake basin briefs, the GEF has followed on from its initial investments at Lake Tanganyika and Lake Victoria with second-phase projects aimed at building on the achievements of the first-phase projects.

While a programmatic approach to GEF funding would help overcome this problem, it would also require a greater commitment from national governments. The African and Europe/Central Asia/Americas workshop attendees supported greater commitment from national governments. The Lake Malawi/Nyasa brief also complained that undertakings by governments to incorporate responsibility for activities at the end of the donor funding period are rarely honored. This observation is valid for many externally-funded lake basin management projects. One consequence is that externally funded development projects may need to concentrate on developing mechanisms for sustainable financing from local sources to reduce dependence on national government funding. Another consequence is that, with an increase in a programmatic approach to lake basin funding, it may be possible to hold governments more accountable for commitments to longer-term national contributions.

Section III

Synthesis

Chapter 10 on planning discusses how the components of lake basin management can be carried out in practice. Chapter 11 provides guidelines for taking action to improve lake basin ecosystems and benefit the people who depend on lake basins.

Chapter 10

Planning for Sustainable Lake Basin Management

Key Lessons Learned about Planning

- Planning processes for lake basins require the integration of the components of good management discussed in Section II. Any plan for a lake basin needs to be aligned with regional and national plans for development and environmental protection.
- Plans vary in their levels of detail and breadth. By focusing on agreed goals, vision statements can be useful first steps to developing more detailed management plans.
- Comprehensive plans have the advantage of improving effectiveness by integrating actions across sectors. However, they can be expensive to implement, costly to coordinate, and inflexible in the face of changing political priorities.
- Statutory plans provide control over day-to-day development activities in a lake basin through the existing legal and institutional framework. Together with Environmental Impact Assessment and Strategic Environmental Assessment frameworks, these existing statutory provisions need to be fully utilized. Implementation of statutory provisions requires a good governance framework and associated institutional capacity.
- At this stage, three of the eight GEF International Waters-funded projects in this study have produced Strategic Action Programs. From the examples available, it appears that these SAPs have been beneficial in promoting contact between sectoral and national institutions and have laid the foundation for joint management interventions.
- Coordination between sectoral and regional plans should first take place where the pressures are greatest. They should be phased over time and be opportunistic.
- Sectoral or regional plans can be coordinated through (1) a separate coordinating project, (2) a post-hoc unification of outputs, or (3) a broadening in the scope of an initially narrow project as it achieves success and gains credibility.
- Plans need to be flexible in the face of changing social needs and external factors. They also need to be responsive to the results of monitoring. Some activities may be less successful than envisaged, and new issues may be identified through the monitoring program.

This chapter covers two broad subjects. The first explores how the terms “plan” and “planning” are used in lake basin management as revealed in the lake basin briefs and how they relate to the discussion of the components of lake basin management. The second focuses on the integration of planning issues, including social consensus, scientific knowledge, and time factors.

Planning for Sustainable Lake Basin Management: A General Overview

Planning and Objectives

Lake basin planning is the process of developing an agreed set of goals for use of a lake basin and the means for achieving those goals, typically within a particular time frame and resource constraints. Plans can be developed at different levels of specificity from local to basin-wide plans, and from sectoral to comprehensive plans.

The process of planning comprises the following stages:

- Establishment of a goal (or a set of goals) agreed by the stakeholders;
- Development of alternative strategies for reaching the goal;
- Selection of the preferred strategy based on an assessment of feasibility;
- Implementation of that strategy with mobilization of necessary resources; and,
- Refinement of the strategy through monitoring and evaluation.

Lake basin planning relies on the components of good governance discussed in Section II of this report (Figure 10.1

and Box 10.1). Development of a plan requires involvement of stakeholders and institutions concerned with lake basin management, the use of reliable and timely information, the assessment and selection of both policies and technological responses to issues, and the identification of financing options for implementing the plan. The lake basin plan is the mechanism for putting the components together in an effective and fair way for resource development, environmental protection, and social benefit.

In both developing and industrialized countries, the viability of a management plan for a lake basin is strongly dependent on the alignment of the plan with regional and national plans for socioeconomic development and environmental conservation. If the policy and institutional contexts are not properly aligned, then the lake basin plan is unlikely to be supported.

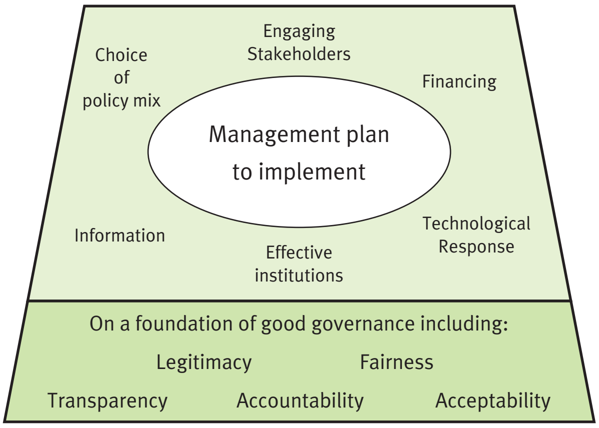

Figure 10.1 A Conceptual Framework of Lake Basin Planning.

Box 10.1 Planning and the Components of Lake Basin Management

"Opportunities for Action" (Lake Champlain Basin Program 2003) illustrates the inclusion of the components of lake basin management, discussed in Section II, into a comprehensive plan. The plan, produced in 1996 and reviewed in 2003, includes a shared vision for the entire lake basin; prioritized actions for water quality and quantity, living resources, cultural heritage, recreation and economic development; and a variety of specific agreements (such as a Water Quality Agreement).

Institutions. There are a variety of institutions involved in the management of Lake Champlain, including:

- The International Joint Commission, which coordinates activities across all boundary waters between Canada and the United States;
- The Lake Champlain Fish and Wildlife Management Cooperative, a federal-state cooperative between the various state and federal fish and wildlife agencies that manages the fish and wildlife resources of Lake Champlain; and,
- The Lake Champlain Basin Program (LCBP) which is a partnership between the states of New York and Vermont, the province of Quebec, and various federal and local government agencies and local groups. The LCBP coordinated the activities of the various sectoral and other institutions in developing and implementing the plan.

Rules. New York and Vermont have agreed on loading and in-lake concentration nutrient targets that have become the basis of a federally mandated phosphorus total maximum daily load (TMDL) plan for Lake Champlain. Vermont and Quebec have also developed an agreement dividing responsibility for phosphorus reductions in the northern section of the lake.

Stakeholder Involvement. Twenty-eight formal public meetings and countless informal meetings were held during the development of the plan. There was similar intensive public involvement when the plan was revised in 2003. There was also a series of advisory committees whose members represented the various interests associated with specific areas of the plan. This consensus-driven approach tends to minimize the polarization of hard ideological positions.

Knowledge. The plan is based on the best available knowledge. A workshop, held in 1992 reviewed existing information and established a research and monitoring agenda. Subsequently, technical projects have been funded to provide key information to inform management decisions. After the plan was completed in 1996, research and monitoring were continued, both in the form of targeted projects investigating particular issues and ongoing monitoring designed to document the long-term trends in the quality of the basin's resources. Monitoring environmental conditions typically requires up to 15 percent of the annual USEPA funds available to the LCBP.

Funding. Comprehensive plans are expensive to implement. Preliminary cost estimates from "Opportunities for Action" implementation actions will require at least $12 to $15 million annually and at least $170 million for the period through 2016.

The LCBP has diversified its federal funding base in recent years. Base funding is provided by the USEPA, with several other federal agencies also contributing. Federal funding supports portions of the coordination, technical, and outreach activities of the LCBP partners. A significant portion of this funding is passed on to NGOs working on local issues throughout the basin, resulting in increased interest, participation, and financial support from local citizens and businesses. The Leahy Center, a combined museum and science center, is funded from private donors, the federal government, and other supporting organizations.

Source: Lake Champlain Basin Program (2003).

In both cases, political decision makers can be powerful influences in drawing up and implementing management plans. They can promote institutional cooperation, ensure alignment with socioeconomic development and environmental conservation plans, and access the necessary finances for implementation. For example, the Chief Minister for the Indian State of Orissa played a prominent role in the development and implementation of the Chilika Lagoon recovery plan. However, there can be a cost to close political involvement, as shown at Laguna de Bay. Some members of the board of the Laguna Lake Development Authority were appointed by the president of the Philippines and, while that provided access to senior political levels, it also meant that the Authority was subject to shifts in government policy, with a consequent lack of continuity in its programs. Hence, it is important for a lake basin management plan to allow for flexibility and to include risk mitigation and adaptation components.

Forms of Plans for Lake Basin Management

Vision Plans

As a step toward developing a detailed management plan for a lake basin, it can sometimes be desirable to develop a vision statement. While strictly not a plan itself, such a statement provides a mechanism for stakeholders (both cross-sectoral and transboundary) to agree on the higher-level goals to be achieved within the lake basin and thereby lay the foundation for a more detailed management plan. The Vision and Strategy Framework for Management of the Lake Victoria Basin is an example of a high-level statement of agreed goals developed through a highly consultative process carried out at local, district, national, and regional levels (over 15,000 submissions were received). The vision contains numerous sectoral strategies, grouped under five policy areas. While the vision statement is well considered and widely accepted, the strategy framework is generalized and lacks priorities and implementation details. The North American Great Lakes Charter, signed in 1985, established a series of principles and procedures for managing Great Lakes water resources and is effectively a vision statement.

A vision plan can be a useful device when the issues to be resolved in establishing a management plan are complex, when there has been no history of cooperation between sectors or countries, or when there is a lack of information and it is premature to decide on detailed actions. The level of institutional commitment and the required financial and human resources for vision statements are likely to be quite moderate compared to the level associated with implementation of projects that are typically associated with basin “action plans” or with sectoral “intervention plans”.

Action Plans and Intervention Plans

Terms such as “action plans” and “intervention plans” are used fairly interchangeably to describe short-term plans with sectoral commitments to carry out specified actions in pursuit of the agreed management goals for the lake basin. The Lake Ohrid Transboundary Watershed Action Plan is typical of these plans. It includes 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 nonpoint-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; and,
- Comprehensive planning through the establishment of micro-watershed planning committees, and by creating a GIS system and building the planning capabilities within the municipalities.

Sectoral agencies are usually responsible for developing short-term management intervention plans for both development and conservation/remediation purposes. A 1993 Water Quality Agreement for Lake Champlain signed by the states of New York and Vermont and the province of Quebec in 1993 included, among other actions and strategies, a phosphorus load reduction strategy from point and nonpoint sources. A review of progress of the strategy showed that all three participant jurisdictions had considerably exceeded their reduction commitments, but that the nutrient reductions from point-source improvements were being offset by increases in other sectors, principally conversion of agricultural land to urban uses. This highlights one of the limitations of such sectoral plans; they are not effective instruments for tackling problems that span numerous sectors, such as the problems found in many lake basins.

Comprehensive Plans

A comprehensive lake basin plan details the long-term structural and nonstructural actions needed across multiple sectors and (if necessary) jurisdictions to meet the development and conservation goals for the lake basin. These goals may have been outlined in a previous vision statement. The actions are carried out by a range of (usually sectoral) organizations and a lake basin coordinating institution, if one exists. Such comprehensive plans are designed to overcome the limitations of sectoral approaches to problem management. However, their time frames may extend well beyond the normal budgeting cycles of government agencies. In addition, the priorities of sectoral agencies change over time in response to political needs. Consequently, there may be only a weak commitment to the long-term implementation of such plans, unless an adaptive approach is used where the plans are designed to be flexible and subject to periodic review.

The Lake Conservation and Management Project at the Bhoj Wetland is an example of a comprehensive plan. It has tackled various issues associated with conservation and management of the upper and lower Bhopal lakes under a multi-sectoral strategy. The strategy includes 16 sub-projects to be implemented by sectoral agencies, including infrastructure for the diversion and treatment of domestic sewage; city and catchment afforestation; de-weeding and aquaculture operations in the large lake; floating fountains for aerating the lake waters and promoting eco-tourism; relocation of clothes washing sites; construction of a road along the lake periphery for easing traffic pressures to stop encroachments in the littoral area; and dredging of silt to increase lake capacity and reduce floods. Many of these actions have now been completed successfully. As a further example, Box 10.2 describes the Lake Biwa Comprehensive Development Plan.

While comprehensive planning has been practiced for many decades in order to tackle longer-term, cross-sectoral issues, the means for developing these plans has changed in response to lessons learned and changing social structures. Thus, the North American Great Lakes brief identifies five eras of lake basin management, each with a different emphasis on planning: "Resources Development" in the late 18th through mid 19th century; "Transition" in the late 19th century; "Federal Leadership" in the early 20th century; "River Basin" in the late 20th century; and the "New" era from the mid-1980s through today. During the "River Basin" era, there was an emphasis on environmental protection and resources management using a top-down, government-dominated approach. In the "new era," planning and management is undertaken using a bottom-up, partnership-based, inclusive approach.

Statutory Plans

Most countries have a form of statutory land use zoning, usually implemented at the local government level, used to control the location of different land uses and impose conditions on uses and changes of use. Such zoning schemes are intended to coordinate land development with the provision of services such as roads, water supply, and power; minimize nuisances between incompatible land uses; indicate conditions that may be required on development proposals; and help protect environmentally sensitive areas. Statutory land use zoning schemes are essentially reactive instruments that are used to respond to development proposals, rather than to actively lead and promote development and conservation activities. Nevertheless, they inevitably affect the development of basins and so can be used to help promote the objectives of lake basin management. There is little discussion in the lake briefs about the use of these statutory zoning instruments for helping protect lake basins, although the Lake Nakuru briefs describes the development of a strategic structural plan for Nakuru city in 1999 that identifies key planning sectors and offers a vision of the intended spatial structure of the city.

However, there are a number of special purpose zoning schemes described in the lake briefs that are designed for lake basin protection and development.

- The zoning scheme for the Issyk-Kul Biosphere Reserve comprises four zones: a core zone; a buffer zone; a transitional zone; and a restoration zone. Goals for protection and development differ from zone to zone, as do standards for use. However, environmental problems in all four zones are closely intertwined with economic

Box 10.2 The Lake Biwa Comprehensive Development Plan (1972–97)

The Lake Biwa Comprehensive Development Project (LBCDP) was a major national project, with its primary object being provision of additional supply of Lake Biwa water to the downstream Kyoto/Osaka/Kobe region. The specific goals of the project were to:

- Construct levees around the lake, with various flow control structures to enable the release of an additional 40 m^3/sec of lake water to the Yodo River;
- Improve the flood control capability of rivers by channelization and by installation of flow control gates along the Lake Biwa coastline, as well as along the Yodo River itself; and,
- Improve the water irrigation pipelines and sewerage systems around the lake.

The financial support for these massive development projects came from the national government, the downstream prefectural and municipal governments, as well as from the Shiga Prefecture. The LBCDP cost 1.9 trillion yen (about $17 billion), and became the largest water resources development project in Japan. The project laid a sound foundation for flood control and water utilization and industrial and urban infrastructure, boosting the economy of Shiga Prefecture. Transportation capability of Shiga Prefecture has also improved significantly with the construction of motorway-topped levees around the lake, which was not however the primary objective of the construction.

However, the LBCDP also triggered the destruction of the lakeshores and littoral ecosystems, and possibly accelerated the degradation of the lake's water quality. In 1976, demanding the right to enjoy clear water, more than 1,000 citizens brought a lawsuit against the central and Shiga Prefectural governments to stop the LBCDP. Although the plaintiffs lost the case, their advocacy led to the enactment in 1992 of the Reed Belt Conservation Ordinance and the Basic Environment Ordinance in 1996.

Source: Lake Biwa Brief.

activity, and so recommendations on environmental improvement of the given areas are intertwined with prospects for economic development.

- There are regulatory zonings on Lake Biwa for recreation use that, for example, designate areas for pleasure boats, prohibit the use of personal watercraft with 2-cycle engines, and forbid the catch-and-release of invasive fish.

- Protected areas have been zoned on the shoreline of Lake Constance by the Hochrhein-Bodensee and Bodensee-Oberschwaben regional associations to protect the valuable and sensitive shallows. For example, 51 percent of Baden-Wurttemberg's shoreline has been designated as belonging to Protected Zone I, which comprises shoreline close to its natural condition and transition zones with biotopes deserving protection or valuable fishing or spawning areas. This zoning not only prevents further shoreline deterioration, but has been used to designate areas for re-naturalization where reeds are being reintroduced, trees and bushes replanted, and impediments to fishing removed.

Environmental Impact Assessments and Strategic Environmental Assessments

Environmental impact assessments (EIAs) are now required by most countries as part of the evaluation, review, and approval process for proposed investment projects. They are typically applied to larger projects (dams, irrigation and drainage, transportation investments, ports and harbors, and so on) and are intended to integrate environmental and social issues into the planning, approval and implementation process for proposed projects. This includes evaluation of alternatives to the proposed project, examination of potential positive and adverse impacts, development of environmental and social management plans to mitigate potential impacts and provision of a framework for monitoring. They also provide an important mechanism for public consultation concerning proposed investments, as well as support the dissemination of information to stakeholders.

While EIAs for proposed developments in lake basins should identify, assess, and propose mitigation measures for any environmental and social impacts, there is almost no discussion of this instrument in the lake briefs. The Kariba Reservoir brief makes the specific point that it was the absence of any requirement for EIA when the Kariba Dam was constructed in the late 1950s that led to many of the deleterious environmental and social impacts that followed. The absence of a formal EIA allowed the governments, developers, and funders to proceed without having to carefully consider the likely detrimental effects of the dam. Today, EIAs are legally required in the countries in economic transition and most countries in the developing world, although many countries lack the capacity to effectively use them in the decision-making process and to implement the mitigation measures in a timely manner. Nevertheless, proposals for loans and grants to multilateral development banks and bilateral donor agencies, including the World Bank, need to be accompanied by EIAs. While EIAs have proven valuable for bringing environmental and social issues into project assessment, they assess only specific proposals (or variants of them) and are sometimes completed too late in the project cycle to have a major influence on the design of the project.

In order to integrate the assessment of potential environmental impacts at a higher level in the planning process, increasing use is being made of Strategic Environmental Assessments (SEA) in many countries, by the World Bank and some bilateral donors. SEAs, which are emerging tools, are applied not to specific project proposals but to policies, plans, and programs, and so allow a more preemptive and strategic assessment to be made of potential environmental and social impacts. Cumulative and incremental impacts can be more easily assessed and potentially beneficial impacts can be identified at an early stage and promoted. Although there are no examples of SEAs cited in the lake briefs, these higher level instruments are being applied in the Nile Basin Initiative to evaluate the larger environmental and social issues associated with river, lake, and wetland management proposals to be supported under this program. During the next few years, the use of SEA by multilateral development banks and bilateral donor agencies is anticipated to increase significantly and is the subject of an ongoing major review by the Development Assistance Committee of the Organisation for Economic Co-operation and Development (OECD).

Strategic Action Programs

The GEF promotes the development of Strategic Action Programs (SAPs) in its international waters projects. The SAP is based on an analysis of issues and their root causes in the lake basin (Chapter 8). The SAP describes the agreed actions to be carried out by the national governments, local governments, and NGOs/CBOs in the lake basin together with their development partners, including the GEF. It contains a clear statement of the actions needed to address transboundary issues; these actions include policy, legal, and/or institutional reforms, as well as remedial measures needed to ensure the sustainable use of a transboundary waterbody. In some cases, countries produce their own national action plans based on the SAP as part of their development planning.

There were eight projects in this study that were funded under the GEF-IW focal area. The Lake Tanganyika, Lake Ohrid, and Lake Chad projects have produced SAPs, while the GEF-IW projects at Lakes Peipsi/Chudskoe and Victoria have not produced SAPs. While the Aral Sea GEF-funded project has not produced a specific SAP, there a number of activities under way to increase the efficiency of water use by upstream countries and to protect at least part of the Aral Sea and its wetlands through engineering intervention. The more recent projects at Lakes Xingkai/Khanka and Cocibolca are committed to producing TDAs and SAPs.

