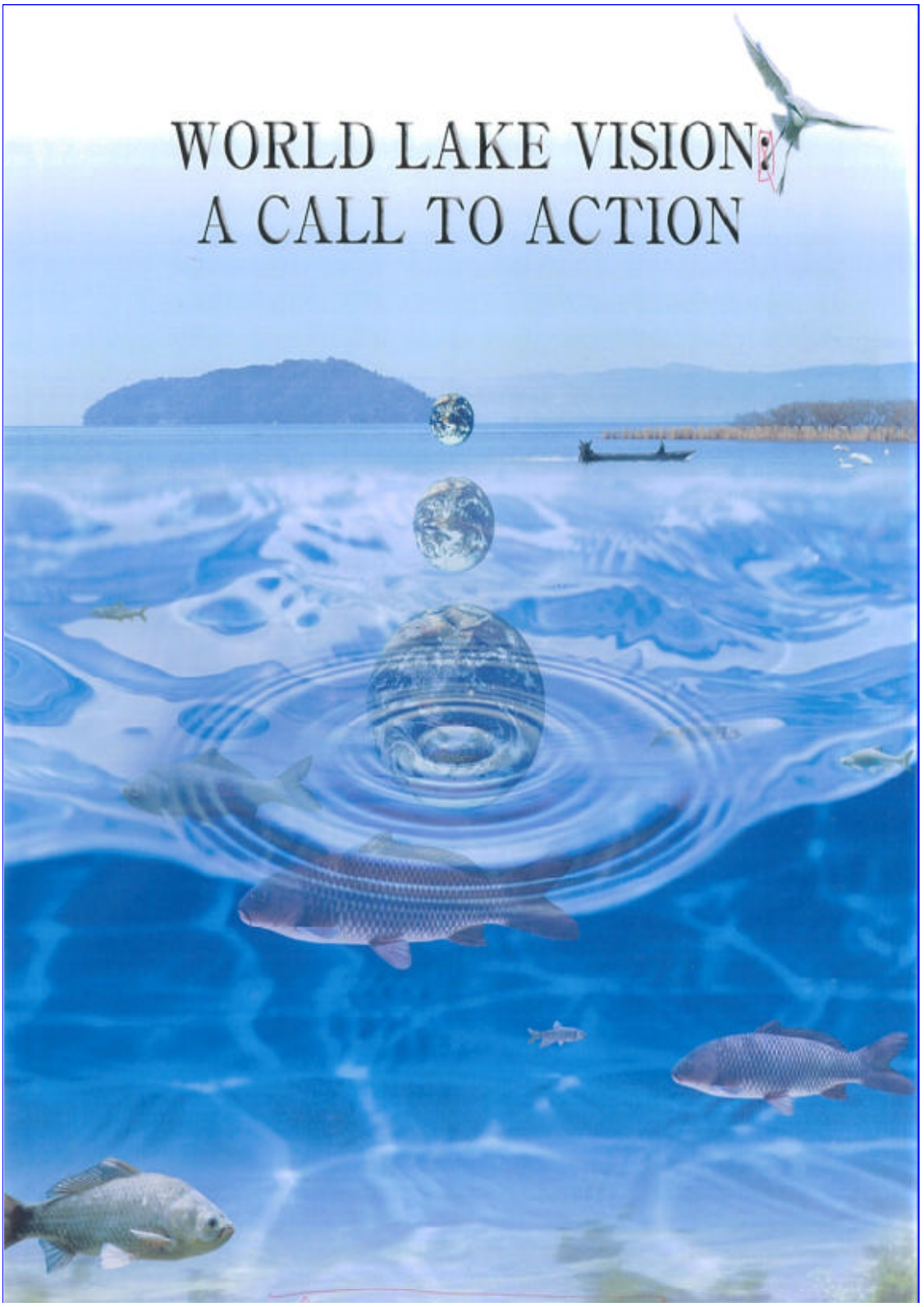
# WORLD LAKE VISION:
# A CALL TO ACTION



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# *WORLD LAKE VISION:*

# *A CALL TO ACTION*

*World Lake Vision Committee*

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*"Logo"* *Lake Environment Committee Foundation, Shiga Prefectural Government and United Nations Environment Committee*

# Acknowledgements

This document is the result of collaborative effort by many organizations and individuals, prepared by the World Lake Vision Committee, and is available on the world wide web at http://www.ilec.or.jp/wwf/eng.

The preparation and production of this report was financially supported and promoted by the International Lake Committee Foundation (ILEC), Shiga Prefectural Government, and United Nations Environment Programme–International Environmental Technology Centre (UNEP-IETC).

Many organizations and individuals contributed to the project by supporting the participation of their member(s) at the meetings and workshops in the development of the ***World Lake Vision***, and by reviewing and/or providing comments (Annexes 3 and 4).

The many other organizations and individuals that have supported the formulation of the ***World Lake Vision***, and those that will support and implement the ***World Lake Vision*** in the future, and who are not listed, are also acknowledged with gratitude.

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First Edition 2003

ISBN 4-9901546-0-6

# *Preface*

## *World Lake Vision: A Call to Action*

*The World Lake Vision is the result of a candid look at what is happening today to lakes around the world, whether natural or artificial, freshwater or saline, and what is likely to happen to them if present trends continue into the future. It recognizes the critical state of many of these fragile, vulnerable, and often strikingly beautiful ecosystems. It seeks to convince people of the need to insure healthy lakes as a primary source and storehouse of the world's easily-accessible water resources, and as sources of food and economic livelihoods, utilizing them in a manner that maximizes their sustainable use for humans and nature, while also preserving their quality and ecosystem integrity for current and future generations.*

*To this end, the World Lake Vision invites everyone with an interest in lakes and reservoirs to support and promote this vision for the future ……..…..*

*……a future in which humanity manages and uses lakes and their resources with the guiding view of preserving and improving them, rather than presiding over their continuing degradation…*

*……a future in which the understanding of lakes includes recognition of their inseparable connections to the drainage basins that surround and nourish them, and to the people whose activities control their health and vitality…*

*……a future in which the importance of water from clean lakes is recognized as a life and death issue for the poorest communities…*

*……a future in which research on lakes is initiated and pursued in a coordinated manner that increases human knowledge of their properties and functions, and benefits effective policy formation and management practices identified as important to the health and sustainable use of lake basin ecosystems...*

*……a future which acknowledges their aesthetic, therapeutic, and even spiritual qualities which, together, form a sparkling and intricate aquatic mosaic across our global landscape.*

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# *1. The World Lake Vision: An Introduction*

*Humans and lakes are interdependent; their sustainability is enhanced by establishing and maintaining relationships that link humanity, aquatic ecosystems and the landscape in an harmonious manner that complements the attributes and addresses the needs of all……*

The need for adequate freshwater supplies for human survival is obvious. Freshwater also has a fundamental role in fueling economic development. Regions with limited water supplies typically exhibit low levels of economic activity. Some basic level of economic development, therefore, appears to be a prerequisite for people to exhibit concern for the state and sustainability of the environment in which they live. Thus, the sustainable use of water resources should contribute directly to sustainable economic development, and to maintaining the health of the environment that supports this development. What is essential, therefore, is to seek a balance between the water needs of people on the one hand, and the maintenance of the terrestrial and aquatic ecosystems that provide economically-important and even life-supporting ecosystem services to humanity on the other hand. This fundamental notion lies at the very core of sustainable development.

Based on this tenet, this document introduces and describes the *World Lake Vision*, which highlights the values, uses and protection of lakes and their resources in human society. It also discusses the environmental and socioeconomic consequences of not using them in a sustainable manner, consistent with the concept of sustainable development.

## Lakes as essential components of global water resources

Seen from space the earth appears as a largely blue planet, suggesting the presence of vast quantities of water. Although this is true, only about two percent of all the earth's water is freshwater, with the majority of even this small fraction being locked up in the form of icebergs and glaciers, or located far underground beyond easy reach. As a relative perspective, if all the water on earth could be put into a four-liter bottle, the readily-available quantity for human use would be about one tablespoon (15 milliliters), or less than one-half of one percent of the total. Nevertheless, even this small amount is deemed sufficient to meet all the present and foreseeable human water needs if it were evenly distributed around the world and protected from degradation, neither of which unfortunately is the case.

Lakes have a fundamental role in nature's continuing cycle of evaporation, precipitation and flow of water on and below the land surface on its journey back to the sea. They form parts of larger aquatic systems that may include rivers, wetlands, and groundwater. However, if one could take a snapshot of all the liquid freshwater on the earth's surface at a given instant, it is estimated that more than 90% of it would be in natural and artificial lakes. Water enters lakes primarily from precipitation and runoff from the surface and/or seepage of groundwater into the lake basin.

*Although the blue color of Earth suggests the availability of large quantities of water, nearly all of it is in the oceans, unsuitable for most human needs.*

From a landscape perspective, a lake consists of two distinct yet interrelated parts, the drainage basin and the water body itself. Both must be taken into account, since the latter cannot exist without the former. About 20 of the world's lakes are considered extremely deep (more than 400 meters in depth), containing a significant portion of our planet's freshwater. For example, Lake Baikal in the Russian Federation contains about 16%, and the Laurentian Great Lakes of North America (Huron, Ontario, Michigan, Erie, Superior) contain about 20%, of all the liquid freshwater on the earth's surface. Lakes Victoria and Malawi in Africa are, respectively, the second and ninth largest lakes in terms of area, with Lake Victoria also being the largest tropical lake in the world. Africa also contains Lake Tanganyika, the second deepest and longest lake in the world. The vast majority of our readily-accessible water resources, however, are contained in numerous lakes of much smaller size and volume, usually less than 20 meters deep. These lakes are typically the most accessible to the greatest number of people, and are especially important to local lakeshore communities that depend on them for their water supplies, food and other resources for their livelihoods. The fundamental concerns in regard to their quality and sustainable use are the same, however, regardless of their area or volume.

Humans throughout history also have constructed artificial lakes, also called reservoirs, impoundments, dams or tanks in different regions of the world, primarily for addressing problems of water scarcity, or alternatively for providing flood protection. In modern times, they also are used for such purposes as hydropower generation, sports and commercial fisheries and water-based recreation. Nearly all the world's major river systems have reservoirs in their drainage basins, and an estimated 800,000 reservoirs are now in operation worldwide. Approximately 1,700 more large reservoirs are currently under construction, particularly in developing countries.

*Humans have constructed reservoirs around the world to meet beneficial water needs.*

Natural lakes and reservoirs have many similarities in common. They also have some significant differences in such variables as their currents and flows, their potential life spans, and their water flushing rates. These similarities and differences must be considered in designing accurate, meaningful monitoring programs for assessing the water quality status of lakes and reservoirs, as well as the implications for the organisms living in them. For the purposes of this document, however, the term "lake" is meant to denote both natural lakes and reservoirs, unless otherwise indicated. Because many of the guiding principles are equally applicable to natural lakes and reservoirs, the ***World Lake Vision*** considers both in the same manner in regard to managing them for their sustainable use.

## The uniqueness, values and uses of lakes

Lakes are among the most dramatic and pleasing features of the planetary landscape, and the most variable of inland water systems. Whereas rivers represent flowing water systems, lakes are primarily water storage bodies. Their sizes, shapes and depths vary considerably, based on their specific mode of origin. They are dynamic aquatic ecosystems, being at the same time storehouses for large quantities of water, sources of food and recreational pleasure for humans. Lakes are home to an amazing range of biodiversity, in some cases containing organisms found nowhere else on Earth. For many indigenous lakeshore communities, lakes also provide the very foundation of people's livelihoods.

Lakes also are significant repositories of natural and human history, with ancient local political centers often arising on or near lake shores. Specific lifestyles based entirely on lakes and their resources have developed in some locations, an example being the indigenous cultures in the Lake Titicaca drainage basin in Bolivia and Peru. Lakes also have fundamental religious and spiritual significance for many cultures. The Huichol in Mexico, for example, consider Lake Chapala a sacred site. Manasarowar Lake in Tibet, China, is another example of a sacred lake, where pilgrims gather from Tibet and neighboring areas. On Chikubu Island in Lake Biwa, the goddess of water "Benzaiten" is enshrined and worshiped.