The Lake Ohrid Transboundary Watershed Action Plan is an example of a SAP produced by a GEF-funded project. The plan, endorsed by the binational Lake Ohrid Management Board, outlines the actions needed and the roles of the stakeholders at both the national and local levels. The four primary action items include:

- Reduction of point-source pollution through actions that stress septic system management and maintenance, homeowner education, and management of solid waste;
- Reduction of nonpoint-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; and,
- Comprehensive planning through the establishment of micro-watershed planning committees, and by creating a GIS system and building the planning capabilities within the municipalities.

The production of the SAP, like the production of the TDA, acts as a mechanism for conducting multilateral dialogues on the broader transboundary subject areas of concern among the riparian nations. In the case of the GEF-funded Lake Tanganyika project, the diverse technical programs, the national working group structure, and the SAP planning process were all cited as good vehicles for generating broad stakeholder participation. As another example, the Lake Ohrid brief stated that, “watershed management committees have been formed and have succeeded in creating comprehensive multistakeholder forums and in initiating pilot projects that have helped to develop a SAP for the lake.”

The GEF advocates that a TDA precede a Strategic Action Program, and that the SAP be developed with widespread consultation, because sustainable and effective management plans need to be based on both reliable knowledge and social consensus. Box 10.3 summarizes the status of reaching knowledge and consensus in selected lake basins included as part of the LBMI process.

Coordinating Lake Basin Planning Activities

Approaches to Coordination

Many lake basin management plans are sectorally or regionally based. Even comprehensive management plans usually consist of numerous sectorally implemented components as illustrated by the Bhoj Wetland example. The temporal and spatial sequencing of projects both within a sector and between sectors can be very demanding in the face of budgetary and other resource constraints, compounded by changing social and political priorities. Coordinating these components so that they are mutually consistent and remain focused on the goals of lake basin management requires considerable flexibility and willingness to adapt to change.

Box 10.3 Dealing with Uncertainties in Planning for Lake Basin Management

High consensus, good knowledge base. Many small-scale sectoral resource development projects (such as in fishery development or tourism) in industrialized countries have strong social support and are based on good understanding. These sectoral plans tend to be very successful. For example, a series of programs to reduce nutrient loads from point sources in both the United States and Canada received widespread public support and were based on a strong scientific knowledge base. These programs have been successful.

High consensus, poor knowledge base. The lake basins facing this situation require plans that would typically include a knowledge development component—such as an intensive monitoring program or a scientific or socioeconomic research component—to reduce the uncertainties. These plans would also be developed under the precautionary principle; that is, management actions would be conservative, so that the chances of causing unforeseen problems would be minimized. Examples of lakes that fit into this category include Lakes Dianchi, Victoria (prior to the LVEMP project), Tonle Sap and Issyk-Kul.

Low consensus, good knowledge base. Lake Nakuru in Kenya provides an example where there is a large number of stakeholder groups, and where there has also been considerable biophysical research undertaken into the water quantity and quality problems of the lake and its drainage basin. 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.” 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.

Low consensus, poor knowledge base. The Lake Chad Basin Commission has been unable to effectively manage the lake basin because some of the countries have pursued independent irrigation development. 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 there is no accepted knowledge base from which comprehensive management decisions can be made. 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.

The management of Tonle Sap and the broader Mekong River system provides an example of coordinating different spatial levels. A number of donor-funded projects have been initiated to assist the Government of Cambodia in developing the human resources capacity to manage this lake basin, which is important for both its productivity and its biodiversity. At the same time, there are a number of initiatives under way to provide assistance to the development and conservation of the Mekong River system. The Mekong Basin WUP commenced in 2000 to help establish a reasonable and equitable water use allocation between the basin countries while maintaining its ecological integrity, including the integrity of Tonle Sap. A complementary program funded by the Finnish government, WUP-FN, is addressing the environmental and socioeconomic issues in the region caused by the unique nature of Tonle Sap, including its unusual flooding cycle, its diverse ecosystems, and the livestyles of the culturally and ethnically diverse populations around the lake.

Box 10.4 provides three broad approaches to coordinating sectoral and regional planning activities over time and space. In the first approach, "coordination by encompassing", separately implemented activities within a sector and between sectors are brought together under an umbrella framework that makes project linkages and the benefits of coordination explicit. The umbrella framework is effectively a comprehensive plan. In the second approach, termed "coordination by unification", the activities within the same sector are implemented over time and space more or less independently and then unified later. While this devolved approach places few demands on staff and budgets, it runs the risk of not achieving lake basin development and protection goals because of the lack of overall direction. The third approach, "coordination by

Box 10.4 Ways of Coordinating Separate Activities

Coordination by Encompassing (Figure 10.2a). This type of coordination occurs when a specific project or program is instituted to coordinate independently developed sectoral or regional programs and projects that are being implemented at the same time. These coordinating programs are introduced when it becomes apparent that greater benefits can be gained by integrating multiple sector activities to a coherent and collaborative framework. Typically, this integration will include cross-sectoral coordination across different government ministries, and different countries for transboundary lake basins. There are numerous examples of this approach in the lake briefs, including the Department of Lake Biwa and the Environment (Lake Biwa), the Lake Dianchi Protection Committee and Bureau (Lake Dianchi), the Mekong River Commission (Tonle Sap and the Mekong River), and the Lake Titicaca Binational Authority (Lake Titicaca).

Coordination by Unification (Figure 10.2b). The Zoning and Management Plan for Aquaculture (ZOMAP) in Laguna de Bay provides a typical example of coordination by unification. The competition for Laguna de Bay's aquatic resources has been fierce for decades, particularly during the 1970s and 1980s following the introduction of commercial fish-pen technology during the mid-1970s. During the 1980s, LLDA introduced various measures to both conserve the fishery resources and support small-scale local fishermen. The comprehensive ZOMAP was approved in 1996 and placed under LLDA's Lake Management Division in 1999. ZOMAP acted as a post-hoc unifying project, providing a basis for the new phase of sustainable fishery resources management for the lake, with clearer delineation of responsibilities and political commitments.

Coordination by Broadening (Figure 10.2c). Some project activities grow because of early successes and expand their spheres of operation either spatially or sectorally. In the case of Lake Constance, the fringing wetlands around the lake 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. The North American Great Lakes provides an example where the scope of management has expanded from control of point sources of pollution, to toxic contaminants, to invasive species, and, more recently, to nonpoint-source pollution.

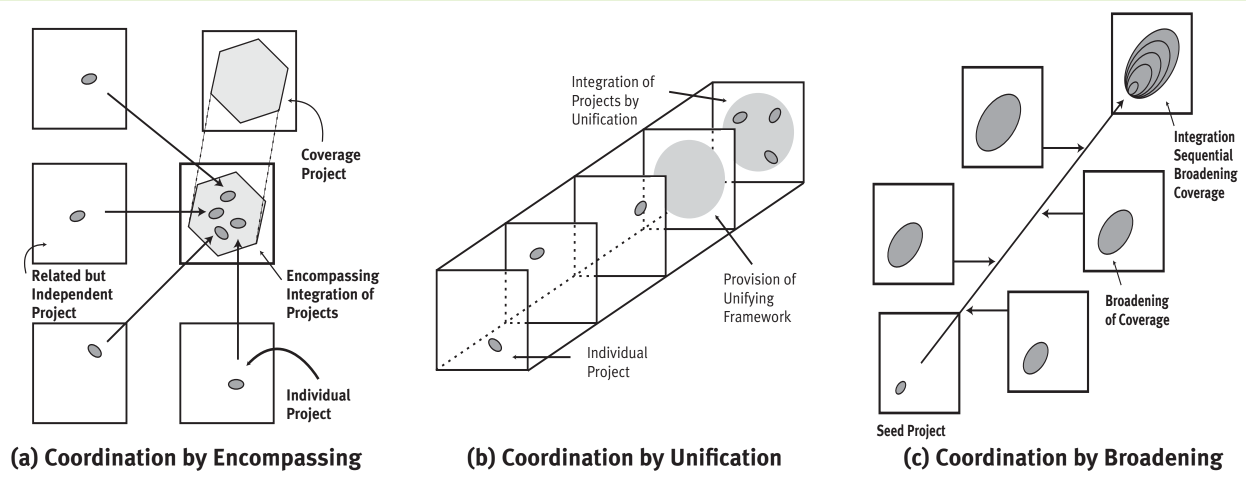

Figure 10.2 Three Forms of Coordination.

evolution", occurs when a single activity grows and matures over time to extend its coverage of issues and regions. The management infrastructure established at the beginning of the activity evolves and provides the coordinating mechanism as the activity grows.

Coordinating through Opportunity

Successful integrated lake basin management requires both political commitment and the necessary enabling conditions. These include effective institutions, genuine involvement of stakeholders, fundamental biophysical and socioeconomic knowledge about the lake basin, and access to sustainable sources of finance. The Lake Chad brief shows that moving too quickly to integrated lake basin management before these conditions are established does not work. A number of lake basin briefs emphasized that it is better to start small, bringing together management agencies and stakeholders where the issues are apparent and where there is a developing social consensus. These opportunities often lie within a sector (such as fisheries), or where the problem is readily apparent (such as pathogens from sewage). Success in correcting this problem builds confidence for tackling other problems. Box 10.5 provides examples from Lake Ohrid and the Chilika Lagoon.

It typically takes many years, even decades, for goals to be agreed, for sufficient knowledge to be accumulated for effective management, for institutions to be established or coordinated, and for laws to be passed and rules developed. Starting small and building on success before developing a more comprehensive lake basin management plan typically takes many years, so all stakeholders need to be committed for the long term. 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 Kenya's Environmental Coordination and Management Act as the lake basin's management body.

The need for long-term commitments also applies to externally-funded assistance projects in developing countries. Even though these projects are usually designed to help develop the enabling conditions for long-term lake basin management, their typical implementation period of 4–5 years is often too short for the institutions, community involvement, and acquisition of knowledge to be fully established. These assistance projects need to be succeeded by follow-on projects that build on the initial development of the enabling conditions. For example, the initial GEF-funded projects at Lakes Tanganyika and Victoria are being followed with further projects that are designed to help basin countries implement stress reduction activities based on the knowledge acquired during the initial projects.

Indicators, Monitoring, and Adaptive Management

It is essential that any lake basin plan includes indicators of success. Not only should these provide quantitative measures of progress in implementing the plan, but they should also be designed to help identify impediments to achieving the plan's goals and help identify emerging issues. The GEF advocates the use of three types of indicators—process, stress-reduction, and environmental status—for their international waters projects (Chapter 8). These same indicator types can be used to track the implementation of lake basin plans. Box 8.3 describes the use of indicators in the North American Great Lakes.

Box 10.5 Building on Initial Success

Lake Ohrid, FYR Macedonia and Albania. An important commercial and cultural fish species, the Lake Ohrid trout, is threatened by overfishing, as well as by pollution, loss of breeding grounds, and competition from introduced species. Both FYR Macedonia and Albania have agreed that the fisheries are in immediate danger and rapid management action is required. Scientific studies show that the fish in the lake form a single population, and so they must be managed jointly by both countries. With assistance from the GEF, multilateral and bilateral donors, government officials and fisheries experts in both countries have agreed to a unification of some of the fisheries regulations. For example, in 2001, both countries agreed to the same allowable net size. Although there have been improvements in management, the lake's native trout fisheries have yet to show signs of recovery. Nevertheless, the confidence and trust gained in working together on this issue, together with other joint activities, has helped the two countries develop a more comprehensive approach to managing the lake and its basin.

Chilika Lagoon, India. Chilika Lagoon, 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 surrounding catchments, the lake exit had become silted up and fish catches had declined dramatically. The Chilika Development Authority was established in 1992 to coordinate and promote lake restoration and development across the operational agencies. Through the CDAs efforts, a new entrance was dredged to the ocean in 2000 to provide more direct interchange between the lagoon and the ocean. The results were dramatic—salinity levels in the northern sector of the lake increased from freshwater levels back to "natural" brakish levels of over 20 g/L, and fish landings increased from 1,600 metric tons before intervention to almost 12,000 metric tons in the following year. There were other benefits in crab catches and in reductions in aquatic weeds. The obvious success of this engineering intervention in the lagoon has strengthened the hand of the CDA in implementing other aspects of management, including catchment management and introduction of environmental flows from upstream water storages.

Sources: Lake Ohrid and Chilka Lagoon Briefs.

The lake basin plan needs to include a monitoring component to provide the data to populate the indicators. The data from monitoring can also be used to develop a better understanding of the biophysical and socioeconomic processes occurring in the lake basin (Chapter 8).

Lake basin plans need to be adaptive, not only in response to the monitoring data, but also in response to changing social needs and external factors. For example, there are uncertainties about ecological processes and functions, about the impact of different patterns of resources use, and about political and social development and the effects of external influences such as changes in international trading arrangements. Lake basin management planning should therefore include a process for reviewing and modifying the plan either at regular intervals or when the indicators suggest that goals are not being achieved.

Chapter 11

Toward 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 governance challenges. It has also discussed the unique biophysical characteristics (integrating nature, long retention times, and complex response dynamics) that make sustainable use and management of lake basin resources a complex environmental and natural resources management challenge.

The 28 lake briefs provide extensive experience from which to draw lessons. But there is also much that can be learned from the management of other natural resources. For example, lake basin management has much in common with sustainable management of whole river basins. Those who are involved in lake basin management can learn by joining networks of these other natural resources managers through the Internet and through meetings, such as the World Lake Conferences, GEF International Waters conferences, Ramsar meetings, the World Water Forum, and the Stockholm Water Symposium.

Nonetheless, lake basins will not receive the management attention they need because of both their importance and their vulnerability, unless the unique characteristics of lakes are clearly understood.

Reassessing Existing Lake Basin Management Programs

The picture emerging from the 28 lakes is that few seem to have succeeded in reversing the general trend of environmental deterioration, although some have had success in tackling specific degradation issues. Many lake basin management programs, however, have advanced far enough to pause and reflect. For them, the past, ongoing, and emerging collective experience in lake basin management does give a great deal of insight into future courses of action.

Key Questions for Managers

What is the state of the lake and its basin today, both biophysically and managerially? What impact has an existing management program had in terms of sustainable management of the lake basin; that is, on the 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 did not know at the beginning? Specific questions include:

- *Institutions*. Is our organizational structure correct? Do we have the necessary legislative powers? Have we formed alliances with all relevant organizations that need to be involved in management? Do we have good links to decision makers and do they listen to us? Has political will and commitment grown, or has it waned? Are our capacity building and training programs effective? What mid-course corrections are needed; For example, are there new skills not considered when we started?

- *Policies*. When we developed rules, did we involve those who would be affected? Do we have adequate resources to enforce the rules or do we need to use another approach? Are economic instruments likely to succeed in controlling the use of lake basin resources? Do we have an environment that would allow charges for use of lake basin resources?

- *Stakeholder Participation*. Are mechanisms in place for effective stakeholder participation? All stakeholders? What has been the change in awareness and understanding of the problems and their links to stakeholder activities? What is the perception of the program's stakeholders? Is there sufficient community participation?

- *Technology*. Will infrastructure be effective over the long term, or does it need institutional changes? Have we budgeted for replacement costs of infrastructure?

- *Information*. What is the status of the knowledge base? Is a monitoring system in place that can measure changes in key indicators? Is the database sufficient? What are the remaining key gaps? Are information management tools good enough to be deployed effectively?

- *Funding*. Can we spend the funds collected locally? Do we have sufficiently strong links to the national government to obtain financial support for major projects? Are there globally important features in our lake basin that warrant international funding? How best can we use external funds so that the fundamental components of management are developed?

- *Planning*. Are the priority elements of a 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". Program managers might consider whether they 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 organization's mandate and objectives, authority (powers and functions), and its work program. Specific questions to ask may include:

- *Staffing.* Can we maintain the staff we have? Do we need an expanded or a reduced 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, and what needs to be done to implement this? How do we avoid having staff numbers beyond what we can maintain given the availability of financial resources?

- *Statutory Basis.* 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?

- *Institutional Capacity.* 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?

- *Champions.* 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 handled without the champion?

Roadblocks to Lake Basin Management

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

Policy Conflicts

Policy conflicts that arise from long-entrenched sector interests, priorities, or prerogatives are widespread in the briefs. In some cases, they are between development-oriented and conservation-oriented sectors; in other cases, they are between sectors that use lake basin resources that are upstream of the lake, within the lake, and downstream of the lake. These conflicts are particularly difficult to deal with because sectoral institutions, such as government departments, possess considerable autonomy. They are responsible directly to government ministers, have their own budgets, and are often mandated through legislation. Unless the government as a whole takes a wider view, each sector can pursue its own agenda to the detriment of other sectors.

Political Motives

While not cited frequently in the lake briefs, political obstruction can impede lake basin management. Actions (or lack of actions) that serve narrow interests advocated by influential politicians are not in the best interests of sustainable use of a lake basin's resources. The influence and power of the senior decision makers involved make these problems very difficult to deal with, although once the politically motivated decisions are widely known, the weight of public opinion can lead to changes.

Lack of a Voice

An unresponsive political system or administration that does not consult widely or disregards credible advice can be difficult to deal with. Such systems are typically inward-focused and uninterested in the necessary reforms that would let affected groups have a say in decisions about use of the resources of a lake basin. The decision by central planners in the Soviet Union to use water from the rivers flowing into the Aral Sea for irrigation—in spite of the evidence that this decision would desiccate the Aral Sea—is a good example of such problems.

Corruption

Corruption can be especially debilitating because it encourages the particular behaviors and actions that programs to improve lake basin management are trying to change. It leads to lake basin resources being used inefficiently; it maintains inequality and suppresses the poor and powerless; and it encourages corruption elsewhere. Unless there is strong leadership and a willingness to tackle corrupt officials, other managers can become dispirited and apathetic in the face of these problems.

Jurisdictional Boundaries

Jurisdictional boundaries can have a similar effect on effective lake basin management to sectoral boundaries. Different levels of government will tend to pursue their own interests unless there is a strong coordinating institution able to bring them together. Transboundary lake basin management is a special case where separate countries need to agree to cooperate if effective lake basin management is to occur. While transboundary lake basin management is usually difficult to organize, there are a number of encouraging examples in the lake briefs, in a number of cases with GEF assistance.

Funding

One of the most common themes in the lake briefs was the need for sufficient funds to carry out basic management operations, including enforcement of regulations. A lack of funds can be discouraging to managers. Even when the enabling environment is conducive to good governance, a shortage of funds means that different agencies and jurisdictions are not coordinated, decisions on allocating resources do not get made or get made on the basis of poor information, and infrastructure is not maintained. It takes considerable time to develop whatever local sources of funds are available, and national funding is usually in short supply in both developing countries and countries in economic transition.

Dealing with Roadblocks

These may appear to be insurmountable problems to those in charge of management of individual lake basins. However, the 28 lake briefs suggest that all these problems can be overcome. The lessons that emerge from the lake briefs include:

Be Creative and Proactive

Often it is a matter of getting the attention of senior decision makers; look for opportunities to engage them. Try to anticipate problems, and when one occurs, make sure that you are in a position to offer a way to manage it. As far as possible, back your advocacy with good data.

Build Coalitions

Managing lake basins requires cooperation from people at all levels and in diverse roles. Some of the most successful examples in this study, such as the Chilika Lagoon, were built on collective action from sectoral agencies and local people. However, it takes considerable time to build these coalitions and constituencies for change. Work hard to create awareness and understanding of the situation and the risks—try to put the case in the terms and forms most relevant to those who can support the changes.

Develop Shared Visions

As part of coalition building, try to build a vision of the use of the lake basin that is shared by all parties. Sometimes this can be done through formal studies; more often it can be accomplished through informal means by leaders with a comprehensive overview and persuasive powers. This means that the goals of different groups need to be understood, accepted, and brought into a common picture for the lake basin.

Political Support

High-level political support can open doors and help build the necessary coalitions. However, getting this support in the face of the numerous demands on politicians is difficult; take advantage of crises that arise to show how better lake basin management can avoid these problems. Build your case by showing the advantages—economic, social, and environmental—of investing in lake basin management.

Leverage External Support

External support from international sources can act as a catalyst for obtaining greater national support as well as mobilizing different sectors and interest groups. If your lake basin has values of global importance, then GEF funding may be available at the request of the national government. However, external funding is available for limited periods and needs to be applied judiciously to put in place the fundamentals of good management. It is important to build national-level support to ensure that national funding continues after the external funding ceases.

Sector Reforms

Pursue sectoral policy reform in, for example, water, agriculture, forestry, energy while building coalitions and shared visions. The reform of the management of these sectors is closely linked to improved lake basin management. Reforms can be resisted by those who gain from current ways of doing things, so seek out the champions of reform in the key sectors. Be active in the reform process, and support it whenever possible. Show how additional benefits can be obtained from these sectoral reforms, by showing how the special vulnerability and associated risks of lakes and reservoirs can be reduced through the reforms.

Evidence

Arguments backed by evidence carry real weight. Marshal the evidence that taking care of the lake basin will benefit various sectors dependent on the resources of the lake basin. Work with local universities and technical groups in government agencies to build your case.

Lessons from the Case Studies

The 28 lake briefs provide a rich diversity of experiences from lake basins in very different physical settings, with different social and economic conditions, and different levels of resources. Nevertheless, there are some common lessons that emerge from these examples.

Focus on Lake Basins

There needs to be a fundamental shift in approach from a focus on lake management to one based on lake basins. This shift is clearly spelled out in the Principles of the World Lake Vision and its application is evident in many of the case studies. Nevertheless, it is also clear in the case studies that many managers, particularly those in parts of the lake basin that are distant from the lake, do not appreciate the impacts of their actions on lakes. A significant number of the problems described in the lake briefs originate in the lake basins, but these problems often come from a diversity of areas and so are difficult to manage without the involvement of all groups in the lake basin.

Promote a Long-Term, Adaptive Approach

Development of effective institutions, promotion of meaningful stakeholder involvement, and acquisition and acceptance of knowledge all require a long-term commitment by local institutions and national governments. This long-term approach should include support for national scientific research and training institutions so that the next generation of managers and scientists are developed. However, a long-term commitment does not imply a rigid approach; it needs to be responsive to new knowledge, changing objectives, and shifts in external circumstances.

Mainstream Lake Basin Management

While lake basin management institutions can coordinate, the reality is that sectoral institutions will continue to take the lead in infrastructure investments and in management of the resources of lake basins. Lake basin management institutions need to raise the awareness of institutions about the importance and the vulnerability of lakes, so that these concerns are fully incorporated into their policies, programs, plans, and strategies.

Coordinate across Sectors and Jurisdictions

The most important role played by successful management institutions in this study (at Lakes Biwa, Constance, Champlain, Dianchi, and Laguna de Bay, the Chilika Lagoon, and the North American Great Lakes) has been to coordinate the activities of sectoral institutions, including across jurisdictions. Although the forms and legal mandates of these institutions vary, they have all successfully promoted a coordinated approach to lake basin management. New coordinating institutions are being developed at Lakes Ohrid, Tanganyika, Victoria and Tonle Sap (and Mekong River Basin) that promise to improve the status of these lakes and the well-being of people dependent on them.

Encourage both Governance and Investments

The lake briefs show that both good governance, and sometimes sustainable investments, are needed to improve the environmental status of lakes. Good governance consists of clear policies that result in sustainable institutions, effective and fair rules governing use of resources, involvement of all affected stakeholders, collection and application of high quality information, and access to sufficient finances for long-term operations and maintenance. In some cases, technological solutions can lead to rapid improvements in the environmental status of lakes—most notably with sewage treatment plants. However, these technological solutions are usually not sustainable if the elements of good governance are not in place.

Involve Stakeholders

One of the most consistent messages in the lake briefs is the importance of involving communities in decisions that will affect them. The benefits include better decisions, improved enforcement, sometimes reduced cost, and support for increased community participation in governance. Lakes where there has been an improvement in environmental status are characterized by strong stakeholder involvement; on the other hand, lakes with severe problems were characterized by a limited involvement of those affected by decisions.

Promote Basin Partnerships

Successful institutions in the case studies have developed cooperative partnerships between sectoral institutions, across jurisdictions, and including stakeholder groups. However, building the trust that underlies these partnerships, obtaining and disseminating the information needed to overcome misconceptions, and building the capacity of community groups to engage effectively all take considerable time. The lake briefs show that governments and development partners need to be engaged over the long term.

Accessing Global Resources

Toward Global Stakeholder Participation and Partnerships

Every global natural resources management experience today points to the importance and the central role of effective stakeholder participation at every step of program and project design, decision making and implementation. The lessons from this project also point in 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, will not 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 suggest 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 nongovernmental. 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 will not be able to meet all the needs for basin management programs for the world's important lakes. Therefore exploring new and innovative approaches for partnership among key agencies is extremely important.

Toward Enhancement of the Global Lake Basin Management Knowledge Base

The importance of developing a broad and reliable knowledge base for lake basin management is very evident throughout the lake basin briefs. However, with the limited financial and human resources available, a great many lake basins in the developing world will continue to suffer from a meager knowledge base. The international technical cooperation agencies, scientific communities, and local and international NGOs specializing in lake basin management must collectively seek ways to mobilize resources to help those lake basins to be able to take advantage of the existing knowledge base developed at better-funded lake basins, as well as to generate important local information resources. 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. As exemplified by many of the lake briefs, the use of modern information management technologies—be they planning tools like GIS, remote sensing, database management, or computerized models—will greatly facilitate the organization, management, and use of the knowledge base.

Much lake basin management information is already available through the GEF-funded IW:LEARN project (http://www.iwlearn.org), the Ramsar Secretariat (http://www.ramsar.org), the World Bank (http://www.worldbank.org/water), the USAID GLOWS consortium (http://glows.fiu.edu/Home/tabid/236/Default.aspx), and the sites for the ILEC (http://www.ilec.or.jp) and LakeNet (http://www.worldlakes.org) organizations. This report, detailing the lessons learned from the Lake Basin Management Initiative project, adds to this growing body of information.

Appendix A

Glossary of Terms

Acidification – The process whereby lakes gradually become more acidic over time, primarily from power plant and factory emissions of acid-forming materials into the atmosphere and their subsequent deposition in the form of rain or snow. It can result in significant negative environmental impacts to both aquatic and terrestrial ecosystems, including degraded water quality and destroyed fisheries.

Activated sludge – The stage of biological treatment of sewage in which the wastewater is mixed with bacteria-laden sludge, with the organic matter in the wastewater subsequently being decomposed by the bacteria; usually called secondary treatment.

Algal blooms – The growth of algae in lakes to excessive levels that can cause a range of negative environmental impacts, including water quality degradation and interference with beneficial human water uses. The decay of large algal bloms can sometimes extract sufficient oxygen from lake waters to lead to fish kills.

Algal toxins – Organic materials associated with microscopic photosynthetic Cyanobacteria in lakes, many of which can be toxic to animals, including humans.

Alkaline – A solute salt or mixture of soluble salts having marked basic properties (in contrast to acidic materials).

Anthropogenic – Being of human origin, or resulting from human activities.

Aquifer – An underground layer of rock or soil sufficiently porous to store significant quantities of water; major source of drinking water on a global scale.

Apex – The uppermost or culminating point.

Artisanal – Referring to a worker or laborer with a particular skill or trade (such as fishers).

Bathymetry – The measurement of water depths in lakes.

Benthic – Referring to organisms that live at or near the bottom of a lake.

Bioaccumulation – The buildup of material (such as toxic substances) within the body of an organism.

Biocide – A chemical that can kill a large variety of living organisms, including humans.

Biodiversity – A measure of the variety of kinds of animals and plants present in a given environmental compartment (such as lakes) over a given time period.

Biomanipulation – An inclusive term referring to methods of artificially changing or altering the biological communities living in a waterbody, primarily to improve water quality. It does not involve genetic manipulation.

Biomass – A measure of the quantity of all the living organisms in a waterbody.

Carbon sequestration – Referring to a family of methods, involving both aquatic (oceans) and terrestrial (forests, soils) components, for capturing and permanently removing or isolating atmospheric carbon dioxide and other greenhouse gases that can contribute to global climate change.

Catchment – the area surrounding a lake from which surface water drains into the lake.

CBOs – Community-based organizations (for example, artisanal fishery associations).

Chemical precipitation – The addition of chemicals to wastewater to remove specific substances.

Chlorophyll – A green pigment found in all plants, responsible for trapping sunlight energy needed for photosynthesis; chlorophyll concentration is often used as a measure of algal biomass in lakes.

Cichlid – Any of a family (Cichlidae) of mostly tropical, spiny-finned freshwater fishes.

COD – Chemical oxygen demand; a measure of the organic material in water (such as sewage) whose bacterial decomposition can consume oxygen in a waterbody.

Consumer surplus – An economic term used to denote the unpaid-for value enjoyed by visitors to recreational sites and protected areas.

Cyanobacteria – A group of microscopic blue-green algae, often occurring in eutrophic lakes in the form of algal blooms; some species can produce organic materials toxic to living organisms, including humans.

Deforestation – Cutting down or removing the trees from a given region; when done at a rate that exceeds the forest growth rate, it can lead to increased soil erosion and associated land degradation.

Denitrification – Bacterially-mediated conversion of nitrates and nitrites in water or soils to nitrogen gas, and its subsequent release into the atmosphere.

Desiccation – The process of removing water from a material or substance.

Diagnostic analysis – As practiced by the Global Environment Facility (GEF), refers to the analysis of the biophysical and socioeconomic characteristics of a lake and its drainage basin as a means of identifying environmentally-associated development problems and their root causes; serves as knowledge base for subsequent development of basin-scale Strategic Action Program.

Diatoms – A form of microscope algae in a lake; often associated with good water quality.

Diffuse source – Referring to sources that can contribute pollutants to a waterbody in the rain or snowmelt-induced drainage from the land surface (in contrast to effluents entering from a distinct point, such as a pipe); often called nonpoint sources, the specific pollutant sources are difficult to identify and quantify, with the pollutant load dependent largely on the climate and land uses characterizing a given drainage basin.

Drainage Basin – The area from which surface water drains into a lake together with the rivers and lakes.

Dublin Principles – The four primary recommendations regarding sustainable use of water resources developed at the International Conference on Water and the Environment, held in Dublin, Ireland, in January 1992; involving experts and representatives from governments, international, intergovernmental and nongovernmental organizations, they call for fundamental new approaches to the assessment, development, and management or freshwater resources; subsequently commended to world leaders at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992.

Enabling environment/framework – The sum of the institutions, policy framework, financial incentives, informed public participation, and similar components that collectively provide the basis for developing and implementing effective programs and activities for the sustainable use of natural resources.

Encroachment – Advancing or intruding beyond proper limits or boundaries.

Endemic – Plant or animals native to a given region or waterbody.

Endocrine – Referring to the human hormonal system, particularly sexual hormones.

Endorheic – Term used to describe a lake with water inflows (such as tributaries), but no outflows; water only leaves the lake via evaporation, generally resulting in higher salinity lake water.

Environmental status indicators – Term used by the Global Environment Facility (GEF) to denote agreed measures of actual performance or success in restoring and protecting a target waterbody (for example, measurable improvements in chemical, physical, or biological parameters).

Eutrophic – The nutrient status of a lake receiving excessive nutrient loads (mainly phosphorus and nitrogen), resulting in excessive algal blooms that degrade water quality and interfere with beneficial human uses.

Eutrophication – The natural aging process of lakes; can be greatly accelerated by human-induced excessive nutrient inputs (so-called cultural eutrophication).

Exorheic – Term used to describe a lake that has both water inflows and outflows, thereby ensuring its waters remain fresh (in contrast to endorheic lakes).

Exotic species – Non-native animals or plants accidentally or intentionally introduced into new lakes; in the absence of natural controls, can displace a lake's native species and alter its biological communities; term often used interchangeably with invasive species.

Externalities – Monetary or other expenses associated with the use or utilization of a natural resource borne by someone other than the individual or groups using the resource.

Hydro-dynamic model – Refers to multiparameter, time-variant models used to simulate and/or predict hydrologic and related biological and chemical responses of lakes to changes in water and material loads entering them and/or other variables that can affect in-lake processes (for example, "forcing factors").

Hydrological – Referring to, or involving, water.

Hypereutrophic – The nutrient status of a heavily nutrient-enriched lake at the extreme end of the eutrophic range, to the extent that its water quality and biological characteristics are essentially completely degraded (also see eutrophic).

Hypolimnion – The bottom water layer in a lake lying below the thermocline.

Hysteresis – A delayed change in a property of a lake, whether in a positive or negative direction, to an altered force or factor acting upon or influencing it.

Ionic – Referring to an atom or group of atoms carrying a positive or negative charge; typically used to refer to the chemical form of materials dissolved in water.

Incremental costs – Term used by Global Environment Facility (GEF) to denote the costs associated with projects that produce international environmental benefits, as opposed to those that only produce national-level benefits.

Indigenous – Having originated in, or occurring naturally in a particular region or environment.

Infrastructure – The underlying foundation or framework of a system or organization; in the context of water resources management at the lake basin level, this refers to dams and weirs for multiple purposes; water transfer structures; water treatment, wastewater collection and/or wastewater treatment systems; irrigation and drainage; and flood control structures.

Insectivorous – Depending on insects for food.

Invasive species – Non-native animals or plants accidentally or intentionally introduced into new lakes; in the absence of natural controls, can displace a lake's native species and alter its biological communities; term often used interchangeably with exotic species.

Invertebrates – Animals lacking a spinal column (e.g., insects, clams).

Limnology – The study of the biology, chemistry, and physics of inland surface water systems.

Littoral – The water in a lake lying near to the shoreline (in contrast to the water in the lake's center).

Macrophytes – Free-floating or rooted aquatic weeds.

Market prices – The price or cost of an activity or action determined on the basis of what people are willing to pay for it in the open market.

Mediation – Intervention between competing parties to promote settlement, compromise, or an agreed solution regarding a given issue(s).

Millennium Development Goals – A set of time-bound, measurable goals and targets for combating global poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women, agreed to by world leaders at the September 2000 United Nations Millennium Summit.

Millennium Ecosystem Assessment – An international work program, launched by the UN Secretary-General in 2001, designed to meet the needs of decision makers and the public for scientific information on a global and regional scale concerning the consequences of ecosystem changes for human well-being, and options for responding to those changes.

Mitigation – Activities undertaken between parties to lessen the negative impacts of a given action(s).

NGOs – Nongovernmental organizations.

Nitrification – Bacterially mediated oxidation (conversion) of ammonia to nitrate and nitrite in water and soils.

Non-market values – Uses of a lake for which it is difficult to proscribe a specific economic value, or for which normal market pricing does not apply (e.g., aesthetics).

Nonpoint source – Referring to pollutant sources that can contribute pollutants to a waterbody in the rain or snowmelt-induced drainage from the land surface (in contrast to effluents from a distinct discharge point, such as a pipe); also called diffuse sources. Specific pollutant sources are difficult to identify and quantify, with the pollutant load dependent largely on the climate and land uses characterizing a drainage basin.

Non-structural – Referring to management interventions that do not involve structures (such as behavioral changes and education).

Nutrients – Nutritive substances (food) required for the growth and reproduction of algae and macrophytes in a lake; primary nutrients are phosphorus and nitrogen compounds.

Oligotrophic – The nutrient status of a lake receiving small nutrient loads, and containing a small algal biomass; oligotrophic lakes typically display good water quality and can support a wide range of beneficial human uses.

Organic load – The quantity of organic materials entering a lake; lakes with large organic loads can exhibit low oxygen levels associated with bacterial decomposition of the materials, resulting in degraded water quality and interference with beneficial human uses.

Oxidizing agent – A chemical or substance used to provide oxygen in a chemical reaction.

PCBs – Polychlorinated biphenyls; a persistent organic pollutant believed to have carcinogenic and other human health impacts.

Photosynthesis – The biochemical process whereby chlorophyll-containing plants utilize sunlight energy to convert carbon dioxide and water to sugars such as glucose.

Point source – Referring to pollutant sources that can be readily identified and quantified, such as effluents from a distinct pipeline (in contrast to pollutants entering a lake in rain or snowmelt-induced drainage from the land surface; also see nonpoint source).

Process indicators – Term used by the Global Environment Facility (GEF) to denote a measure of progress in project activities involving procurement and production (inputs and outputs) of goods, physical structures and services (e.g., formation of high-level steering committee for project preparation and implementation; completion of country-endorsed Transboundary Diagnostic Analysis).

Ramsar Convention – An intergovernmental treaty signed in 1971, which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Ramsar site – Wetlands designated as internationally important under the Ramsar Convention.

Red tides – Seawater discolored by the presence of large numbers of certain types of algae, which can produce a toxin poisonous to many forms of marine life and to humans who consume infected shellfish.

Reforestation – The process of replanting areas after the original trees and other vegetation are removed.

Remediation – The act or process of providing relief, whether in the form of money, actions, or other approaches, that can satisfy or rectify conflicting activities or policies.

Retention time – The period of time a given quantity of water may spend in a lake; typically calculated as lake volume divided by the water inflow (or outflow); lakes with short retention times exhibit more rapid water flushing (and associated pollutants) than lakes with long retention times.

Riparian – Relating to, or located on, the bank of a natural watercourse, such as a lake or river.

Runoff – Storm-generated water drainage from the land surface to lakes, rivers, and other watercourses, including the materials dissolved in, or carried by, the water; also called storm runoff.

Saline – Used to refer to water containing elevated concentrations of dissolved salts, mainly sodium, potassium or magnesium.

Salinity – A measure of the quantity of salts contained or dissolved in water.

Sedimentation – The process whereby soil and other particles carried in water settle to the bottom of a waterbody.

Sensitivity analysis – A model assessment exercise used to identify the model parameters most sensitive to changing inputs ("forcing functions").

Siltation – The process whereby a waterbody becomes filled or choked with soil and other particles carried in water.

Sludge – Solid matter produced during water and sewage treatment processes, usually by adding chemicals to precipitate the matter.

Social capital – Referring to the personal and institutional relationships with key stakeholders that collectively facilitate effective lake basin management.

Storm runoff – Storm-generated water drainage from the land surface to rivers, lakes and other water courses, including the materials dissolved in, or carried by, the water.

Stress reduction indicators – Term used by the Global Environment Facility (GEF) to denote specific on-the-ground measures implemented by the collaborating countries to produce measurable changes in transboundary water systems (for example, reduced releases of pollutants from point sources; area of eroded land stabilized by reforestation).

Structural – Referring to management interventions that involve structures (such as dams, water treatment plants).

Subsidiarity – Referring to the lowest effective level of management of a waterbody.

Subsidy – A grant or cash award offered by a government to a private individual or company to assist an enterprise deemed advantageous to the overall public good.

Subsistence – Referring to the minimum levels of food, shelter, and other items necessary to support human life.

Supernationality – The buy-in and agreement by riparian nations to common measures and activities regarding the effective use and management of shared natural resources, including water systems.

Supply-side – The economic theory that encourages expanded economic activity (and increased utilization of natural resources), via such measures as reducing tax steps (in contrast to managing demand for the resources).

Sustainable development – Economic development within the constraints of the available natural resources base, in contrast to uncontrolled exploitation of the resources.

Sustainability – A measure of the degree that exploitation of natural resources for economic development can be continued indefinitely without permanently affecting the current resources base or its accessibility to future generations.

Synergy – The interaction of two or more factors or processes so that their combined effect, whether positively or negatively, is greater than the sum of their separate effects.

Tariffs – Charges, user fees, or duties imposed by governmental entities for goods or services.

Tectonic – Referring to the deformation of the earth's crust by the movement of surface geological layers over a geologic time scale, and the resulting geologic forms (e.g., lakes).

Temperate – Refers to regions of the world that experience moderate climate; generally comprises the earth's surface occupying the intermediate lateral position on both sides of the equator between the tropical zone and boreal or sub-arctic climate of the polar zones.