*Lake fisheries provide the livelihood for many indigenous communities.*

| *Economic Value of Some Lake Fisheries* | |
|---|---|
| ?? | *More than 60% of the fish consumed in Tanzania come from inland fisheries, and about 60% of the protein intake in Malawi is freshwater fish.* |
| ?? | *The creation of Lake Kariba produced a viable regional fishery in an area in which freshwater fish were previously absent from the diet of Zimbabweans.* |
| ?? | *The above-noted fisheries in the Zambezi/Luapula and other drainage basins provide employment for nearly 100,000 indigenous fishermen and fish traders.* |
| ?? | *Lake Victoria generates an annual GDP of US$ 3-4 billion, providing more than 25,000 people with an average annual income of US$ 90-270 per capita.* |
| ?? | *In contrast, the eutrophication of Lake Chivero threatens the health and livelihoods of nearly three million inhabitants in the greater Harare/Norton urban areas, and caused the virtual collapse of a once-thriving fishery.* |

The large quantities of water stored in lakes are especially useful for meeting human and ecosystem water requirements when natural climatic conditions would not otherwise supply the water when it was most needed. On the other hand, the ability of lakes to store water also helps protect the lives and property of downstream communities during flood events. At the same time, it may significantly raise lake water levels, thereby affecting people living along the shoreline. Because water also can absorb a large quantity of heat, lakes with large water volumes also can moderate the local climate by reducing the range of atmospheric temperature fluctuations in the atmosphere.

*The goddess of water is enshrined on Chikubu Island in Lake Biwa, Japan.*

Lakes also are among the most vulnerable and fragile aquatic ecosystems. They are sinks for inflowing substances, including sediments, minerals, aquatic plant nutrients and organic materials from their drainage basin. Such materials tend to accumulate in the water column or on the lake bottom. In sparsely-populated drainage basins, this typically leads to a relatively slow aging process. In densely-populated or industrialized drainage basins, however, human activities can significantly accelerate this natural aging process, and degrade the water quality and the lake bottom environment. Because of this property, lakes serve as sensitive indicators and unique records of the effects of human and natural activities inside their drainage basins and also sometimes from activities occurring outside their basins.

Regardless of their size, lakes are primary repositories of rich aquatic biodiversity, with many having a range of native and endemic species. Their biodiversity, however, is very sensitive to hydrological disturbance, water quality degradation, and the introduction of non-native species without sufficient scientific knowledge of their impacts. Lakes can suffer significant loss of their endemic and native species when, in the absence of their natural predators or other control mechanisms, invasive species proliferate and replace them.

There are many lakes around the world with relatively saline or salty waters, caused by the weathering of minerals from the bedrock of their drainage basins and typically exist in closed drainage basins. Others have become saline because of excessive diversions or withdrawals of water. In spite of their varying salinities, these lakes have many of the same uses as typical freshwater lakes, particularly in arid and semi-arid regions. Saline lakes in the prairie and plains regions of North America and East Africa, for example, support 50-80% of the production of the continent's waterfowl population. They are not readily used, however, for domestic or irrigation water supplies.

Not to be forgotten is the intrinsic beauty of lakes, many of which exhibit breath-taking aesthetic features. Lakes evoke a pleasing range of emotional, spiritual and intellectual responses in humans. Lakes have been described as "pearls on a river string," and "islands of water in an ocean of land." Although they are extremely important features, the aesthetic values of lakes are the most difficult to quantify, compared to their other uses.

*Lakes represent some of the most breathtaking features of the global landscape.*

## Saving our lakes: The *World Lake Vision* as an important investment in our global water future

Adequate supplies of water are essential for human survival and socioeconomic development, as well as for maintaining economically-important and life-supporting aquatic ecosystems. Accordingly, this document focuses on the sustainable use of lakes as a vital component of our available water resources. Because they are readily-accessible sources of large quantities of water, the value of lakes in meeting our water needs is enormous. An unfortunate consequence of this need, however, is that many lakes are now facing increasing threats from human activities to both their water quantity and quality and to the viability of their biological communities, including important fisheries. Human neglect or indifference is exacerbating these problems in other cases.

The need to protect water resources has been the subject of a number of high-level global and regional conferences and discussions in recent decades. This topic was recognized, for example, at the 1992 International Conference on Water and the Environment ("Dublin Conference"), resulting in the development of the Dublin Principles. It also was highlighted in Chapter 18 of Agenda 21, developed at the 1992 United Nations Conference on Environment and Sustainable Development ("Earth Summit") held in Rio de Janeiro. In 1999, the World Water Council developed a document, the "World Water Vision," as a contribution to the global dialogue on ways to provide fundamental

guidance regarding the sustainable use of these resources to freshwater stakeholders. Among its components is a call for application of the concept of integrated water resource management, first articulated in Dublin. The World Summit on Sustainable Development, held in Johannesburg in 2002, more recently identified water as one of the global priorities for the 21st Century.

| ***Dublin Principles*** |
|---|
| ?? *Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment;* |
| ?? *Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels;* |
| ?? *Women play a central role in the provision, management, and safeguarding of water;* |
| ?? *Water has an economic value in all its competing uses, and should be recognized as an essential good.* |

The ***World Lake Vision*** was developed to insure that humanity recognizes that lakes are not merely convenient sources of water and food, or interesting recreational outlets, but also water systems of profound biological complexity and intrinsic beauty, as well as cradles of cultures, history and social development. The ***World Lake Vision*** is a significant call to action regarding the sustainable use of lakes and their significant values, focusing on their uniqueness, their range of uses, and their fundamental importance to the human condition and the natural order now and in the future. It complements the "*World Water Vision*" in embracing the notion of integrated water resources management as a primary guiding principle for the sustainable use of lakes.

## The beneficiaries of the *World Lake Vision*

The ***World Lake Vision*** also emphasizes the need for an integrated approach or framework for comprehensively identifying and addressing freshwater issues. Although there are some examples of positive lake management efforts based on such an approach that have been undertaken in different parts of the world, the reality is that well-conceived and environmentally-sustainable management plans do not exist for most lakes. Data and information on the conditions of the world's lakes have been increasing over the past several decades. Nevertheless, a comprehensive vision of the future of the world's lakes in general, and the development of specific visions for individual lakes, is still lacking. Complicating the problem is that the causes of lake problems may be of local, national, international or even global origin. Another complication is that the sustainable use of transboundary or international lakes must effectively integrate the national interests of the riparian countries that share them.