Tertiary wastewater treatment – An advanced stage of wastewater treatment for removing dissolved pollutants left after primary and secondary treatment are completed; typically used to remove phosphorus and nitrogen from wastewaters.

Total social welfare – Referring to a social welfare approach in economic valuation in which the "whole" (total social welfare) is equal to the sum of the parts ("individual welfare measures").

Tradable rights – Rights to the use of natural resources that can be traded, in the same manner as goods or services, between individuals or organizations, as a means of influencing natural resources utilization and management.

Transaction costs – The costs or obligations, whether material or otherwise, to the involved individuals or organizations of altering management structures and functions in pursuit of sustainable use of natural resources

Transboundary – Referring to natural resources, including water courses (lakes, rivers) shared or used by two or more countries.

Trophic levels – Specific levels of energy flow through ecosystems and their living resources; often used to delineate organisms in different levels of a food chain.

Trickling filters – The stage of biological treatment of sewage in which the wastewater is sprayed over the surface of bacteria-laden rocks or other substrates, with the organic matter being decomposed by the bacteria; classified as secondary treatment (also see activated sludge).

Vector-borne diseases – Diseases spread from one host to another by organisms that live in, or whose live cycles are associated with, watercourses.

Watershed – the boundary between two catchments. Now more commonly used to refer to the catchment itself.

Water hyacinth – An aquatic weed (macrophyte) that often grows to excessive levels in lakes and interferes with beneficial human water uses; a symptom of cultural eutrophication in many parts of the world.

Wetlands – Areas periodically or permanently covered with water, including swamps, tidal marshes, coastal wetlands, and estuaries.

World Commission on Dams – An independent, international commission convened in 1998, and comprised of representatives of governments, private sector, international financial institutions, civil society organizations and affected peoples, to (1) review the development effectiveness of dams and assess alternatives for water resources and energy development, and (2) develop internationally-accepted standards, guidelines and criteria for decision-making in the planning, design, construction, monitoring, operation and decommissioning of dams.

Appendix B

Authors of Lake Briefs, Thematic Papers and Chapters

Experience and Lessons Learned Brief Authors

Brief	Authors
Aral Sea	Gulnara Roll, Natalia Alexeeva, Nikolay Aladin, Igor Plotnikov, Vadim Sokolov, Tulegen Sarsembekov, Philip Micklin
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Thematic Paper Authors

Thematic Paper	Authors
African Lake Management Initiatives: The Global Connection	Robert Hecky, Harvey Bootsma and Eric Odada
The Caspian Sea	Nikolay Aladin, Igor Plotnikov
Conservation and Management Challenges of Saline Lakes: A Review of Five Experience Briefs	Robert Jellison, Yegor Zadereev, Priya Arora DasSarma, John Melack, Michael Rosen, Andrei Degermendzhy, Shiladitya DasSarma and German Zambrana
Directory of Non-Governmental Organizations (NGOs) and Inter-Governmental Organizations Working on Conservation and Management of Lakes in Africa	OSIENALA
Institutional Aspects of Asian Lake Basin Management	James Nickum
Involving the People in Lake Management: Values, Education and Participation	Oyugi Aseto
Lake Basin Management Problems in Africa: Historical and Future Perspectives.	Shem Wandiga
Management Challenges of Freshwater Fisheries in Africa	Richard Ogutu-Ohwayo and John Balirwa
Management of Lakes in India	M.S. Reddy and N.V.V. Char
Possibilities and Limitations of Environmental Infrastructure Provisions for Lake Basin Management	Shinji Ide
The Role of Communication, Education and Public Awareness (CEPA) in Lake Basin Management	Rebecca D'Cruz
The Role of Local Authorities in Lake Management	Aniruddhe Mukerjee
The Role of Protected Areas in Lake Basin Management	Rebecca D'Cruz
The Role of Public Participation and Citizen Involvement in Lake Basin Management	Oliver Avramoski
The Role of Sound Science in Lake and Reservoir Management for Sustainable Use	Walter Rast
Water Allocation and Environmental Flows in Lake Basin Management	William Young
Women's Participation in Lake Basin Management From a Gender Perspective	Sonia Davila-Poblete

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Chapter 2: Biophysical Characteristics of Lakes	Thomas Ballatore and Victor Muhandiki
Chapter 3: Human Use of Lakes	Masahisa Nakamura and Richard Davis
Chapter 4: Institutions for Lake Basin Management	James Nickum and Masahisa Nakamura
Chapter 5: Identifying Effective Actions	John Dixon and Richard Davis
Chapter 6: Involving People and Stakeholders	David Read Barker, Lisa Borre and Masahisa Nakamura
Chapter 7: Responding with Technology	Thomas Ballatore and Richard Davis
Chapter 8: Informing the Process	Walter Rast and Thomas Ballatore
Chapter 9: Mobilizing Sustainable Financing	John Dixon
Chapter 10: Planning for Sustainable Lake Basin Management	Masahisa Nakamura and Richard Davis
Chapter 11: Toward the Future	Walter Garvey and Richard Davis

Appendix C

Summary Outcomes from the Regional Workshops

Regional Workshop for Europe, Central Asia and the Americas

The regional workshop for the European, Central Asian and American lakes in the study was held in Burlington, Vermont, USA near the shores of Lake Champlain in June 2003. The lake basins included: Aral Sea, Baikal, Champlain, Cocibolca, Constance/Bodensee, Issyk-Kul, North American Great Lakes, Ohrid, Peipsi/Chudskoe, Sevan, Titicaca, and the Tucurui Reservoir. In addition, delegates from the Caspian Sea and Shkodra Lake (Albania, Montenegro) participated in the workshop.

The workshop was organized by LakeNet and hosted by Saint Michael's College with funding from the GEF and USAID. The timing of the workshop was planned in connection with the 10th World Lake Conference in Chicago and the opening of ECHO, a lake aquarium and science center at the Leahy Center for Lake Champlain.

More than 80 lake basin managers representing 24 countries and twelve lake basins in Europe, Central Asia, and the Americas gathered to review lake briefs and share experiences in lake basin management.

The participants were: Nicolay Aladin, Natalya Alexeeva, Juan Skinner Alvarado, Oliver Avramoski, Rasul Baetov, Mary Lou Baker, Thomas Ballatore, David Read Barker, Emilia Battaglini, Adem Bekteshi, Francesca Bernardini, Adelina Santos-Borja, Lisa Borre, Anthony Brunello, Vladimir Budarin, Vasilije Buskovic, Peter Clavelle, David Coen, Marilyn Cormier, Paulo Coutinho, Maximo Liberman Cruz, Sonia Davila-Poblete, J. Richard Davis, Canute Delmasse, Sunny De Vese, James Douglas, Al Duda, Laurie Duker, Phelan Fretz, John Gannon, Walter Garvey, Udo Gattenloehner, Reginald Gilbert, Herb Gray, Bernhard Griesinger, Salvador Montenegro Guillen, Susanna Hakobyan, Marion Hammerl, Rafik Hirji, Buzz Hoerr, William G. Howland, Karen Jenderedjian, Sven Eric Jorgensen, Anastasio A. Juras, Aija Kosk, Richard Kujawa, Sandri Kycyku, Stephen Lintner, Benjamin Lugo, Jon MacDonagh-Dumler, Eric Madden, Christopher Magadza, Carlos Frederico Silveira Menezes, Kisa Mfalila, Valery S. Molotov, Victor Muhandiki, Masahisa Nakamura, Eric Odada, Dejan Panovsky, Robert Paquin, Victoria Pebbles, Sylvain Primeau, Veli Puka, Walter Rast, Mario Francisco Revollo, Alberto Lescano Rivero, Wayne Roberts, Betsy Rosenbluth, Marco Aurelio dos Santos, Jacobo Sanchez, Cynthia Scott, Lirim Selfo, Silas Rondeau Cavalcante Silva, Payaman Simanjuntak, Dann Sklarew, Art Stemp, Jose Galizia Tundisi, Robin Ulmer, Marc vanderHeyden, Amy Villamagna, Lea Vedder and Mary Watzin. Facilitators: Eric Boyer, Steven Burks, Jon Erikson, Doug Facey, Larry Forcier, Tom Hudspeth, Miranda Lescaze, Vanessa Levesque, Mark Lubkowitz, Declan McCabe, Reza Ramazani, Elizabeth Royer, Trish Siplon, Robyn Smyth, Michaela Stickney, Mazeika Sullivan, Bill Wilson, Joan Wry. Interpreters: Silvia Delcastillio-Devine, Andrei Izurov, Jane Anne Miller, Jessica Noyes, and Helen Wagg.

The main lessons on lake basin management that emerged from the workshop included the following:

- **We know enough to get started—**Collectively, we have already reached a good understanding about the essential elements of effective lake basin management. What is needed is to apply that understanding. Although the experience shows that enough is known to get started, in some cases there is not sufficient motivation or will.

- **International borders complicate lake basin management—**This is true both when an international border crosses a water body and when it crosses the watershed/lake basin. "Hidden" international water lakes include Baikal, which is entirely in the Russian Federation, but 70 percent of the water flowing in comes from Mongolia. The more countries in the basin, the more complex management becomes.

- **Waiting for crisis—**In almost every case, concerted action for lake basins has been taken only after a sense of crisis has been reached. For example, the Cuyahoga River (Cleveland, Ohio, USA) caught fire in June 1969, which led to the establishment of the United States Environmental Protection Agency (EPA) and the passage of the Clean Water Act (CWA). Another example is the Aral Sea drying up, forcing international collaboration. This is true despite universal endorsement of the Precautionary Principle (Agenda 21) and evidence that prevention is more cost-effective than restoration.

- **Science and Technology—**Application of science and technology produces very positive results in the early phases of "concerted action." For example, municipal wastewater treatment plants reduce water pollution in lake basins.

- **Key scientific challenges—**One challenge is to translate science in ways that can increase public awareness and understanding. A second challenge is conducting research and monitoring programs that can inform public policy, law, and regulations. Another challenge is creating an inter-disciplinary interface between the natural and social sciences.

- **Rich and poor countries—**Differences between rich-country and poor-country lake basins are not as great as might be expected. For example, 45 percent of lakes in the United States are impaired for one or more designated uses.

- **Effective involvement of citizens is essential but has been achieved at very few lakes—**The participants agreed that the experiences on Lakes Champlain, Constance, Ohrid and Peipsi/Chudskoe are some of the more successful examples.

- **Key problems are universal—**The World Lake Vision identifies threats from within and outside lake basins. The lake briefs show that there are only a few basic types of threats, and they are universal. Participants agreed that global experience-sharing, such as through the Lake Basin Management Initiative, is helpful.

- **"GEF" versus "Non-GEF" lake basins—**The Global Environment Facility (GEF) support is important to help focus on institutions, but it has several limitations. Short-term, project funding in some cases is inadequately integrated with existing institutions and other bilateral investments. The GEF's focus on awarding grants to national governments may overlook local institutions, which are important for creating and sustaining commitments.

- **Economic valuation—**There is a crucial need to harmonize economic development, watershed management, and biodiversity conservation. It is also important to put a value on resources: economic, ecological, aesthetic, cultural, and social—this provides the basis for investment and consideration of trade-offs.

- **Lake biodiversity conservation—**In general, biodiversity loss is poorly tackled; there is very little guidance on how to proceed. Activities often start at scientific rather than political institutions. Immediate crises often relate to water shortages. Many biodiversity initiatives focus only on the flora and fauna of a lake, rather than the basin as a whole (including rivers and wetlands). Integrated Water Resources Management (IWRM) must address ecological aspects.

- **Transboundary commissions—**These are crucial to facilitate and enforce agreements; identifying key problems through Transboundary Diagnostic Analysis (TDA) in the grant planning process; preparing a Strategic Action Program (SAP); coordinating funding; and building local support. It requires decades of effort to develop strong transboundary commissions—it is impossible in just a few years.

- **Land and water interactions—**Wise management of land results in protection of the health of lakes. Control of point-source pollution may be successfully addressed through engineering solutions. Nonpoint-source pollution is more difficult and requires zoning and land use plans; changing management practices on the land; increasing public environmental awareness; and behavioral changes in society.

Regional Workshop for Asia

The regional workshop for lake basins in this study from Asia was held in Manila, Philippines in September 2003. The Asian lake basins discussed at the workshop included Lakes Biwa, Bhoj Wetland, Chilika Lagoon, Dianchi, Laguna de Bay, Toba, Tonle Sap, and Xinghai/Khanka.

The workshop was organized and hosted by the Laguna Lake Development Authority with funding from the GEF. The workshop was attended by 82 lake basin managers from throughout Asia.

The participants were Nurul Amin, Augusto Baculio, Thomas Ballatore, David Read Barker, K.S. Bhatta, Jerry Bitoon, Lisa Borre, Manuel Bravo, Joanne Caldito, Jose K. Carino, Calixto R. Cataquiz, Jiahoa Chen, S.S. Chitwadgi, Chanrithy Chuon, D.P. Dash, Juan Du, Maristel Espiritu, Fumio Fukada, Abundio Galicia, Jr., Tony Garvey, Asish Kumar Ghosh, Bebeth Gozun, Nathaniel Halili, Gadis Haryani, Liping He, Peter Hehanussa, Rafik Hirji, Shinji Ide, Robert Jaworski, Xiangcan Jin, Marko Keskinen, Mohan Kodarkar, Seakly Kung, Y. Lavy, Sopha Lieng, Eduardo V. Manalili, Diego Mapandi, Sinta Marpaung, Xiannan Meng, Shive Mangal Misra, Haryatiningsih Moedjodo, Crispinna Muan, Victor Muhandiki, Aniruddhe Mukerjee, Hiroshi Murata, Tadashi Nagao, Reiko Nakamura, Masahisa Nakamura, Pradip Kumar Nandi, Shigeo Naruse, Ricardo Natividad, Wifrido Nava, Dolora Nepomuceno, James Nickum, Antonio Oposa, Gil Orgil, Ajit Pattnaik, Sokhem Pech, Elrem Peña, S.S. Phadnis, Walter Rast, Soleda Reyes, Bernardino Reyes, Filemon Romero, Violeta Sabuyao-Faizaz, Maricel Santiago, Ruben Santos, Adelina (Lennie) Santos-Borja, K. Jude Sekar, Jansen Sinamo, Victor Soliman, Kim Sour, Dennis Tiongson, Clariza Tullo, Felix Tumangger, Chiharu Uyama, Olli Varis, Li Wang, Lilei Wu, Xiaogang Yu, Pingyang Zhai, and Bo Zhou.

The main lessons to emerge from the three-day workshop were as follows:

- **Management institutions and stakeholder involvement—**A central authority for managing the lake can be effective, but management with wide stakeholder participation is more effective. If the stakeholders are not convinced of the value of actions to safeguard and improve lakes, then management actions, even when they are well-coordinated, are unlikely to be effective.

- **Lake basin management functions—**A lake authority with strong policy making role and regulatory function is likely to be more successful than an institution with only a coordinating role. This is because a clear policy direction is necessary to ensure that sectoral and other institutions all understand their contributions to lake basin management.

- **Political support—**Political interest and commitment are essential for sustainable lake basin management. Without this level of active support, the sectoral and other authorities will tend to focus on their narrow constituencies and not work together.

- **Education, engineering and enforcement—**These terms make up the 3 E's of policy implementation. Education is essential for knowledgeable involvement by stakeholders; engineering solutions can sometimes be very effective; and unless rules are enforced, there will be disputes regarding the use of the lake and its resources.

- **Start simple, and fine tune—**Don't delay because of a lack of full knowledge about lake basin management. Instead, it is better to start using whatever information is available and modify the approach as experience builds up.

- **Finances are essential—**Failure to implement management plans is usually due to a lack of financial resources rather than a lack of management expertise and willingness. However, obtaining sufficient finances is extremely difficult, especially in developing countries.

- **International funding—**International funding, such as GEF funding, is a big boost to environmental protection and enhancement in a lake basin. These funds are usually much larger than the national and local funds available to lake managers in developing countries and provide many opportunities to establish the basics of good management. However, they are also usually accompanied by many restrictions and administrative requirements.

- **The value scientific information—**The funds wasted because of a lack of scientific knowledge far outweigh the required investment in science. A scientifically well-informed decision is important not because it will always be correct, but because it can be assessed and corrected with new scientific findings.

- **Communicating scientific information—**Unless scientific information is made simple for the general public and becomes common knowledge among people, it is unlikely to be accepted.

- **Coordinated community participation—**Community participation needs to be coordinated and supported to be effective. Community groups need access to information and, in some cases, may need financial support and training. They also need to have an acknowledged role to play in the management of the lake basin.

- **Lake resources are major economic goods—**Heavy exploitation of lake resources becomes inevitable when poverty levels are high, to the point where resources can be overexploited if there are not well-developed rules in place and good enforcement mechanisms. Economic valuation is necessary to determine the costs and benefits of lake basin resources in these circumstances.

- **Biodiversity conservation and poverty reduction—** Sustainable management of natural resources should be integrated into a developing country's overall poverty reduction strategy. If it is not, then biodiversity conservation will not be relevant to people struggling to make a living.

Regional Workshop for Africa

The regional workshop for the African lakes in this study was held in Nairobi, Kenya in November 2003. The lake briefs for Lakes Baringo, Chad, Malawi/Nyasa, Naivasha, Nakuru, Tanganyika, Victoria and the Kariba Reservoir were discussed, as well as thematic papers on:

- African Lake Management Initiatives: The Global Connection;

- Lake Basin Management Problems in Africa: Historical and Future Perspectives;

- The Management Challenges of Freshwater Fisheries in Africa;

- Sustainability of Lake Management Projects in Africa; and,

- Lake Basin Management Problems in Africa.

The workshop was hosted by the Pan-African START Secretariat in Nairobi, Kenya with funding support from the GEF. Workshop attendees included 122 water resources managers from 24 countries.

The participants were: William Ainoshirogo, Mai Moussa Katiella Abdou, Mady Pascal Amule, Oyugi Aseto, Augusto Hojas Baculio, John S. Balirwa, Moses Banda, David Read Barker, Robert Becht, Benoit Bihamiriza, Rodrigues Bila, Lisa Borre, Fred Bugenyi, Phillip Bwathondi, Alberto Calcagno, Kipyego Cheluget, Munyaradzi Chenje, K.G. Chesang, Oscar Chilanga, Deonatus B.R. Chitamwebwa, J. Richard Davis, Salif Diop, Micheal B. Dolozi, Maura Finlay, Nathan Gichuki, Nancy Gitonga, Gabriel Hakizimana, Robert Hecky, Sarah Higgins, Shinje Ide, Iyabo Olanrewaju Idowu-Ominiyi, Sven Erik Jorgensen, Abakar Mahamat Kaila, Clarkson Karan, Jerome Karimumuryango, J.W. Kariuki, Martha Karua, F. Katangira, E. Katunzi, Sixtus Kayombo, Misa Kemmiya, Sean Khan, George Okeyo Khroda, Elija Kinyangi, Philip Kisoyan, Shadrack Mulei Kiithia, Michel Dimbele Kombe, Asa Kule, Andrew Kulecho, Levy Kusangaya, Patrick Machio, Christopher H.D. Magadza, A. Mahatane, Esther Makwaia, Kisa Mfalia, Ratemo Michieka, Patrick Milimo, Theresa Mjenge, Malcolm Moodie, Mahamane Moussa, Rose Mugidde, Victor Muhandiki, Ruzika N. Muheto, Edith Nana Mussukuya, Masahisa Nakamura, Hermes Mushayuma Namegabe, Robert Ndetei, Charles Ndlovu, Ebozo Daniel Ndong, Magnus Ngoile, Vida Ngomuo, Jim Nickum, Karoli Nicholas Njau, Francois Xavier Kachuka Nkomerwa, Hudson Hamis Nkotagu, Muderhwa Nshombo, Gaspard Ntakimazi, John Ntambirweki, Micheni Ntiba, Fiona Nunan, Christopher M. Nyirabu, Jerome Nzojibwami, Peninah A. Obudho, Eric O. Odada, Ngure Odeny, Johnson Oguntola, Richard Ogutu-Ohwayo, Tom Okurut, Daniel Olago, Obiero Ong'ang'a, Japheth Onyando, George E.O. Owiti, Lekan Oyebande, James Phiri, Marie Prchalova, Jackson Raini, Walter Rast, Richard Robarts, Mouhyddine M. Saleh, Adelina Santos-Borja, Henry M. Sichingabula, Richard Dawson Sipawe, Suleiman Garba Suleiman, Alphonse Marie Takougue, Lambert Tam, C. Tapfumanei, Anna Tengberg, Anada Tiega, Atsuko Toge, Mwakio Tole, Micheal J. Tumbare, Anne-Marie Verbeken, Mathias W. Wafula, Enock Wakwabi, George Wamukoya, Jane Wamuongo, Shem Wandiga, Portia Chiyedza Wanink, Bartholemew Wanyama, Kelly West, and Yuji Yoshioka.

The main lessons to emerge from the workshop discussions were as follows:

- **Shared visions are important for transboundary lakes—**It takes time, but unless everyone agrees and is working toward a shared goal and objectives, then it probably is not worth continuing with attempts at joint management. The time taken may appear as planning paralysis to outsiders, but it is essential. Also, countries are different and any workplan needs to recognize that countries are all working at different levels and capacities. To keep them interested, the workplans must be tailored to their individual needs.

- **Climate change is a real issue—**Climate change is complex and affects lake basins in different ways. In some lakes, it is already apparent in the form of reduced water inflows. Lake basin planning should include the effects of climate change.

- **Political support is crucial—**Lake basins can only be managed with political support. In the effort to obtain funding, lake managers need to strategize on funding to convince politicians.

- **Cultural issues are important—**Community organization needs to take cultural issues into account, including gender issues.

- **Identify stakeholders—**Although community participation is key to lake basin management, it can be difficult to identify the stakeholders. They may be groups far distant from the lake itself, including in the upper lake basin.

- **Appropriate technology—**Technologies that are introduced into lake basin management should be within the capacities and financial means of local institutions. There need to be adequate resources assigned to manage and operate technologies such as databases and GIS.

- **Water is a social and an economic good—**Water is an economic good that should be paid for by the user in order to cut down on waste. It is also a social good and there needs to be provision for the poor who cannot afford to pay for the water.

- **Institutions need to be long-term—**It is crucial to set up necessary institutions that would take care of enforcement and monitoring after the project is completed.

- **Institutional representation at the lakeshore—**When the lake is remote from the capital city and its institutions, such as the ministries, much thought needs to be put into sustainability. Do you take the institutions that are on the lakeshore and train them to do things that are outside their mandate, or do you wait for appropriate institutions to be established in the lake basin?

- **Importance of research and teaching—**Research and education should be key project components. Lake basin management needs to be incorporated into the education curricula of universities.

- **Local expertise—**Local expertise should be used whenever possible. Some projects overlooked local expertise in their design and implementation. Indigenous knowledge should be used in the design and implementation of projects.

- **Dialogue between managers and researchers—**Research must be designed to contribute to management interventions. There needs to be dialogue at the beginning between resources managers and researchers so that the scientific interventions will best address the management needs. Managers need to communicate to scientists as much as vice-versa. In this way, policy makers will be educated by scientists so that the right policies are put in place. There is also a need to simplify scientific research to include the aspirations of politicians.

Appendix D

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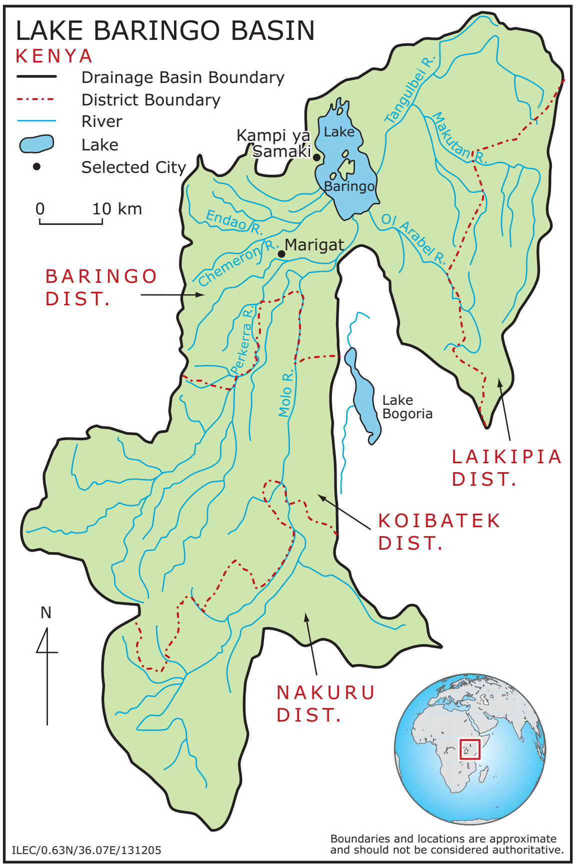
Appendix E

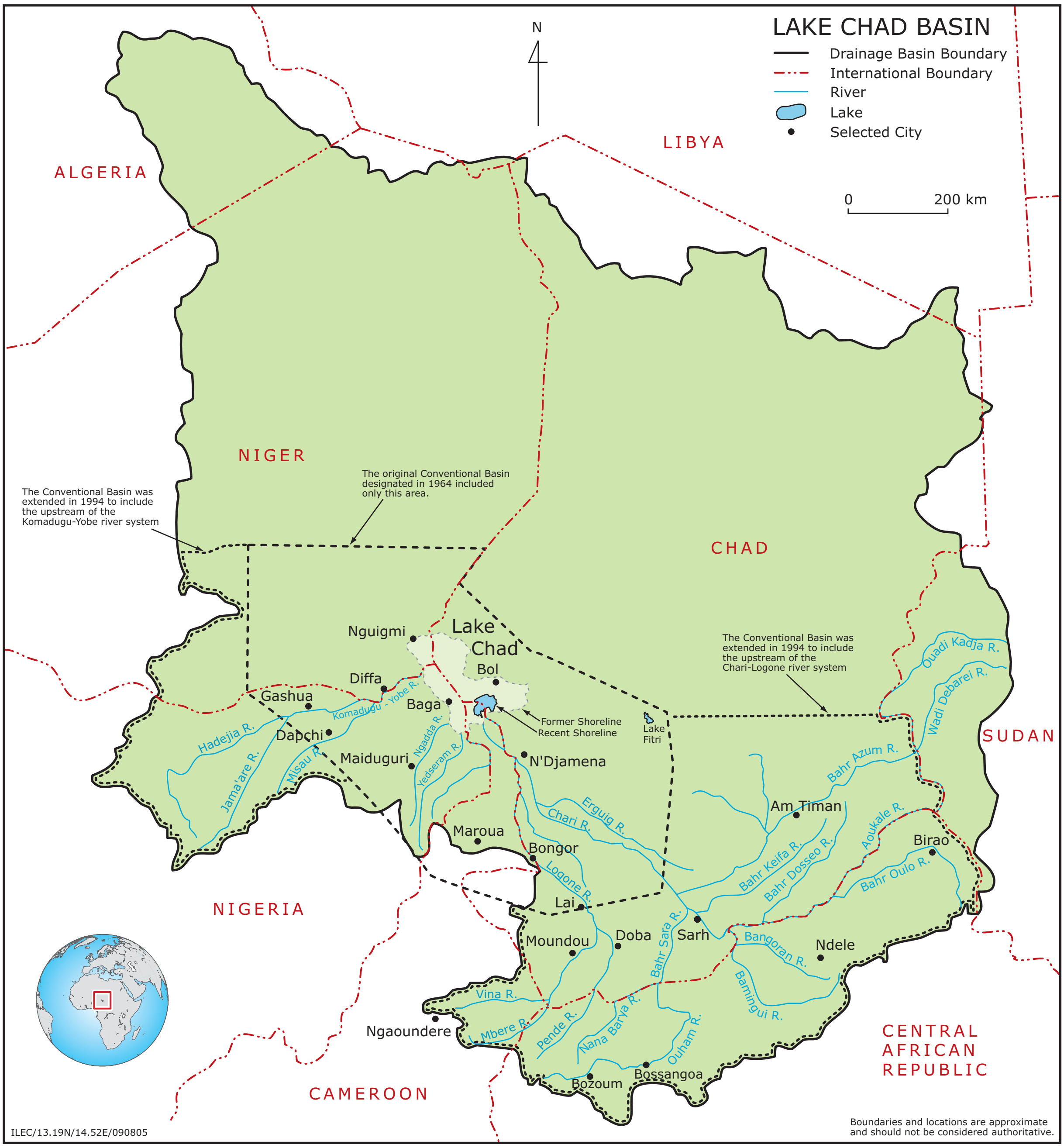
Maps of the 28 Lake Basins

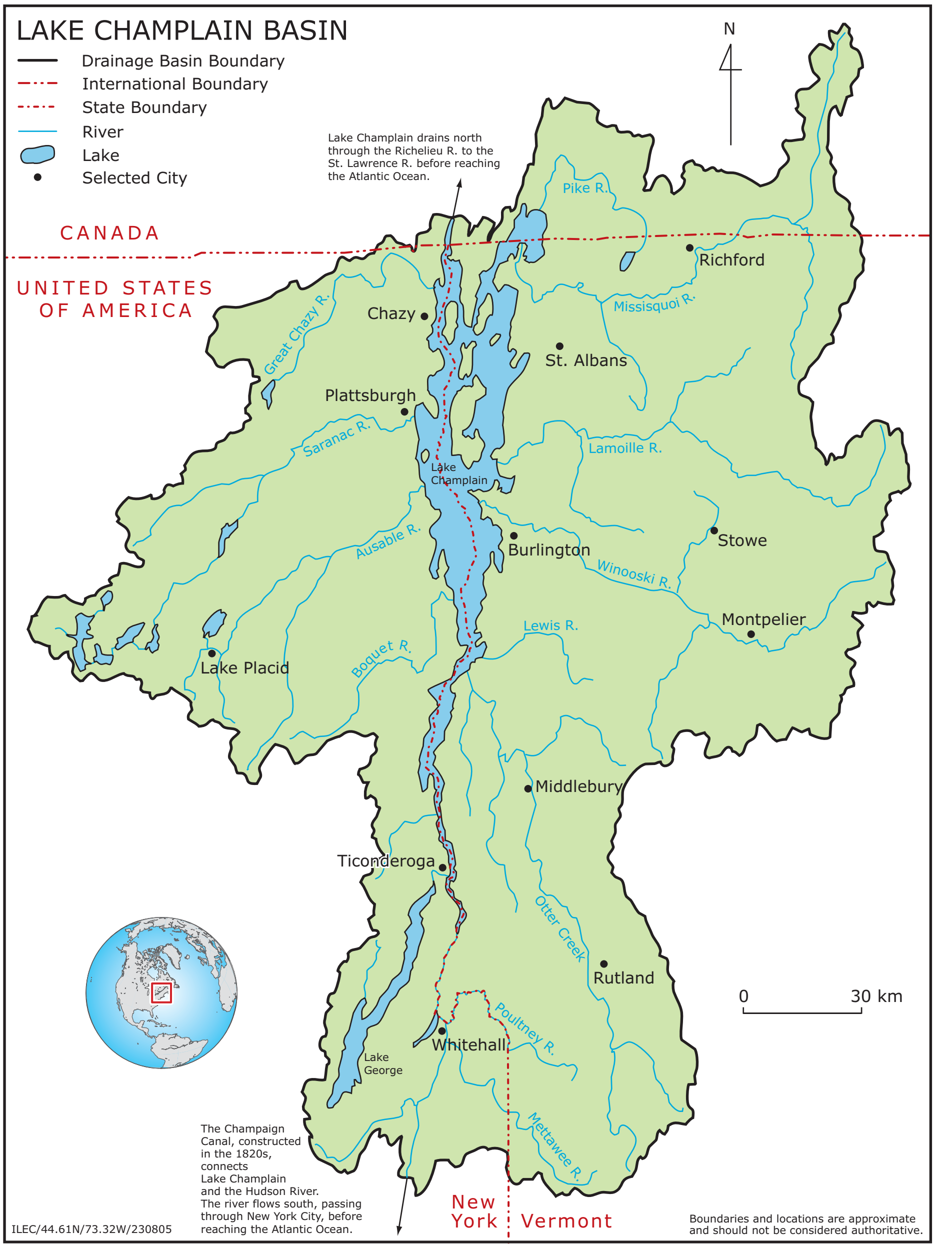

LAKE BAIKAL BASIN
Drainage Basin Boundary
International Boundary
Oblast or Republic Boundary
River
Lake
Selected City
N
The Angara R. flows into the Yenisey R. before reaching the Arctic Ocean
Angara R.
Irkutsk Oblast
Buryatia Republic
Ust-Ordynskiy
Severobaikalsk
Upper Angara R.
Barguzin R.
Lake Baikal
Dam
Irkutsk
Buryatia Republic
Slyudyanka
Baikalsk
Uda R.
Ulan Ude
Selenga R.
Khilok
Khilok R.
Chita Oblast
RUSSIAN FED.
Lake Hovsgol
Zakamensk
Kyakhra
Egiyn Gol
Moron
Selenga R.
Darhan
Ideriyn Gol
Tosontsengel
Hanuy Gol
Orhon Gol
Ulan Bator
MONGOLIA
0
100 km
Tsetserleg
ILEC/53.37N/108.17E/230805
Boundaries and locations are approximate and should not be considered authoritative.


LAKE BARINGO BASIN
KENYA
Drainage Basin Boundary
District Boundary
River
Lake
Selected City
0
10 km
Kampi ya Samaki
Lake Baringo
Tangulbei R.
Makutani R.
Endao R.
Chemeron R.
Marigat
Ol Arabel R.
BARINGO DIST.
Perkerra R.
Molo R.
Lake Bogoria
LAIKIPIA DIST.
KOIBATEK DIST.
N
NAKURU DIST.
ILEC/0.63N/36.07E/131205
Boundaries and locations are approximate and should not be considered authoritative.


BHOJ WETLAND BASIN
INDIA
Drainage Basin Boundary
District Boundary
River
Lake
Selected City
N
Bairagarh
Old Bhopal
Upper Lake
Dam
Lower Lake and its Sub-Basin
Kolhukhedi
Phanda
Mugalia
Gora
New Bhopal
BHOPAL DIST.
Kaliasote Reservoir
Nandni
SEHORE DIST.
Teelakhedi
Ratibad
Kolanskala
Dabla
Bilkisganj
0
5 km
Bamulya
Kolans R.
Uljhawan
ILEC/23.25N/77.35E/050805
Boundaries and locations are approximate and should not be considered authoritative.


Sea of Japan
LAKE BIWA -
YODO RIVER BASIN
JAPAN
Drainage Basin Boundary
Prefecture Boundary
River
Lake
Selected City
0
10 km
N
L. Yogo
Takatoki R.
Ane R.
Imazu
Nagahama
Ado R.
North Basin
Lake
Biwa
Hikone
SHIGA
PREF.
Omi
Hachiman
Echi R.
Katata
KYOTO
PREF.
Katsura R.
South Basin
Hino R.
Kyoto
Otsu
Kusatsu
Canal
Yasu R.
Seta R.
Seta
Weir
Daido R.
OSAKA
PREF.
Uji R.
Yodo R.
Lake Biwa Basin
Lake Biwa -
Yodo River Basin
Kizu R.
MIE PREF.
Kobe
Osaka
Osaka
Bay
NARA PREF.
ILEC/35.32N/136.15E/090805
Boundaries and locations are approximate
and should not be considered authoritative.

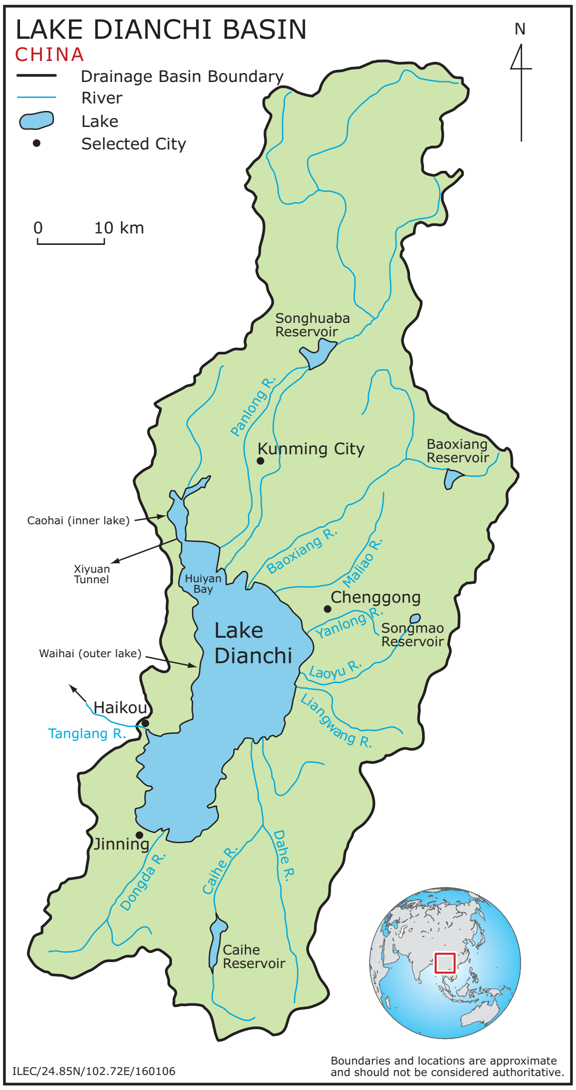

LAKE CHAD BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
200 km
N
ALGERIA
LIBYA
NIGER
CHAD
SUDAN
NIGERIA
CAMEROON
CENTRAL AFRICAN REPUBLIC
The Conventional Basin was extended in 1994 to include the upstream of the Komadugu-Yobe river system
The original Conventional Basin designated in 1964 included only this area.
The Conventional Basin was extended in 1994 to include the upstream of the Chari-Logone river system
Lake Chad
Nguigmi
Diffa
Gashua
Baga
Bol
Dapchi
Maiduguri
N'Djamena
Former Shoreline
Recent Shoreline
Lake Fitri
Maroua
Bongor
Lai
Moundou
Doba
Sarh
Am Timan
Birao
Ndele
Ngaoundere
Bozoum
Bossangoa
Hadejia R.
Jama'are R.
Misau R.
Komadugu - Yobe R.
Ngadda R.
Yedseram R.
Chari R.
Erguig R.
Logone R.
Bahr Sara R.
Bahr Keita R.
Bahr Dosseo R.
Aoukale R.
Bahr Azum R.
Ouadi Kadja R.
Wadi Debarei R.
Bahr Oulo R.
Bangoran R.
Bamingui R.
Vina R.
L. Mbere R.
Pende R.
Nana Barya R.
Ouham R.
ILEC/13.19N/14.52E/090805
Boundaries and locations are approximate and should not be considered authoritative.