The ***World Lake Vision*** provides guiding principles, as well as a toolbox or menu of strategies and opportunities, as fundamental components of an integrative framework for identifying significant lake problems and developing practical solutions. In providing such opportunities and motivation, it considers the implications of lake problems and their solutions in a manner (1) that is readily understood by the public, decision-makers

and scientists alike; (2) that can be implemented across a wide range of social and economic conditions; and (3) that will facilitate the sustainable use of these critical freshwater ecosystems in meeting human water needs for socioeconomic development, while at the same time addressing the water needs of nature, and the future of both.

*Lakes are a source of interest and inspiration for people of all ages.*

The management and conservation of lakes for their sustainable use is a dynamic process. Narrowly-focused or static approaches that only highlight the elimination of specific threats to water systems, such as control of floods and pollution, are not sufficient when trying to develop a comprehensive vision for an individual lake. A visionary assessment of policy, planning, financing, technology and education to provide fundamental guidance on managing and conserving the world's lakes, therefore, requires that the scope of this ***World Lake Vision*** not be unduly limited. Rather, it must develop and evolve on the basis of the participation of the widest range of stakeholders. Recent opportunities and new knowledge directed to enhancing ecosystem capacity are emerging as novel, integrative approaches for managing water resources for their sustainable use (e.g., ecological engineering, ecohydrology, phytotechnology). The ***World Lake Vision*** is intended, therefore, to be a living document, to be reviewed and periodically adjusted on the basis of changing conditions, improved knowledge, strategies and technological advances, as well as the lessons learned from lake management experiences throughout the world.

There is a large and ready audience for the ***World Lake Vision,*** including individuals, environmentalists, governments, non-governmental organizations, the private sector, advocacy groups, the media, and scientific and educational institutions, among others. Notwithstanding, the ***World Lake Vision*** is first and foremost aimed to the citizens that inhabit lake drainage basins and use lake resources, because they typically constitute the primary users for individual lakes and in some cases, the primary cause of lake problems. They usually are the first to experience the impacts of degraded water quality. They also can be the first ones to initiate changes and programs to solve such problems.

The lack of a comprehensive vision for guiding human efforts regarding their sustainable use and conservation may lead to fragmented or insufficient lake management actions.

Of equal concern is that this trend will ultimately hinder achievement of desired socioeconomic development. Without a holistic, integrated approach to lake management that focuses on their sustainable use, scores of lakes around the world can be expected to be less and less able to perform their ecosystem functions and provide life-supporting services, thereby also threatening the human communities that depend on them. The development of the ***World Lake Vision*** to address these needs, therefore, is both fundamental and essential.

# *2. Barriers and Threats Facing the Sustainable Use of Lakes*

*"A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature"*
*…….Henry David Thoreau*

Many lakes are beset by a myriad of problems affecting their sustainable use. Further, a lake and its drainage basin are fundamentally linked, and interactions between humans and their water and land resources are critical factors influencing a lake's health and its potential long-term uses. Just as the impacts of unsustainable lake uses are felt within the waterbody, along its shoreline or in other parts of its drainage basin, the causes of the problems may lie along their shorelines, elsewhere in their drainage basins, and even outside their drainage basins (Fig. 1). The use of water and land resources within a drainage basin, therefore, determines the types and magnitude of its environmental stresses. Further, because many of the world's lakes are being impacted simultaneously by multiple problems, their remediation often is more difficult and more costly than addressing one problem alone. Lake problems do not necessarily affect only the people living along its shorelines, but also can have significant economic, health and/or environmental impacts on inhabitants further afield, both within and outside their drainage basins.

## Socioeconomic factors contributing to the unsustainable lake use

Major environmental or water use problems generally accompany substantial human settlement of a lake's drainage basin, resulting in the need for large quantities of water for drinking and economic development. In most developing countries, lakeshore communities are heavily or completely dependent upon lakes for their livelihoods through such activities as open-water fishing and intensive aquaculture, one example being the Seven Crater Lakes of San Pablo City in the Philippines. Many of the problems facing lakes are deeply rooted in socioeconomic issues, and a major causative factor for the variety of problems facing lakes, in fact, is their multiple roles within human society. Factors contributing to decreased or degraded lake uses range from insufficient scientific knowledge and understanding, to technical shortcomings, to inadequate intellectual, financial and/or technological resources, and to inappropriate development and governance. There is no disagreement, however, that the excessive stresses placed on lakes to meet human water needs are a major factor. Such stresses, as well as the issues

identified below, have the potential to fundamentally affect the livelihoods of people that depend directly on lakes for their food and basic economic well-being, particularly the indigenous peoples and lakeshore communities.

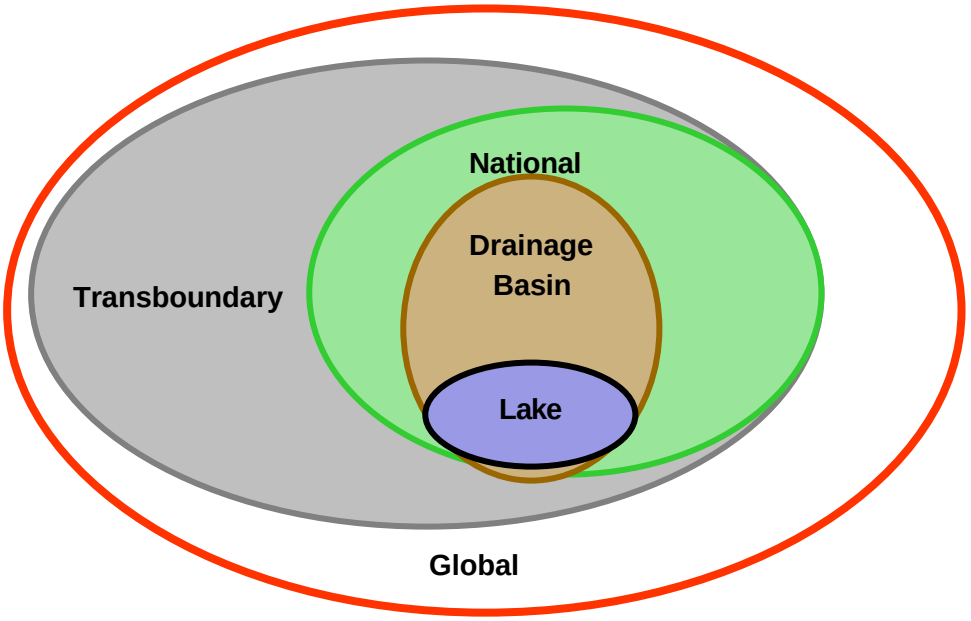


*Figure 1. Diagrammatic representation of the interconnectedness of the origin and nature of threats facing lakes.*

***Increased demands for developing and using lake resources***

The world's population is predicted to grow from six billion today to about nine billion by the year 2050, putting increasing pressure on local authorities and planners to supply water to satisfy growing agricultural and urban water and sanitation demands. Untreated or inadequately treated sewage already is a major water pollution issue in virtually all developing countries, particularly those undergoing explosive urbanization. Industrial water demands also will continue to grow with increasing economic development pressures. It is predicted that approximately two of every three persons will live under conditions of water-stress by the year 2025 if present water use trends continue. Since most of the water taken from lakes and rivers is eventually returned directly or indirectly to these sources, it is necessary that increased lake water withdrawal and usage be accompanied by the development of basic sanitation and wastewater treatment. Excessive water withdrawals from a lake also can cause significant water-level fluctuations directly affecting lake ecosystems and, in some cases, the very existence of a lake itself.

Growing human populations will tend to increase agricultural water demands. It is predicted that global food production in the next 30 years must double to keep pace with population needs. The need for increased food supplies is causing farmers in many

locations to increasingly cultivate marginal lands, resulting in greater use of fertilizers and other agricultural chemicals, and increasing the potential for lake eutrophication and the accumulation of pesticides, with the accompanying human and ecological problems.

In some regions of the world, population-related stresses on the availability of freshwater resources may occur against a background of intensifying adverse impacts of climate change on regional hydrology. This phenomenon could have profound impacts on water inflows and lake levels, especially in inland drainage basins. For lakes that normally receive significant quantities of water from snow melt, reduced snowfield areas associated with climate change also can lead to lower hydrological inputs.

***Limited public awareness and understanding of human impacts on lakes***

Limited public awareness of the human impacts on lakes contributes to the degradation of the values and uses of lakes. Inadequate public awareness may result from insufficient knowledge, data and/or understanding on the part of citizens, local authorities, decision-makers, the media, industry and others of their roles, either individually or collectively, in causing lake problems or in helping to solve them. Lake scientists and experts can do more to conduct applied lake research and inform the public and policymakers about their results. Further, in some cases, governmental agencies and/or decision-makers may believe that the only appropriate role for the public in such matters is to provide the required funds for the programs and activities to address lake problems, in contrast to the proactive approach of working with the public to identify and resolve current problems and/or avoid similar problems in the future. On the other hand, citizens may think they need to rely exclusively on governmental agencies and/or decision-makers for solutions to such problems. Experience around the world, however, suggests that, where it is feasible, the involvement of the public can be beneficial in identifying lake problems and in developing sustainable and publicly-supportable solutions to them.

A major contributor to the lack of understanding and awareness by the public and decision-makers regarding lake degradation is the subtle nature of many types of lake problems. Such problems can manifest themselves very slowly, often over generations. They may only become evident after the degradation has become very severe, and even potentially irreversible. This subtle nature of lake environmental degradation makes it harder to create awareness of lake problems among the public and decision-makers, and to initiate needed remediation or restoration activities in a timely manner.

***Insufficient governance and accountability systems***

Assuming that an institutional framework for lake management already exists, the lack of proper accountability on the part of citizens and governments is one of the most significant root causes of unsustainable lake use. Poor public consultation, inadequate stakeholder participation, and a lack of appropriate and effective governmental institutions and regulatory mechanisms are major hindrances to sustainable lake use. The lack of clear policy frameworks that recognize lakes as important aquatic resources, and that specifically address lake management issues, is another threat to sustainable lake use.

Further, many countries around the world suffer from inadequate legal expertise in the fields of environmental law and management, resulting in inconsistent enforcement of environmental regulations. Many also lack sufficient primary and secondary level teachers with the necessary education and training regarding important environmental issues and their relevance to human conditions and well-being and, hence fail to convey the urgency of the need for awareness and participation by youth and communities in lake management efforts.

Available avenues for seeking governmental and stakeholder accountability often are limited by fragmented governmental jurisdictions and competing or overlapping responsibilities. As a result, public policies and practices often appear to be insensitive to lake use issues, especially at the local level. A lack of transparency in the decision-making process is surprisingly common. Further, in emerging democracies, there often is an asynchrony between the process of developing good governance and the urgency of implementing accountable environmental stewardship. This situation can be exacerbated by not recognizing the linkages between the concerns of environmental managers on the one hand, and water managers on the other hand.

Effective training for local and national governmental and non-governmental staff, particularly for building coalitions, managing projects, and increasing monitoring and evaluation skills, also is lacking in many countries. Further, although many countries may have central environmental authorities, effective institutions for initiating and overseeing the development and implementation of comprehensive, long-term plans for the sustainable use of lakes and their drainage basins often are lacking.

Factors such as these strongly constrain the development and implementation of environmentally-compatible and cost-effective management plans for the sustainable use of lakes and their resources.

***Inadequate mechanisms for managing international lake systems***

Many lakes in the world are shared by two or more countries. Although some riparian countries have discussed the management of international river systems, far fewer people are aware of the implications of lakes as international water systems. Some involve upstream-downstream relationships and issues between countries sharing a lake, while others involve lakes that serve as international boundaries between countries. This lack of international lake awareness can be manifested in the unsustainable use of water from a shared lake by one or more of the countries in its drainage basin, as well as in changes in water quantity and quality, wetland ecosystems, aquatic plants and animals communities, etc.

Cooperation and collaboration between countries sharing an international lake would obviously facilitate the identification and implementation of solutions to lake problems. After nearly 30 years of development, for example, the United Nations General Assembly in 1997 adopted the "United Nations Convention on the Law of the Non-navigational Uses of International Watercourses." Unfortunately, there is no similar intergovernmental

consensus regarding a code of conduct for managing international lakes as shared water resources. The 1909 Boundary Waters Treaty between the United States and Canada, and the subsequent formation of the International Joint Commission to address transboundary water issues is a useful model of international cooperation. It has served the two countries well over many decades, including facilitating the sustainable use of the North American Great Lakes. The Binational Authority for Lake Titicaca in the South American Andes Mountains is another example of the benefits of international cooperation in lake management. Such models are rare, however, and require diligence efforts from the countries entering into them.