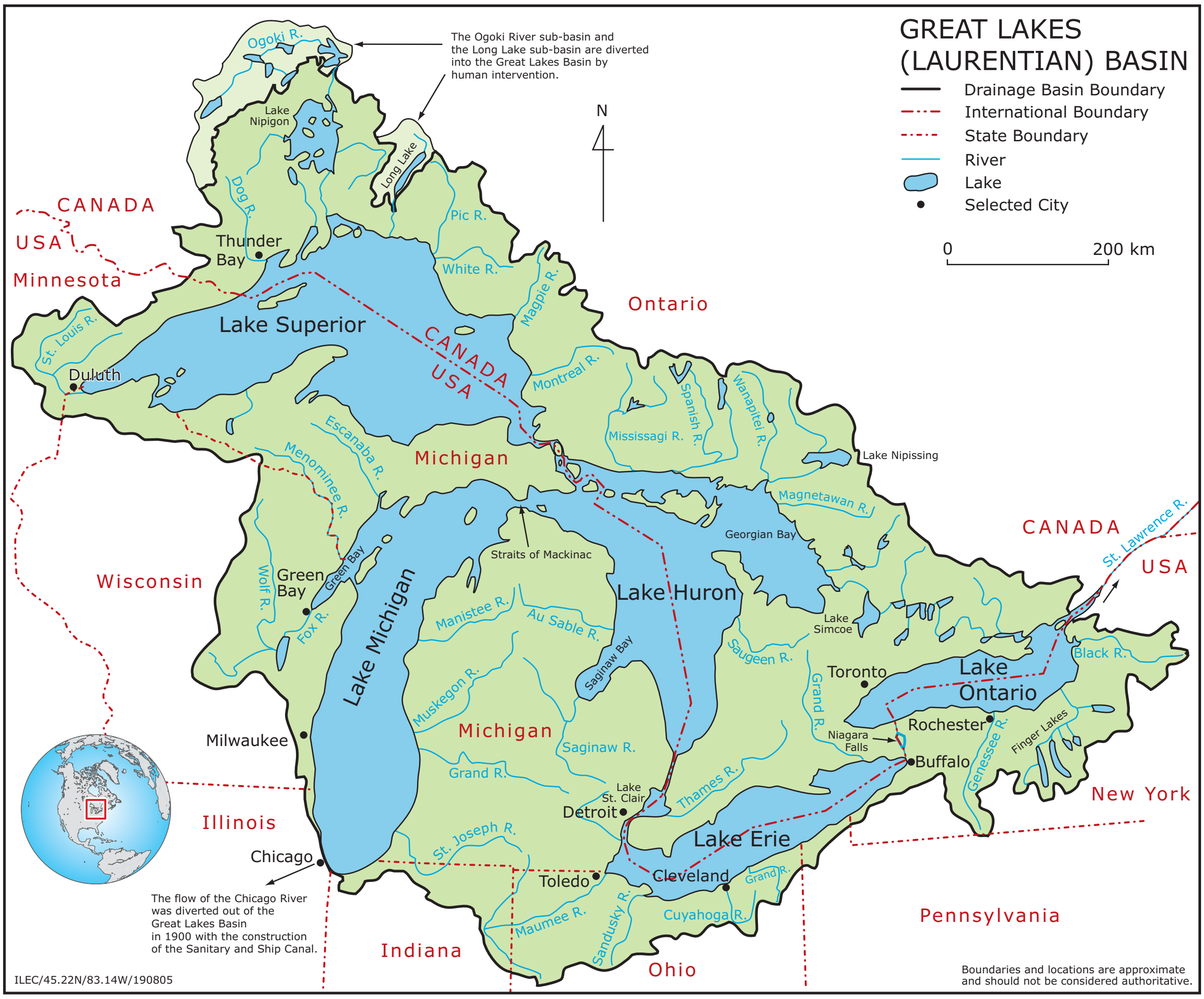

LAKE CHAMPLAIN BASIN
Drainage Basin Boundary
International Boundary
State Boundary
River
Lake
Selected City
N
Lake Champlain drains north through the Richelieu R. to the St. Lawrence R. before reaching the Atlantic Ocean.
CANADA
UNITED STATES OF AMERICA
Pike R.
Richford
Missisquoi R.
Chazy
Great Chazy R.
St. Albans
Plattsburgh
Saranac R.
Lamoille R.
Lake Champlain
Stowe
Burlington
Ausable R.
Winooski R.
Montpelier
Lewis R.
Lake Placid
Boquet R.
Middlebury
Ticonderoga
Otter Creek
Rutland
0
30 km
Poultney R.
Whitehall
Lake George
Mettawee R.
The Champaign Canal, constructed in the 1820s, connects Lake Champlain and the Hudson River. The river flows south, passing through New York City, before reaching the Atlantic Ocean.
New York
Vermont
ILEC/44.61N/73.32W/230805
Boundaries and locations are approximate and should not be considered authoritative.

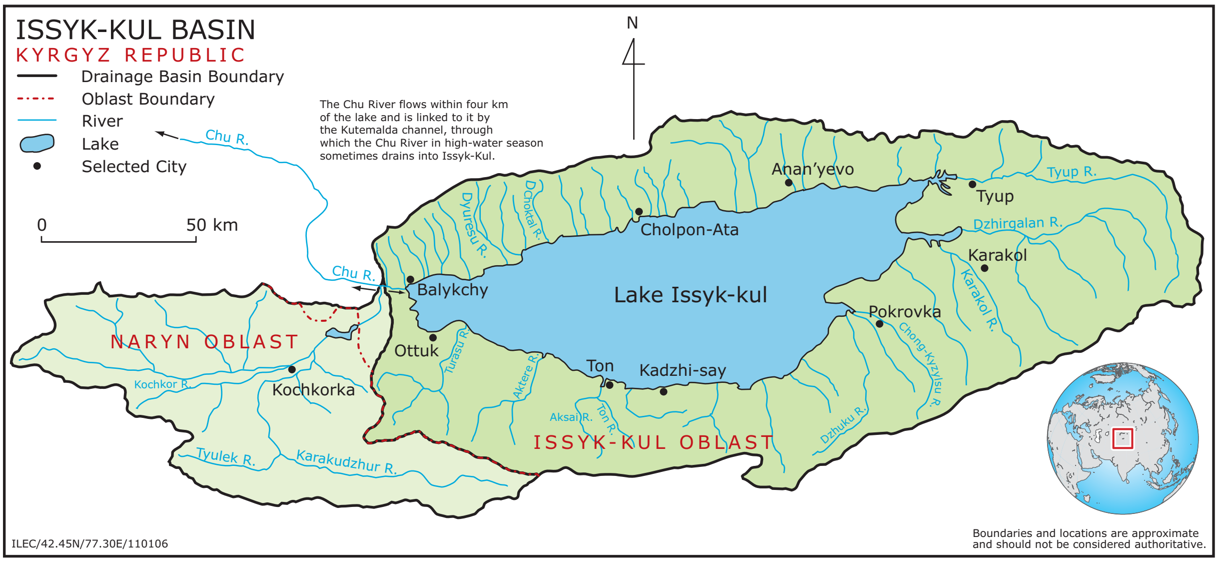

CHILIKA LAGOON BASIN
INDIA
Drainage Basin Boundary
River
Lake
Selected City
0
20km
N
The Mahanadi River starts far to the west and is not fully depicted on this map.
Mahanadi R.
Cuttack
Bhubaneshwar
Begunia
Mahanadi Catchement
Bologarh
Khurda
Jatani
Daya R.
Pipili
Ranpur
Malaguni R.
Delang
Kanas
Satyabadi
Western Catchment
Tangi
Salia R.
Kusumi R.
Nuna R.
Bhargavi R.
Kansari R.
Chilika
Northern Sector
Chilika Lagoon
Puri
Brambagiri
Banapur
Central Sector
Magarmukh Channel
NALABANA IS.
Old Mouth
Outer Channel
Numerous levees confine the Bhargavi R. flow. Interestingly, the river itself forms the catchment boundary in this area.
Krishnaprasad
Newly Opened Mouth
Southern Sector
Catchment along the Sandbar
Bay of Bengal
Rushikulya R.
Palur Canal
ILEC/19.75N/85.41E/300106
Boundaries and locations are approximate and should not be considered authoritative.


LAKE COCIBOLCA - SAN JUAN RIVER BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
50 km
N
Lake Apanas
Water from the manmade Lake Apanas is diverted into the Lake Managua Basin to power a hydroelectric plant before reaching the Viejo River.
Lake Managua Basin
Until the mid-1800s, the Tipitapa River was a regularly flowing river draining Lake Managua to Lake Cocibolca. However, the river has only discharged a few times in the last century, most recently during Hurricane Mitch in October 1998, effectively making the Lake Managua Basin a closed basin.
Lake Cocibola Basin
Lake Cocibolca - San Juan River Basin
NICARAGUA
COSTA RICA
Pacific Ocean
Caribbean Sea
Viejo R.
Sinecapa R.
Pacora R.
Malacatoya R.
Lake Managua
Mateare
Tipitapa
Managua
Juigalpa
Cuisala R.
Acoyapa
Ojocuapa R.
Oyate R.
Tepenaguasapa R.
Tule R.
Masaya
Granada
Lago Apoyo
Nandaime
ZAPATERA IS.
Lake Cocibolca
Altagracia
OMETEPE IS.
Rivas
SOLENTINAME ISLANDS
San Carlos
La Cruz
Niño R.
San Juan R.
Sabalos R.
Los Chiles
Frio R.
Poco Sol R.
Infiernito R.
San Carlos R.
Tres Amigos R.
San Juan del Norte
Chirripo R.
Sucio R.
Lake Arenal
Arenal R.
Altamira
Quesada
ILEC/11.54N/85.39W/190705
Boundaries and locations are approximate and should not be considered authoritative.


N
GERMANY
GER.
SWITZERLAND
AUSTRIA
LIECHTENSTEIN
SWITZERLAND
LAKE CONSTANCE BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
Stockacher R.
Seefelder R.
Rotach R.
Schussen R.
Radolfzeller R.
Uberlinger See
Zeller See
Rhein R.
Argen R.
Leiblach R.
Bregenzer R.
Alter Rhein R.
Rhein R.
Vorderrhein R.
Glogn R.
Rabiusa R.
Albula R.
Hinterrhein R.
Radolfzell
Uberlingen
Konstanz
Kreuzlingen
Friedrichshafen
Lake Constance
Wangen
Lindau
Bregenz
Arbon
Rorschach
St. Gallen
Dornbirn
Feldkirch
Bludenz
Vaduz
Chur
Davos
0
20 km
ILEC/47.62N/9.41E/050805
Boundaries and locations are approximate and should not be considered authoritative.

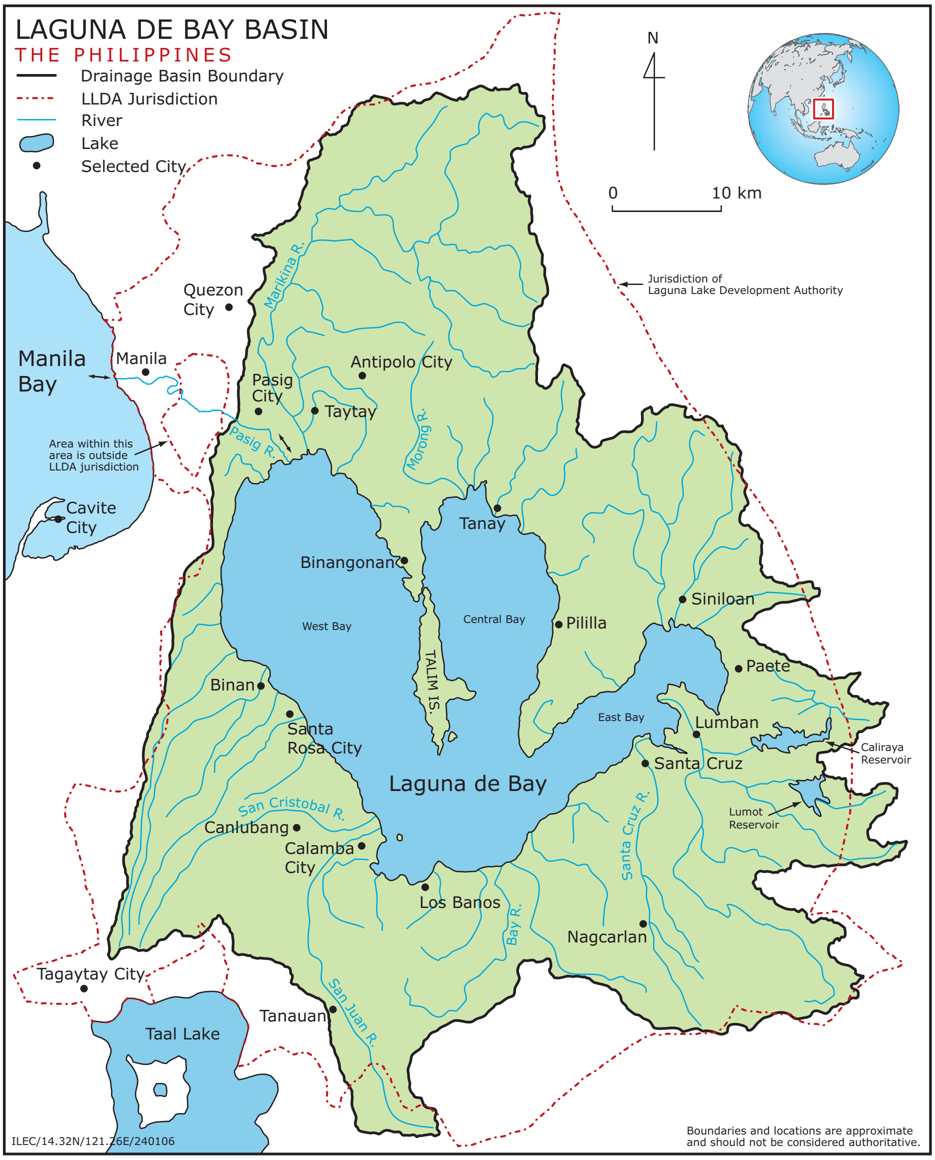

LAKE DIANCHI BASIN
CHINA
Drainage Basin Boundary
River
Lake
Selected City
N
0
10 km
Songhuaba Reservoir
Panlong R.
Kunming City
Baoxiang Reservoir
Caohai (inner lake)
Xiyuan Tunnel
Huiyan Bay
Baoxiang R.
Maliao R.
Chenggong
Yanlong R.
Songmao Reservoir
Lake Dianchi
Waihai (outer lake)
Laoyu R.
Liangwang R.
Haikou
Tanglang R.
Jinning
Dongda R.
Caihe R.
Dahe R.
Caihe Reservoir
ILEC/24.85N/102.72E/160106
Boundaries and locations are approximate and should not be considered authoritative.


GREAT LAKES (LAURENTIAN) BASIN
Drainage Basin Boundary
International Boundary
State Boundary
River
Lake
Selected City
0 200 km
N
The Ogoki River sub-basin and the Long Lake sub-basin are diverted into the Great Lakes Basin by human intervention.
The flow of the Chicago River was diverted out of the Great Lakes Basin in 1900 with the construction of the Sanitary and Ship Canal.
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/45.22N/83.14W/190805
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Georgian Bay
Green Bay
Saginaw Bay
Straits of Mackinac
Lake Nipigon
Long Lake
Lake Nipissing
Lake Simcoe
Lake St. Clair
Finger Lakes
CANADA
USA
Minnesota
Wisconsin
Michigan
Illinois
Indiana
Ohio
Pennsylvania
New York
Ontario
Thunder Bay
Duluth
Green Bay
Milwaukee
Chicago
Toledo
Detroit
Cleveland
Toronto
Rochester
Buffalo
Niagara Falls
Ogoki R.
Dog R.
Pic R.
White R.
Magpie R.
Montreal R.
Mississagi R.
Spanish R.
Wanapitei R.
Magnetawan R.
St. Louis R.
Escanaba R.
Menominee R.
Wolf R.
Fox R.
Manistee R.
Au Sable R.
Muskegon R.
Saginaw R.
Grand R.
St. Joseph R.
Maumee R.
Sandusky R.
Cuyahoga R.
Thames R.
Saugeen R.
Genessee R.
Black R.
St. Lawrence R.

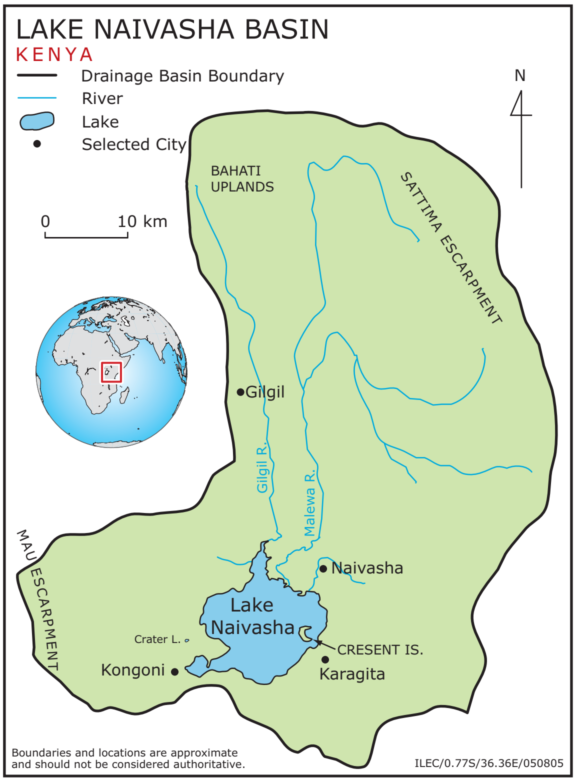


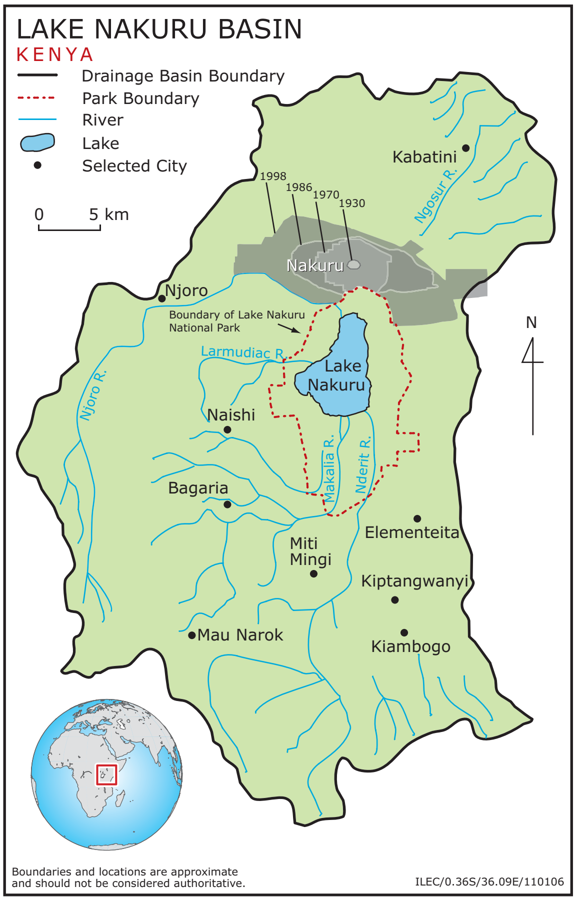
ISSYK-KUL BASIN
KYRGYZ REPUBLIC
Drainage Basin Boundary
Oblast Boundary
River
Lake
Selected City
0
50 km
N
The Chu River flows within four km of the lake and is linked to it by the Kutemalda channel, through which the Chu River in high-water season sometimes drains into Issyk-Kul.
Chu R.
Chu R.
Dyuresu R.
Dchoktal R.
Anan'yevo
Tyup R.
Tyup
Cholpon-Ata
Dzhirgalan R.
Karakol
Karakol R.
Balykchy
Lake Issyk-kul
Pokrovka
Chong-Kyzylsu R.
NARYN OBLAST
Ottuk
Turasu R.
Ton
Kadzhi-say
Kochkor R.
Kochkorka
Aktere R.
Aksai R.
Ton R.
Dzhuku R.
ISSYK-KUL OBLAST
Tyulek R.
Karakudzhur R.
ILEC/42.45N/77.30E/110106
Boundaries and locations are approximate and should not be considered authoritative.