In regard to lake management issues in general, whether on an international or national scale, it is further noted that we have not yet developed a clear picture on what has worked, what has not, and under what conditions. The lack of such information, data and experience limits our insight and capabilities about what can be done in the future to improve drainage basin-scale lake management programs. A systematic evaluation of the effectiveness of previous lake management efforts throughout the world, particularly those directed to sustainable lake use, is urgently needed to provide such information and guidance.

## Threats arising from within lake drainage basins

### *Excessive water withdrawals or diversions*

Withdrawing or diverting excessive quantities of water from lakes can reduce their water levels and volumes to the extent that their water quality, and the biological communities they support, is seriously threatened and shoreline characteristics altered. A dramatic example is the demise of the Aral Sea, a large lake in a closed drainage basin in southcentral Asia. Because of the significant diversion of the lake's inflowing tributaries for irrigation purposes during the last half century, the Aral Sea has shrunk significantly in surface area and volume, experienced a major increase in salinity, and undergone fundamental changes to its biological communities. Water withdrawals for the purpose of land reclamation also can have profound impacts. The reclamation of paddy fields from lakes in the Hubei Province of China, for example, reduced the number of lakes with surface areas over 0.5 $km^2$ from 1,066 in the 1950s to 309 in 1981. The reclamation of land from lakes for building houses in Wuhan City, China, is significantly impacting existing lakes as well.

In addition, hydraulic structures used for water withdrawals or diversions can change the flow patterns in lakes. They also can change the relationship between the upstream and downstream communities and water use possibilities. Actions in an upstream lake drainage basin, for example, can significantly affect downstream drainage basins in regard to flood risks, water supply, ecosystems services, etc. In contrast, water withdrawals in a downstream drainage basin may limit or otherwise impact the potential water uses in an upstream drainage basin.

| *Water Withdrawals and Diversions: The Dead Sea (Israel, Jordan, Palestine)* |
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| *Lying in the heart of the Syrian-African rift valley at the southern outlet of the Jordan River, the Dead Sea, 417 meters below sea level, is the world's saltiest large waterbody. It is severely threatened by excessive water withdrawals from Jordan River in the north, and dams and industrial development in the south, as a result of ever-increasing industry, agriculture and tourism. The annual flow of the Jordan River was approximately 1,370 million $m^3$ in the 1950s, while today the total river discharge to the Dead Sea is about 300 million $m^3$ per year. As a result, about one-third of the world's saltiest lake has already been drained, with its level dropping by about one meter each year. Although Jordan, Israel and Palestine have numerous development plans for the Dead Sea, there currently is no master plan for these development efforts.* |

### *Water quality concerns*

A variety of pollutants can degrade lake water quality, including the following:

***Excessive nutrient loads*** (primarily phosphorus and nitrogen) can cause accelerated eutrophication, the accelerated growth of algae and aquatic plants to nuisance levels (e.g., algal blooms and floating weeds), with accompanying degradation of water quality and significant imbalances to lake ecosystems and their biological communities. Excessive nutrient inputs can stimulate the growth of toxic blue-green algal species detrimental to both livestock and human health. They also can interfere with beneficial human water uses, such as causing taste and odor problems in drinking water, and providing precursors of trihalomethanes, chemical compounds which have been identified as carcinogenic.

*Algal scum, symptomatic of advanced lake eutrophication*

| *Impacts of Lake Sedimentation in Lake Baringo (Kenya)* |
|---|
| *Until the mid-1979s, Lake Baringo was very rich in biodiversity. Growing human and livestock populations, drainage basin destruction, indiscriminate cutting of* |

*forests and charcoal burning, and poaching have since reduced this richness. For example, although there were seven rivers continuously flowing into the lake in the mid-1970s, only one river now flows into the lake during all seasons. It is estimated that five million cubic meters of sediment are currently being deposited into the lake each year from the drainage basin. The combination of reduced inflows and increased sediment loads has reduced the depth of the lake from about 8.9 meters in the mid-1970s to about 1.9 meters today. It is estimated that if the lake continues to accumulate sediment at the present rate, it will change dramatically in character within the next 20 years, possibly drying up altogether or becoming a swamp. The impacts of sedimentation are best illustrated by its effects on fish biodiversity, with species that contributed to local livelihoods (e.g., Labeo) becoming almost extinct. Depleted fish stocks also have had impacts on other biodiversity, including fish-eating birds, many species of which have been significantly reduced since 1980.*

***Contamination of water and sediments from toxic and hazardous substances*** can occur from many sources. Those of greatest concern to human and ecosystem health are some heavy metals (e.g., mercury, arsenic, cadmium, lead, chromium) and persistent organic pollutants (e.g., dioxins, polychlorinated biphenyls (PCBs), DDT and other pesticides). These pollutants are of particular concern because of their long life, and their ability to accumulate in lake sediments and in humans, aquatic and terrestrial organisms. Many are thought to cause birth defects, tumors and cancers in humans and wildlife. Chemicals that mimic natural hormones ("endocrine disruptors"), and pharmaceutical and medicinal residues with potentially adverse human health and reproductive implications, also are being detected in lakes with increasing frequency.

*Water pollutants enter lakes from a range of point and nonpoint sources.*

***Increased erosion and sedimentation*** can result from deforestation and other land and soil disturbances associated with clearance and conversion of land to agricultural and urban purposes, producing large quantities of sediment that can enter lakes, degrade water quality, and destroy lake habitats. Sedimentation can rapidly fill many lakes, and can significantly reduce their water storage capacity and recreational potential, interfere with flow control mechanisms, and reduce their flood control capacity. The Nizamsagar

reservoir in India, for example, has lost more than 60% of its water storage capacity in 40 years. The siltation of Lake Dongting in China has reduced its surface area from 6,000 to 3,000 $km^2$ over the last century. Sediments entering lakes also can contain sediment-bound nutrients and toxic metals and chemicals that can be released into the water column under certain conditions.

***Unsustainable fishing practices and aquaculture***

Unsustainable fishing practices (e.g., inappropriate fishing gear, poisons, explosives) can indiscriminately remove juvenile and breeding populations, ultimately diminishing or destroying a fishery's capacity to be self-sustaining. The same is true for over-fishing for a prolonged period of time, which can diminish or destroy commercial fisheries. Non-native fish species also have been introduced into lakes to enhance fish production, some with devastating consequences to native fish species. Aquaculture can cause serious water quality problems, including nutrient pollution and increasing quantities of antibiotics and hormones entering a lake.

*Examples of fishing nets and gear that are illegal in some countries*

***Loss of aquatic biodiversity and habitats***

Lakes provide habitats for many aquatic organisms (fish, crustaceans, mollusks, turtles, amphibians, birds, mammals, insects, aquatic plants, etc.) and support biodiversity in the surrounding land areas, including many migrating bird species. These native species are well-suited to local conditions and typically live in balance with other aquatic life. Many support local fisheries and other economic activities. Around the world, however, thousands of water species have become threatened or endangered in recent decades. The loss of aquatic habitats from natural or human-induced modifications to the landscape (e.g., draining wetlands for pastoral and agricultural purposes, cutting forests along rivers, clearing lake frontage to enhance human access, removing aquatic vegetation in nearshore areas, land reclamation) is another significant cause of the loss of aquatic biodiversity, and increases the potential for the expansive growth of non-native species.

*The huge numbers of organisms utilizing lake ecosystems attest to their ability to support significant biodiversity.*

### *Human health risks*

Waterborne disease is the single greatest cause of human illness and death on a global scale. Unbalanced lake ecosystems can provide enhanced survival opportunities for disease-causing organisms that have an aquatic phase in their life cycle (e.g., mosquitoes). Human diseases, such as typhoid and cholera, are readily transmitted via contaminated waters, with poor sanitation facilities and contaminated drinking water supplies being major pathways for the spread of both the disease and the disease-causing organisms. Because human wastes also contain large quantities of aquatic plant nutrients, particularly phosphorus and nitrogen, lack of proper sanitation facilities also contributes to the accelerated eutrophication of lakes.

### *Accumulation of litter and garbage*

The consequences of accumulated litter (durable goods, biodegradable items, containers and packing materials, etc.) include physical obstruction and reduction of the natural beauty of lake systems, and the less-obvious impacts associated with chemicals leaching from the litter. Macropollutants or solid wastes such as litter and garbage contribute to the spread of human disease organisms and can adversely affect native wildlife and domestic animals, particularly waterfowl. In areas where refuse collection is unavailable, discarded wastes from households, farms and marketplaces are often dumped into nearby ditches and streams. Where these water systems drain into a lake, they can cause oxygen depletion in its bottom waters, contributing to a "mucky" lake bottom, and decreasing the lake's aesthetic values. Indiscriminate dumping of solid wastes also may clog waterways and cause floods that can destroy property and human lives. During floods, these wastes can be spread over a large area.

*Litter degrading the lake shoreline*

### *Loss of natural beauty*

Over-development or inadequate control of construction activities, particularly along lake shorelines, degrades the natural beauty of lake landscapes, and can have negative impacts on lake water quality and nearshore biological communities. Although difficult to categorize in a quantitative sense, the aesthetic quality of a lake can readily disappear over time as a result of increasing human settlement and related activities in its drainage basin. Litter transported from drainage basins to beaches, littoral zones or left floating on the lake surface, also can reduce the economic value of lakes to local economies.

*Inappropriate shoreline development can destroy aquatic habitats and degrade the aesthetic quality of lakes.*

## Threats arising from outside lake drainage basins

### *Long-range transport of airborne pollutants*

The atmosphere can be a significant mechanism for transporting contaminants to lakes, both within a drainage basin and from sources outside the basin. The best example of this phenomenon is lake acidification resulting from the atmospheric transport of acid-forming compounds from distant industrial smokestacks and vehicular emissions. Lake acidification has eliminated acid-sensitive fish (e.g., trout, bass) in certain parts of the

world, including Scandinavia, northeastern United States and southeastern Canada. Other pollutants, such as pesticides and other agricultural chemicals, and soils from eroding land surfaces, also can be carried great distances via atmospheric transport.

*The long-range transport of airborne pollutants can cause water pollution problems far from the pollutant source.*

### *Invasive species*

Invasive or non-native animal and plant species intentionally or accidentally introduced into a lake can proliferate rapidly in the absence of their natural predators and other control mechanisms. Once established in a new location, they can disrupt native lake flora or fauna, even eliminating them in some instances. Invasive species can enter lakes from a number of sources, including ballast water discharges from ships, the transfer of water between drainage basins, release of aquarium specimens, disposal of fish bait, escape of organisms from aquaculture operations or research facilities, and from intentional introductions to boost fishery production, enhance sport fishing or eliminate other aquatic species. Although there are a few successful examples of introducing non-native species to a lake (e.g., the introduction of water sardines into Lake Kariba (Zimbabwe/Zambia), apparently with minimal biological impacts), experience around the world has repeatedly demonstrated that once an invasive species becomes established in a new aquatic habitat, it is usually extremely difficult and expensive to eradicate. A prominent example is the proliferation of the water hyacinth plant (*Eichhornia crassipes*) in many lakes in Africa, southeast Asia and other parts of the world. The plants grow in thick mats that begin at the shore and extend toward the lake center, inhibiting navigation. The density of the vegetation also slows down fishing trips and makes some parts of a lake completely inaccessible to ordinary boats, thereby also threatening lakeshore communities that depend on fisheries for their livelihoods. Water hyacinth also provides a habitat for the snail that causes the debilitating disease bilharzias or schistosomiasis.

*Invasive species, such as water hyacinth, can interfere with many lake uses*

| *Invasive Species: Nile Perch and Lake Victoria (Kenya, Uganda, Tanzania)* |
| --- |
| *Nile perch were introduced into Lake Victoria in the mid-1950s, with the goal being to boost the local fishery. With a voracious appetite for other fish species in the lake, the Nile perch has, since its introduction, nearly destroyed the lake's 350 native species of fish, reducing the number to less than 50 today, according to some accounts. In short order, it also has worked its way to the top of the lake's food chain. The Nile perch can grow to enormous sizes, with typical commercial sizes ranging between 7-13 pounds (3-6 kilograms). As a result, the nature of the indigenous fisheries also has changed. The native Lake Victoria fishes were much smaller and amendable to sun drying, whereas the larger Nile perch require factor processing. Some factories were built for this purpose, but were never operated to capacity, given the disconnect between the indigenous fishing activities and the commercial nature of the fish processing enterprise.* |

***Climate change***

The predicted impacts of climate change, particularly global warming, vary throughout the world. Many will likely manifest themselves, however, in the form of altered precipitation patterns and drainage basin hydrology. The ultimate impacts will be a function of the magnitude of the changes from the present conditions in a drainage basin. Lakes are particularly vulnerable to changes in climatic parameters. Variations in such climate variables as air temperature and precipitation, for example, can directly cause changes in water evaporation, lake levels and water volumes, water balances, and biological productivity. Under extreme conditions, lakes may even completely disappear.
Lakes at high altitudes and high latitudes, and in arid and semi-arid regions, may be more sensitive to climate change impacts than those in other regions.