KARIBA RESERVOIR BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
ANGOLA
D.R. OF CONGO
N
Lubumbashi
Luena
Solwezi
Zambezi R.
Kabompo R.
Lunga R.
Kafue R.
ZAMBIA
MOZ.
Menongue
Mongu
Cuando R.
Lusaka
Lago de Cahora Bassa
Kafue Flats
Zambezi R.
Kariba Reservoir
Kariba Town
Cubango R.
Zambezi R.
Cuito R.
Ume R.
Sanyati R.
ANGOLA
NAMIBIA
Livingstone
Zambezi R.
Victoria Falls
Harare
Linyanti R.
Sengwa R.
Okavango R.
Gwai R.
Magwegqana R.
OKAVANGO DELTA
Nata R.
Grootfontein
Maun
Bulawayo
Boteti R.
Lake Ngami
Makgadikgadi Salt Pans
Eiseb R.
ZIMBABWE
Omatako R.
Deception Salt Pans
Hanahai R.
Ghanzi
Windhoek
Okwa R.
MOZ.
This sub-basin connects to the main basin when extensive flooding occurs.
SOUTH AFRICA
0
200 km
NAMIBIA
BOTSWANA
Gaborone
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/16.90S/28.04E/090805


LAGUNA DE BAY BASIN
THE PHILIPPINES
Drainage Basin Boundary
LLDA Jurisdiction
River
Lake
Selected City
N
0
10 km
Jurisdiction of
Laguna Lake Development Authority
Manila
Bay
Quezon
City
Manila
Marikina R.
Antipolo City
Pasig
City
Taytay
Pasig R.
Morong R.
Area within this
area is outside
LLDA jurisdiction
Cavite
City
Tanay
Binangonan
West Bay
Central Bay
Pililla
Siniloan
TALIM IS.
Paete
Binan
Santa
Rosa City
East Bay
Lumban
Caliraya
Reservoir
Santa Cruz
Laguna de Bay
San Cristobal R.
Canlubang
Calamba
City
Lumot
Reservoir
Santa Cruz R.
Los Banos
Bay R.
Nagcarlan
Tagaytay City
San Juan R.
Tanauan
Taal Lake
ILEC/14.32N/121.26E/240106
Boundaries and locations are approximate
and should not be considered authoritative.

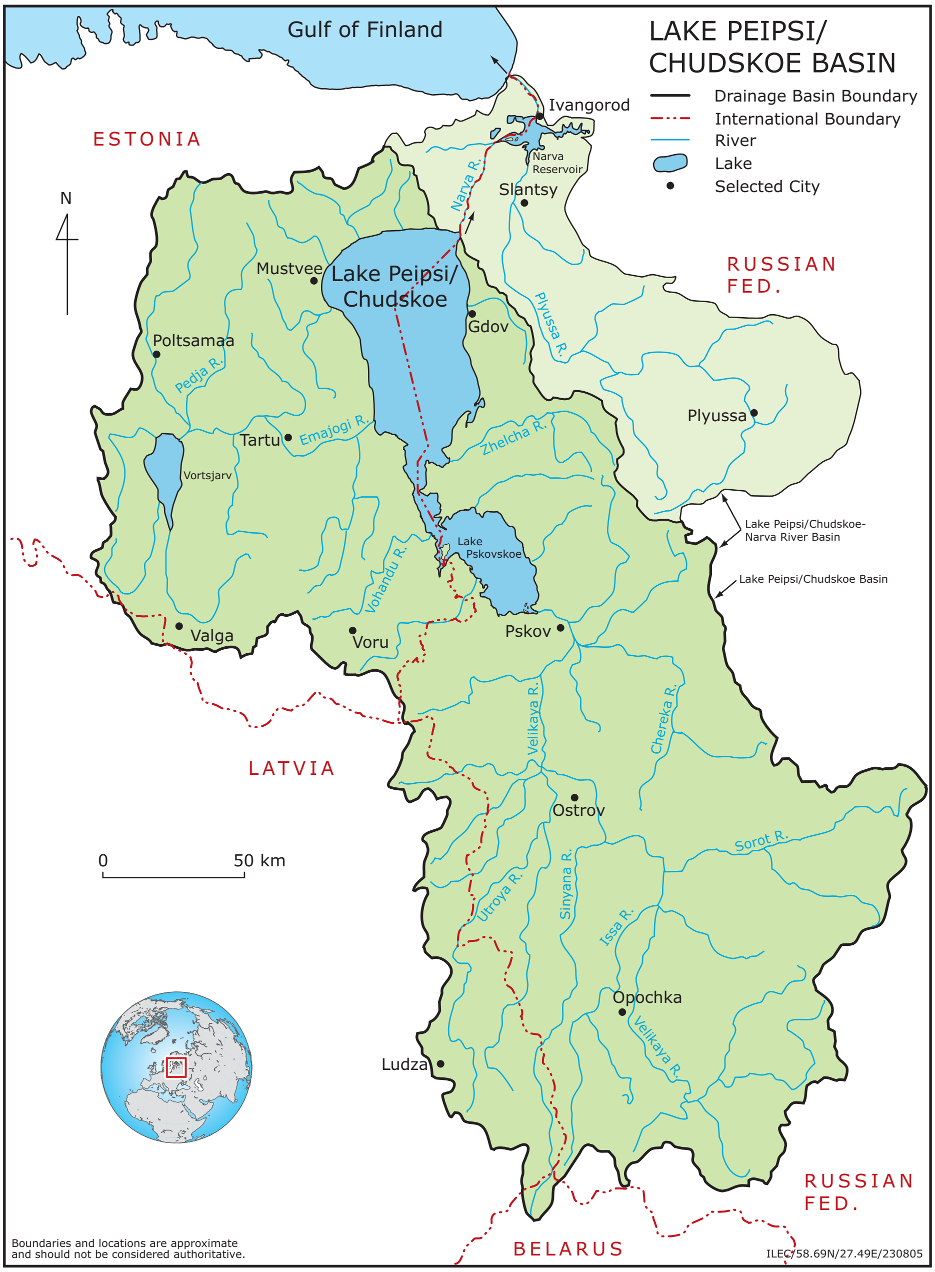

LAKE MALAWI/NYASA BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
50 km
TANZANIA
Songwe R.
Kyela
Chitipa
Karonga
N. Rukuru R.
N
Ruhuhu R.
Lake Malawi/Nyasa
TANZANIA
Rumphi
ZAMBIA
S. Rukuru R.
Kasitu R.
Nkhata Bay
Mzimba
CHISUMULU IS. (Malawi)
LIKOMA IS. (Malawi)
MALAWI
Metangula
Dwangwa R.
MOZAMBIQUE
Nkhotakota
Kasungu
Bua R.
Ntchisi
Dowa
Salima
Senga Bay
to Lugenda River
Mchinji
Lilongwe
Monkey Bay
Lilongwe R.
Linthipe R.
Dedza
Mangochi
L. Chiuta
L. Malombe
Ntcheu
MOZAMBIQUE
Shire R.
Machinga
Zomba
Lake Chilwa
Mwanza
Chiradzulu
to Zambezi River
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/11.90S/34.53E/050805


LAKE NAIVASHA BASIN
KENYA
Drainage Basin Boundary
River
Lake
Selected City
N
0
10 km
BAHATI UPLANDS
SATTIMA ESCARPMENT
Gilgil
Gilgil R.
Malewa R.
Naivasha
MAU ESCARPMENT
Lake Naivasha
Crater L.
CRESENT IS.
Karagita
Kongoni
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/0.77S/36.36E/050805



LAKE NAKURU BASIN
KENYA
Drainage Basin Boundary
Park Boundary
River
Lake
Selected City
0
5 km
1998
1986
1970
1930
Nakuru
Kabatini
Ngosur R.
Njoro
Boundary of Lake Nakuru National Park
Larmudiac R.
Lake Nakuru
Njoro R.
Naishi
Makalia R.
Nderit R.
Bagaria
Elementeita
Miti Mingi
Kiptangwanyi
Mau Narok
Kiambogo
N
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/0.36S/36.09E/110106


LAKE OHRID BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
N
0
10 km
to Lake Skhodra and the Adriatic Sea
Globocica Reservoir
Black Drim R.
Original path of Sateska R.
Botun
Sateska R.
The Sateska River was diverted in 1962 from its natural course (directly into the Black Drim R.) into Lake Ohrid to drain the Sateska Swamp and to boost the hydroelectric potential of Lake Ohrid.
Sateska R. Basin
FYR of MACEDONIA
Struga
Kalista
Koselska R.
Velgoska R.
Ohrid
Radozda
Resen
Lin
Lake Ohrid
Carev Dvor
Golema R.
Podmocani
Pestani
Trpejca
Udenisht
Stenje
Lake Macro Prespa
Krani
St. Naum
Brajcinska R.
Pogradec
Tushemisht
ALBANIA
Dolno
Agios Germanos R.
Cherava R.
Agios Germanos
Psarades
Liqenas
Pill
Lake Micro Prespa
GREECE
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/41.03N/20.72E/270106

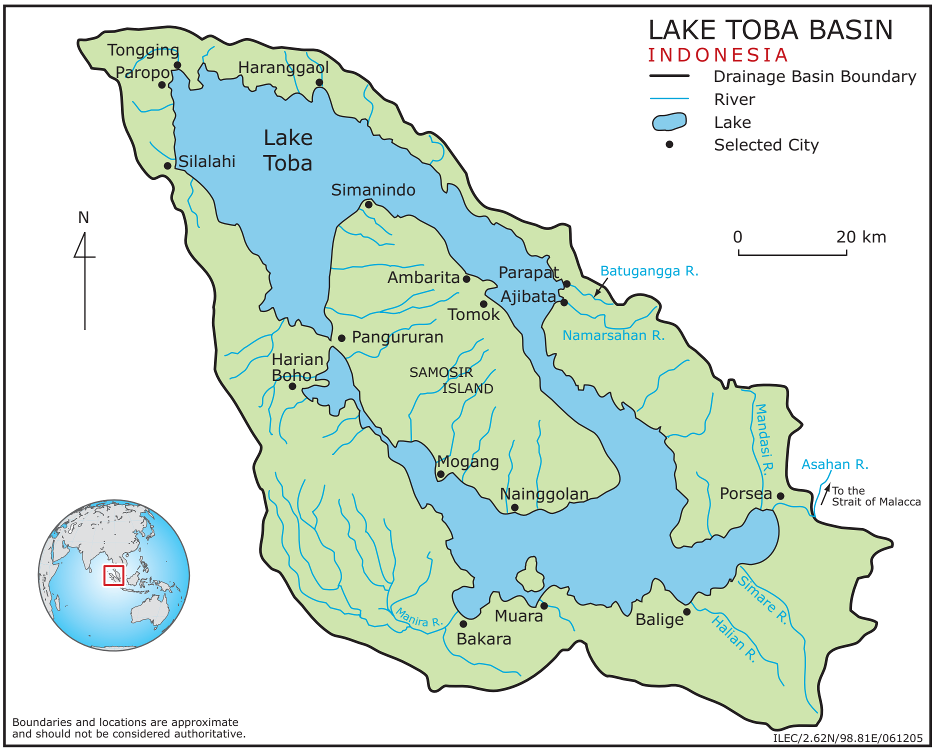


LAKE PEIPSI/ CHUDSKOE BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
Gulf of Finland
ESTONIA
RUSSIAN FED.
LATVIA
BELARUS
RUSSIAN FED.
N
Ivangorod
Narva Reservoir
Narva R.
Slantsy
Mustvee
Lake Peipsi/ Chudskoe
Gdov
Plyussa R.
Poltsamaa
Pedja R.
Plyussa
Tartu
Emajogi R.
Zhelcha R.
Vortsjarv
Lake Peipsi/Chudskoe-Narva River Basin
Lake Pskovskoe
Lake Peipsi/Chudskoe Basin
Vohandu R.
Valga
Voru
Pskov
Velikaya R.
Chereka R.
Ostrov
0
50 km
Sorot R.
Utroya R.
Sinyana R.
Issa R.
Opochka
Velikaya R.
Ludza
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/58.69N/27.49E/230805

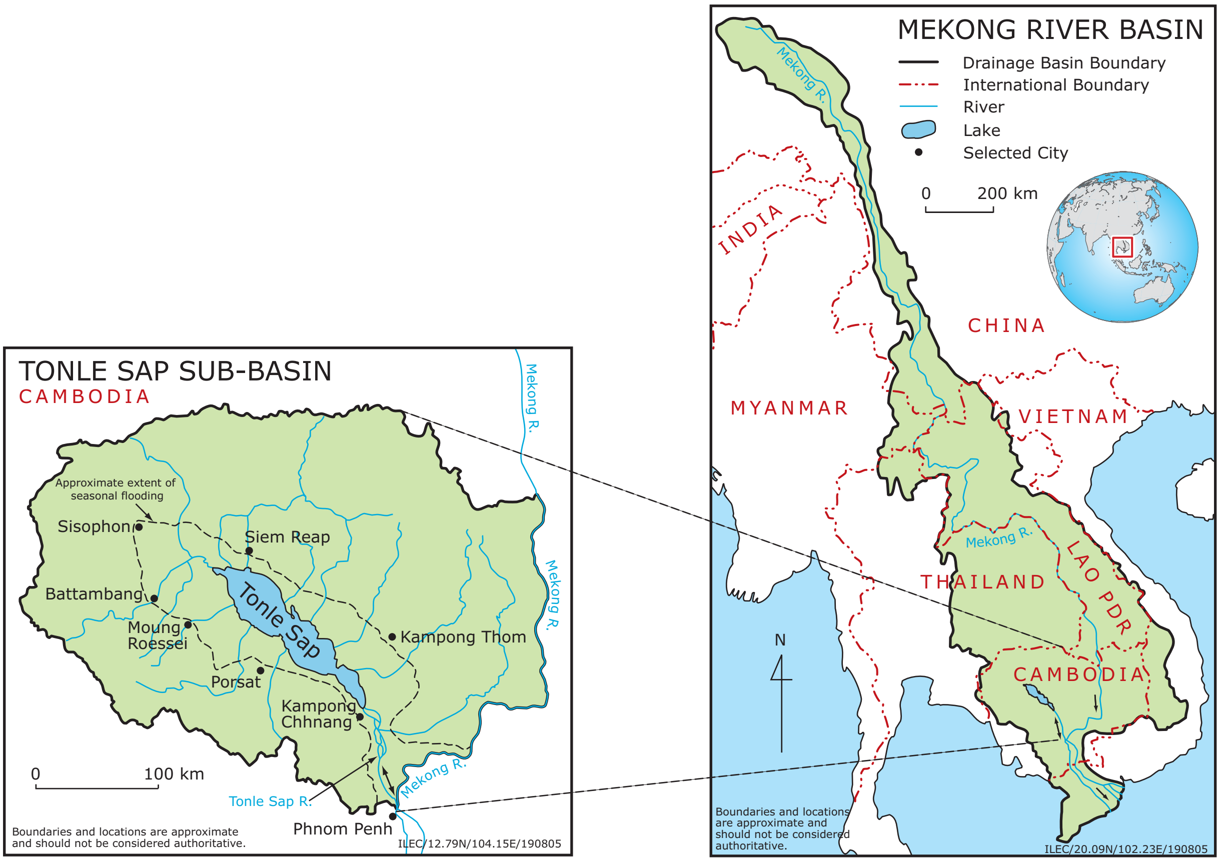

LAKE SEVAN BASIN
ARMENIA
Drainage Basin Boundary
River
Lake
Selected City
N
0
10 km
Hrazdan R.
Sevan
Minor
Sevan
Tsovazard
Shorja
Artanish
Lake
Sevan
Gavar
Gavaraget R.
Major Sevan
Masrik R.
Mets Mazra
Vardenis
Yeranos
Lichk
Martuni
Vardenik
Argichi R.
Vardenik R.
The Arpa-Sevan Tunnel brings water from the Arpa River into Lake Sevan.
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/40.32N/45.38E/160206

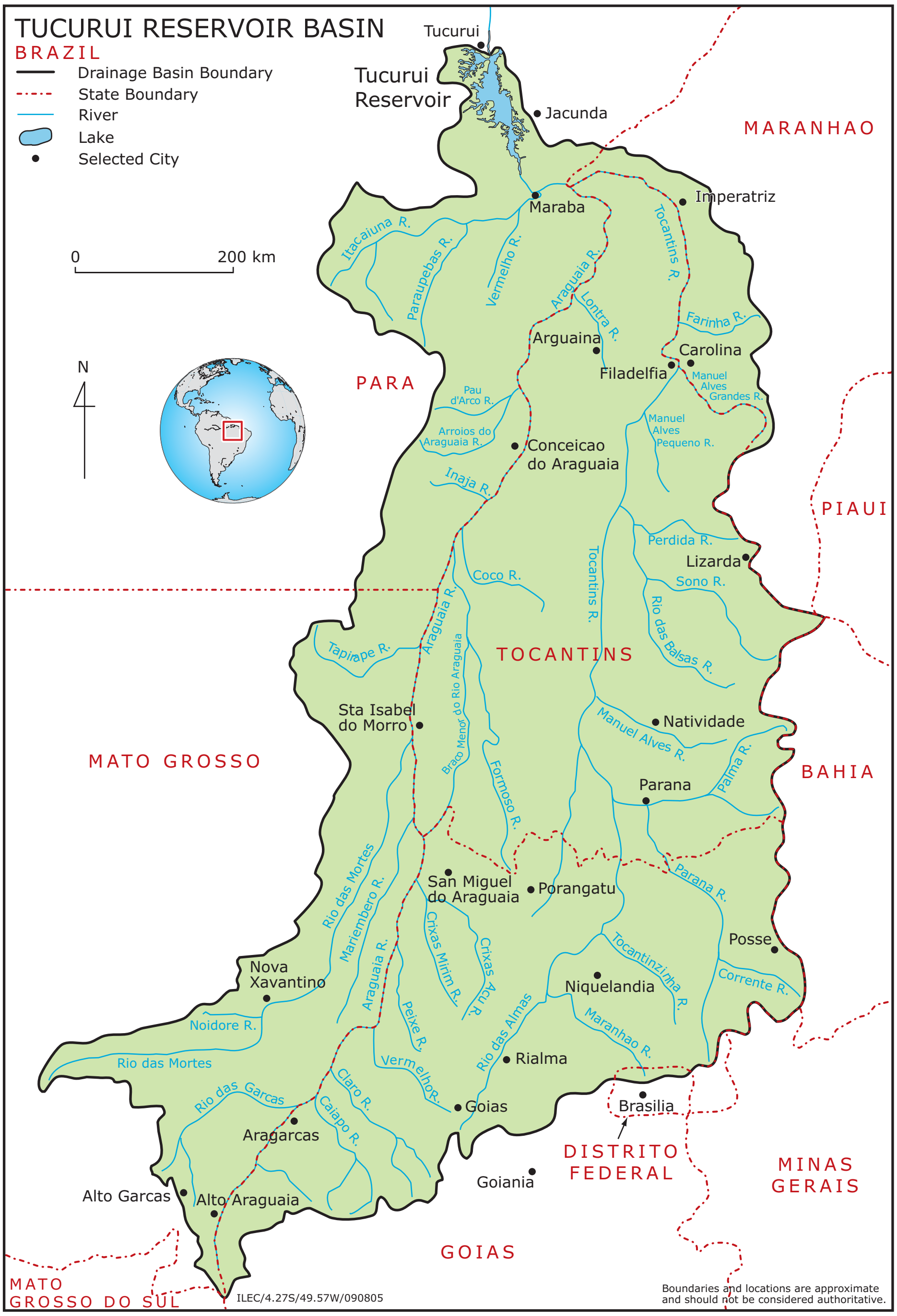

LAKE TANGANYIKA BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
100 km
N
RWANDA
Kigali
Lake Kivu
Bukavu
Rusizi R.
BURUNDI
Bujumbura
Uvira
Malagarasi R.
Moyowosi R.
Kigosi R.
Kasulu
Kigoma
Gombe R.
Tabora
Urambo
D.R. OF CONGO
Malagarasi R.
TANZANIA
Wala R.
Lake Tanganyika
Lukuga R.
Kalemie
Ugala R.
Mpanda
Shama R.
Rungwa R.
Lake Rukwa
Sumbawanga
Lake Mweru Wantipa
Lake Mweru
Lufubu R.
Mpulungu
ZAMBIA
MALAWI
Lake Malawi
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/6.13S/29.60E/061205


LAKE TITICACA - DESAGUADERO RIVER - LAKE POOPO COIPASA SALT LAKE (TDPS) BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
50 km
N
Ayaviri
Azangaro
Carabaya R.
Putina R.
Ayaviri R.
Azangaro R.
Lake Arapa
Palca R.
Lake Ananta
Juliaca
Lake Lagunillas
Lake Umayo
Puno
Lake Titicaca
Suches R.
Ilave R.
Copacabana
Achacachi
Catari R.
La Paz
Guaqui
Viacha
Huenque R.
PERU
Lake Titicaca Basin
Desaguadero River, Lake Poopo, and Coipasa Salt Lake Basin
Desaguadero R.
Mauri R.
Umala
Desaguadero R.
Oruro
Lake Uru Uru
BOLIVIA
Lago de Chungara
Lauca R.
Cosapa R.
Lake Poopo
Pacific Ocean
CHILE
Lake Coipasa
Coipasa Salt Flat
Lacajahuira R.
Sevaruyo R.
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/15.94S/69.27W/090805

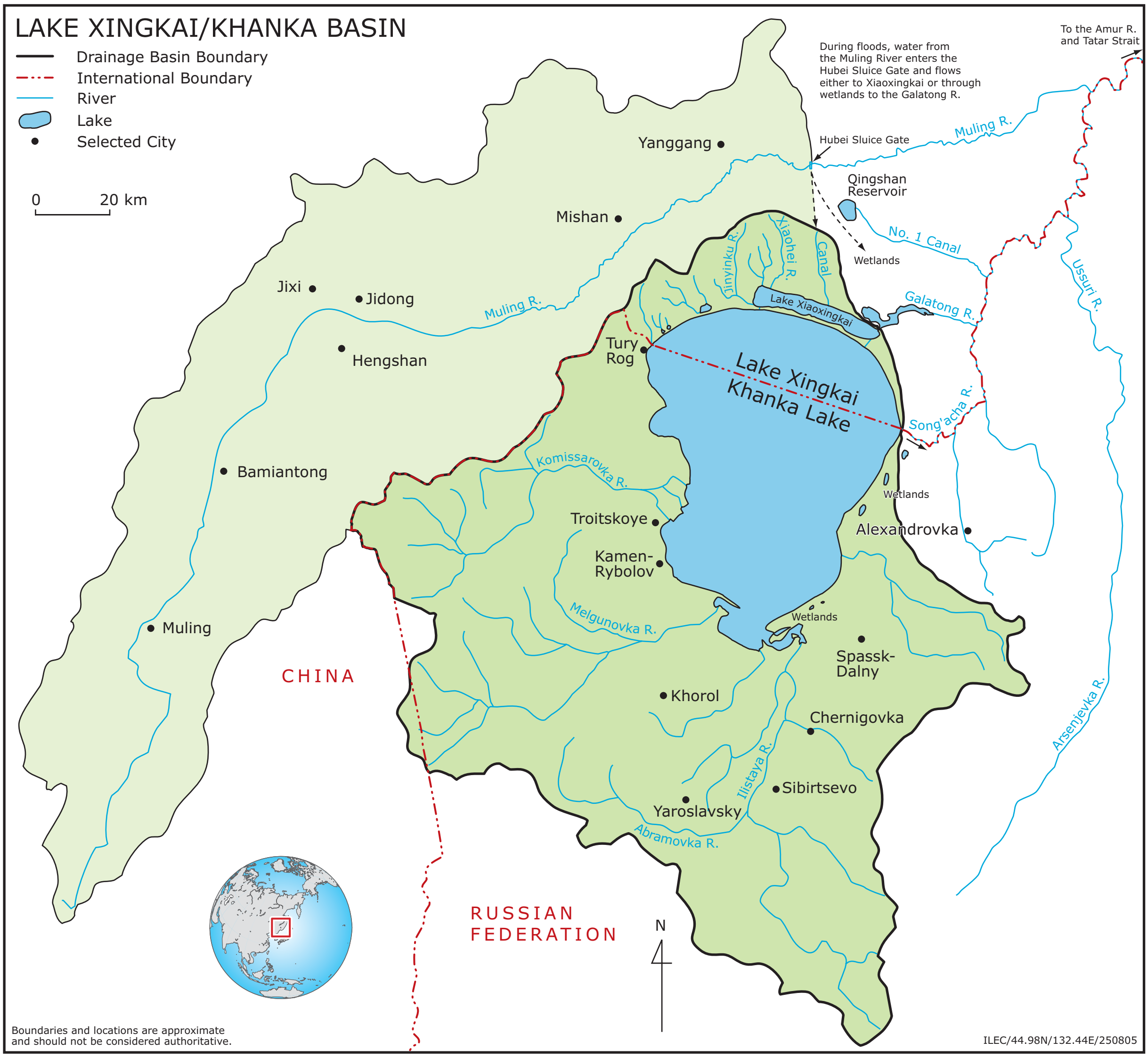


LAKE TOBA BASIN
INDONESIA
Drainage Basin Boundary
River
Lake
Selected City
0
20 km
N
Lake Toba
Tongging
Paropo
Haranggaol
Silalahi
Simanindo
Ambarita
Parapat
Ajibata
Batugangga R.
Tomok
Namarsahan R.
Pangururan
Harian Boho
SAMOSIR ISLAND
Mogang
Nainggolan
Mandasi R.
Asahan R.
To the Strait of Malacca
Porsea
Simare R.
Halian R.
Manira R.
Muara
Bakara
Balige
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/2.62N/98.81E/061205


TONLE SAP SUB-BASIN
CAMBODIA
Approximate extent of seasonal flooding
Sisophon
Siem Reap
Battambang
Tonle Sap
Moung Roessei
Kampong Thom
Porsat
Kampong Chhnang
Mekong R.
Tonle Sap R.
Phnom Penh
0
100 km
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/12.79N/104.15E/190805
MEKONG RIVER BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
200 km
INDIA
CHINA
MYANMAR
VIETNAM
THAILAND
LAO PDR
CAMBODIA
N
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/20.09N/102.23E/190805


TUCURUI RESERVOIR BASIN
BRAZIL
Drainage Basin Boundary
State Boundary
River
Lake
Selected City
0
200 km
N
Tucurui
Tucurui Reservoir
Jacunda
MARANHAO
Imperatriz
Maraba
PARA
Arguaina
Filadelfia
Carolina
Conceicao do Araguaia
PIAUI
Lizarda
TOCANTINS
Sta Isabel do Morro
Natividade
MATO GROSSO
BAHIA
Parana
San Miguel do Araguaia
Porangatu
Posse
Nova Xavantino
Niquelandia
Rialma
Goias
Brasilia
Aragarcas
DISTRITO FEDERAL
MINAS GERAIS
Goiania
Alto Garcas
Alto Araguaia
GOIAS
MATO GROSSO DO SUL
ILEC/4.27S/49.57W/090805
Boundaries and locations are approximate and should not be considered authoritative.

LAKE VICTORIA BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0
100 km
UGANDA
KENYA
D.R. OF CONGO
RWANDA
BURUNDI
TANZANIA
Lake Albert
Lake Kyoga
Lake Bisina
Victoria Nile R.
Jinja
Kampala
Lake Wamala
Katonga R.
Murchison Bay
Lake George
Lake Edward
Masaka
Lake Kachira
Lake Nabugabo
Mbarara
SESE ISLANDS
Lake Kyanebalola
Kagera R.
Lake Victoria
Bukoba
Lake Mujunji
Lake Ikimba
Lake Kivu
Nyawarungu R.
Kigali
Lake Ihema
Lake Burigi
Akanyaru R.
Lake Cahoha Sud
Lake Rweru
Ruvuvu R.
Lake Tanganyika
UKEREWE IS.
Speke Gulf
Sengerema
Mwanza
Geita
N
Simiyu R.
Mbalageti R.
SERENGETI PLAIN
Gurumeti R.
Mara R.
Musoma
Kisii
Sondu R.
Nyando R.
Winam Gulf
Kisumu
Nzoia R.
Kakamega
Eldoret
Lake Baringo
Lake Bogoria
Lake Nakuru
Lake Naivasha
Lake Magadi
Lake Natron
Lake Eyasi
Lake Manyara
ILEC/1.11S/32.92E/190705
Boundaries and locations are approximate and should not be considered authoritative.


LAKE XINGKAI/KHANKA BASIN
Drainage Basin Boundary
International Boundary
River
Lake
Selected City
0 20 km
During floods, water from the Muling River enters the Hubei Sluice Gate and flows either to Xiaoxingkai or through wetlands to the Galatong R.
To the Amur R. and Tatar Strait
Hubei Sluice Gate
Muling R.
Yanggang
Qingshan Reservoir
Mishan
No. 1 Canal
Wetlands
Jinyinku R.
Xiaohei R.
Canal
Jixi
Jidong
Muling R.
Lake Xiaoxingkai
Galatong R.
Ussuri R.
Tury Rog
Hengshan
Lake Xingkai
Khanka Lake
Song'acha R.
Komissarovka R.
Bamiantong
Wetlands
Troitskoye
Alexandrovka
Kamen-Rybolov
Melgunovka R.
Wetlands
Muling
Spassk-Dalny
CHINA
Khorol
Chernigovka
Arsenievka R.
Ilistaya R.
Sibirtsevo
Yaroslavsky
Abramovka R.
RUSSIAN FEDERATION
N
Boundaries and locations are approximate and should not be considered authoritative.
ILEC/44.98N/132.44E/250805

Appendix F

Nairobi Statement, Nairobi Declaration, and Kampala Resolution

This Appendix presents the Conference Statement and the Water Ministerial Resolution issued at the conclusion of the 11th World Lake Conference held in Nairobi, Kenya from 31 October through 4 November 2005, and the Main Points of the Declaration issued during the 9th Meeting of the Ramsar Convention held in Kampala, Uganda from 8-15 November 2005. Collectively, they capture important messages and the way forward regarding the integrated management of lakes, wetlands and other impounded waters and their basins.

Nairobi Statement of the 11th World Lake Conference

4 November 2005, Nairobi, Kenya

As fossil footprints in ancient lake beds testify, the rich resource of lakes were a magnet for early humans tens of thousands of years ago here in Africa, and they have continued to be so through human history to our own day. The challenge now facing us is to preserve the world's lakes, complex life-supporting ecosystems containing more than 90 percent of the liquid freshwater on the earth's surface, so they can continue to provide physical and spiritual support for the generations that follow us.

To address this management challenge, we must recognize that the future of lakes depends on our understanding and appreciation of the wider connections:

- With the surrounding landscape and human activities on it,
- With the linking water system of rivers, groundwater, and wetlands,
- With the winds that carry nutrients and contaminants in from afar,
- With the rapid human changes to the Earth's atmosphere which are driving climatic instability.

We must also recognize the primary importance of the people who use lake resources and immediately experience damaging consequences. These lake dwellers, both men and women, carry the cultural memory of the community and the lake through time, and often have the best knowledge about the source of problems and viable solutions. This long-term perspective is essential because lakes have long memories when abused, and harbor many secrets in their complex dynamics. For these reasons:

- We must base management decisions first and foremost on local knowledge and insight, and
- We must use available resources to build institutional capacity and scientific understanding at the community level, and to enhance the power of local people to find solutions, thereby bridging the gap between scientists, decision-makers and society.

At the same time, local people on the front line must assume responsibility along with power, since local behavior is often the source of damage to lakes. They must recognize that a healthy lake comes at a cost, and that an unhealthy lake has its costs. In cases where user fees are the chosen tool to encourage wise behavior, it is vital that the community retain a good part of the proceeds to continue their efforts.

National institutions also are vital for fostering awareness, promoting participation, and bringing together diverse interests within lake basins. When capable and effective, they provide the arena for developing broad management efforts that consider the lake basin as a whole, and its broader connections with the linking water systems and atmospheric influences. They also provide a forum for addressing the often conflicting needs of those who inhabit lake basins and depend on lake resources. Without such an overarching framework and comprehensive perspective, there are few means for resolving conflicts over water or lake resources, or for integrating local efforts to maintain lake health into national programs and development plans. In setting these policies, national authorities must consider lake communities and ensure that the *widest* range of interests depending on lakes enjoy their benefits. In addition, national leaders act in the international arena, where they can illuminate problems—such as transboundary management, long distance air pollution and climate change—and press for solutions. The World Lake Vision, launched at the 3rd World Water Forum in Japan, and the lessons learned from the Lake Basin Management Initiative launched at this 11th World Lake Conference, highlight these issues and suggest ways to achieve successful lake basin management.

International assistance can provide a vital impetus for sustaining the health of lakes and their resources, but it is not the ultimate solution for managing the interaction between human activity and these living systems. Experience around the world shows that international funding from sources such as the GEF, can catalyze efforts to manage human activities in lake basins. But in the longer term, local and national governments must ensure the ongoing and stable funding needed to continue the task. Local governments will have to experiment with innovative approaches, such as fees for lake use, in order to achieve this goal. It is equally essential that communities retain and use some of the funds raised in this way to further their efforts on behalf of the lake, and those living and working in the lake basin. Above all, when addressing lake problems, international agencies must place primary importance on local needs when developing their action agendas and programs.

Over recent decades, we have been slowly learning how to manage the interactions between human activity and these living systems. This experience underscores the key role of lakes in integrated water resources management. These experiences, which scientists and managers have gathered and synthesized, provide important lessons for sustaining the health of both natural and manmade lakes that provide water for humans and nature. It is imperative to embrace these lessons and build on them if we are to meet our pressing water needs in the decades ahead.

The fact that water underpins virtually all the Millennium Development Goals provides persuasive evidence of the need for strategic partnerships, including the private sector. These can encourage equitable access to lakes and their resources, in order to alleviate poverty, provide secure food supplies and economic development, improving the lives and livelihoods of those depend on lakes and their resources.

Nairobi Resolution of the Water Ministerial Dialogue at the 11th World Lake Conference

4 November 2005, Nairobi, Kenya

This Nairobi Resolution was endorsed by a high-level African Water Ministerial Dialogue on *"Management of Lake Basins for their Sustainable Use: Global Experience and African Issues"* held during the 11th World Lakes Conference in Nairobi between October 31-November 4, 2005. According to the UNEP Executive Director, Klaus Topfer, "This biennial World Lake Conference, held for the first time in Africa, represents a significant step in the efforts of the international community to put our planet on a sustainable development path. It reinforces the commitments of the 170 Heads of States and Government at the 2000 Millennium Summit, renewed by the World Leaders at the 2005 World Summit in New York in September. They have recognized the need for high-level attention and significantly increased resources to achieve the water related Millennium Development Goals (MDGs) and the 2005 Integrated Water Resources Management (IWRM) targets, in clear recognition that water underpins all other MDGs."

The Ministerial Dialogue underscored the principles of the World Lake Vision launched at the Third World Water Forum in Kyoto in 2003, the recommendations of the Report of the Lake Basin Management Initiative (LBMI) entitled, "Managing Lakes and their Basins for Sustainable Use: A Report for Lake Basin Managers and Stakeholders" launched at the 11th World Lake Conference and the proceedings of the 11th World Lake Conference as important contributions for enhancing equitable access to water resources for ensuring food security, addressing poverty and promoting economic development in Africa.

The Ministerial Dialogue recognizes:

- That lakes, both natural and manmade, are essential elements of the overall water resources system.
- That lakes and lake basins provide many uses for sustainable livelihoods and economic development, and are important natural habitats for global biodiversity, as well as serve religious and cultural values.
- That transboundary lakes provide opportunities for regional integration and cooperation.
- That lakes and their basins are fragile and complex ecosystems under serious stress.
- That lake basins have some unique characteristics often with peculiar management needs.
- The important role of science in informing public policy and management decision making.
- The essential role of planning and sustained financial support for effective lake basin management.

The Ministerial Dialogue reinforces:

- That lake basin management is critical for sustainable development and responsible economic growth.
- The central role lakes and reservoirs play in integrated water resources management.
- The importance of both investments and good governance for sustainable lake basin management and development.
- The need for developing sustainable institutions—from community based to local/National level to Transboundary level management structures.
- The need for sound policies for promoting sustainable lake basin management.

- The essential role of all stakeholders, including the private sector, in the planning and management decision making of lake basins.
- The need for mainstreaming gender in integrated water resources management.
- The cooperative management of transboundary lake basins.
- The use of both scientific and local knowledge to support management decision making.
- The need for good planning and mobilization of sustainable financing for lake basin management.

The Ministerial Resolution calls for making integrated management of lake basins a long-term element of:

- Government and public priorities.
- Planning and financing processes.
- Integrated water resources management.
- Habitat and biodiversity conservation programs.
- Economic development programs.

The Ministerial Resolution recommended:

- The strengthening of local capacities for managing lake basins in a sustainable manner.
- The establishment of a center for excellence in Africa for promoting a new generation of water and environmental planners and managers with skills in lake sciences, limnology and aquatic and environmental sciences.
- That the UN consider establishing an International Year for Lakes.
- The mobilization of funds for supporting IWRM to meet the MDGs.

Main Points of the Kampala Declaration of the 9th Meeting of the Conference of the Parties to the Convention on Wetlands (Ramsar Convention)

12 November 2005, Kampala, Uganda

The Ministers and high level representatives present at the informal ministerial dialogue...

...STRONGLY FEEL it is becoming critical thus to redress this situation of continuing loss and degradation of wetland ecosystems globally and the impacts of these losses on people and livelihoods, and:

1. UNDERTAKE to enhance conservation, develop communication and increase capacity in Contracting Parties to the Convention, as well as in nations not yet Contracting Parties in order to achieve a full balance between people and wetlands;

2. EMPHASISE that the role of wetlands in supporting people's livelihoods is best achieved through the active participation and involvement of local communities, although governments and the international community have a key role in influencing the wise use and conservation of wetland resources and CALL upon the private sector and civil society to collaborate and play and an active role in mobilizing funding for wetlands, to promote and sustain the wise use concept;

3. UNDERTAKE to implement concrete actions to address the commitment in the Johannesburg Plan of Implementation which urges countries to reduce biodiversity loss by 2010 and FURTHER UNDERTAKE to strengthen the list of Wetlands of International Importance as a contribution to the global network of protected areas initiated at the World Summit for Sustainable Development;

4. EMPHASISE that wetlands, with surrounding ecosystems, are essential in mitigating against natural disasters (such as hurricanes, typhoons and tsunamis) and adapting to global climate change including the negative impacts of desertification;

5. ENCOURAGE the rehabilitation and restoration of wetlands, especially in coastal systems and lake shores, in order to enhance and sustain benefits for people;

6. CALL for appropriate valuation of wetland resources, adding value to wetland products and services, and for smart marketing of wetland products by the involvement of private sector or through Public/Private Partnerships in order to promote wetland wise use and conservation; We emphasize the need for innovative economic incentives;

7. AFFIRM that there is a need for synergistic relationships between the Convention on wetlands and other relevant conventions in the field of sustainable development to obtain the best ecological outcomes for wetlands. For this we ADVOCATE harmonizing and de-sectoralising the development and implementation of policies at all levels, international, regional, national to local, and integrating water and biodiversity policies including in integrated water resource management (IWRM). We also CALL for cross agency and cross donor cooperation;

8. ADVOCATE and URGE development and implementation of transboundary and cross national systems and approaches to the management of wetland ecosystems is necessary;

9. REAFFIRM that the international support given by the World Summit of Sustainable Development (WSSD) for the implementation of the NEPAD Environment Action Plan

is essential and we URGE the Ramsar Secretariat and its IOPs to liaise with development partners, and multilateral organizations and facilities (GEF, Regional Development Banks, EU, etc.) to identify sustainable funding mechanisms for the implementation of the Convention in Africa. We recognize the Arusha Call of April 2005 as a valuable cornerstone for the coordinated work on wetlands in Africa and EMPHASISE the need for stronger coordination of environment, water and wetlands related initiatives;

10. EXPRESS our concern about the incidences of the highly pathogenic avian influenza (HPAI) and the risks to people, migratory birds and poultry farming, and highlight the necessity of developing good monitoring systems. We also EMPHASISE the need for further research and exchange of information and knowledge on HPAI in relation to wetlands within and between member states.