# *3. Principles for Implementing the World Lake Vision*

*If you are planning for a year, sow rice; if you are planning for a decade, plant a tree; if you are planning for a lifetime, educate people*
*…….…Chinese Proverb*

In addition to being important water sources for supporting economically-important aquatic ecosystems, lakes are primary water sources for human survival and for economic development. At the same time, however, lakes are especially sensitive to the impacts of human activities. Thus, actions or strategies directed to the sustainable use of lakes and their resources must be based on principles rooted in the notion of sustainability.

Sound lake management rests on the concept of integrated water resources management (IWRM). Lakes also are prime candidates for application of the Precautionary Principle. This principle is invoked as a political decision rule to address scientific uncertainty in situations involving risks and their consequences. It is based on the notion that, where there are threats of serious or irreversible environmental damage, the lack of full scientific certainty should not be used as a reason to postpone cost-effective measures to prevent environmental degradation and human health risks. It also suggests that problems about which incomplete knowledge is available should receive more attention than those better understood. Thus, the Precautionary Principle provides an impetus for making decisions that seek to avoid serious damage, as well as fundamental guidance for decisions directed to facilitating the sustainable uses of lakes and their resources.

The 1992 Dublin Conference promulgated principles for the sustainable use of freshwater, characterizing it as a finite and vulnerable resource, one with an economic value in all its competing uses. It also identified the need for water development and management within a participatory framework involving all stakeholders. The Dublin Principles have subsequently been widely accepted as fundamental guidance for managing water resources for their sustainable use. The ***World Lake Vision*** readily accepts them, as well as the Precautionary Principle, as logical starting points for developing management programs and actions for sustainable lake use.

Lakes are major hydrologic components of the drainage basins in which they are located, and cannot be effectively managed in isolation of their basins. Thus, effective lake and drainage basin management are intimately interrelated and complementary. Therefore, to address the threats facing lakes and their root causes as discussed in the previous chapter, the ***World Lake Vision*** offers a common set of management principles for those who directly or indirectly involved in the sustainable use of lakes and their resources, and who are affected by the degradation or loss of their values.

These principles, implemented within the framework of integrated water resources management, provide substantial guidance to the public, decision-makers, scientists and other lake stakeholders for managing lakes for their sustainable use. They will facilitate our ability to provide water from lakes for drinking, sanitation, food production, economic development and flood control, while at the same time insuring ecosystem health. Against this background, the ***World Lake Vision*** aspires to the following principles, which are presented in no strict order of priority:

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

Lakes are dynamic ecosystems. In addition to being significant natural amenities, lakes are important inland water resources for meeting increasing human drinking water demands. They also have significant economic values, including supplying water for irrigation and power generation, providing food via fish and other aquatic products, and preserving the health and biodiversity of important life-supporting aquatic ecosystems. Excessive utilization and degradation of lake resources, however, is causing significant lake problems in many countries. This situation limits the possibilities for managing them for meeting human and ecosystem needs in a sustainable manner. It is necessary, therefore, to insure that humans respect the natural capacity of lake ecosystems to meet their various water needs, even in the face of changing water uses over time. To do otherwise will insure that individual lakes will eventually be unable to meet water demands for virtually any needs, whether for humans or nature.

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

A lake and its drainage basin, including its inflowing and outflowing tributaries, comprise an inseparable system. Although some causes of lake degradation may originate from outside its drainage basin, most result from human activities within the basin. Lake management, therefore, should best focus on the scale of the drainage basin, effectively integrating hydrological and ecological processes, as well as socioeconomic realities. Further, it must consider not only the water needs of the drainage basin in which a lake is located, but also of downstream drainage basins. Water withdrawals, diversions or discharges in the former can affect the quantity and quality of water available in the latter. Conversely, water needs in downstream drainage basins may limit or otherwise modify the range or magnitude of potential water uses in an upstream drainage basin. The health and sustainable use of lakes, therefore, depends on how humans use their land and water resources, and recognizing and utilizing this fundamental interrelation must be an essential part of effective lake drainage basin management.

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

In the face of increasing human populations and their water needs, it is not sufficient merely to protect lake ecosystems from human impacts, but also to enhance their capacity to meet human water needs while at the same time maintaining ecosystem functions. Further, because of the complexity of lake ecosystems, including their water levels and volumes, flushing rates and related hydrological factors, the initial detection of lake

problems may be delayed for years. Thus, implementation of necessary corrective actions in a given situation may be delayed for years, decades or even longer. Experience throughout the world, however, has repeatedly demonstrated that remediation of lake problems after they have developed is usually significantly more costly, and more difficult to treat, than preventing the problems in the first place. Therefore, a preventative or proactive approach that attempts to identify and address problems *before* they happen, including the need for continuing monitoring, assessment and corrective actions, is a key element in managing lakes for their sustainable use, in contrast to the reactive approach of responding to lake problems or crises *after* they have happened.

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

The study and management of individual lakes for their sustainable use requires a multidisciplinary approach, including the physical, chemical, biological and social sciences, as well as consideration of socioeconomic, institutional, political, technological, historical and cultural factors. Equally important in some situations is the knowledge and experiences of people directly exposed to a lake, either as part of the lakeshore community or as individuals who depend on a lake for their economic livelihood. Effective policy development and decision-making for lake management must be based on current, accurate data and information, as well as other relevant lake experiences. At the same time, however, although scientific methods and laws are universal, no two lakes necessarily have the same landscape, ecosystem characteristics, or socioeconomic or cultural conditions. To develop and implement sound lake management practices for individual lakes, therefore, it is essential that systematic, continuous and up-to-date monitoring and evaluation of environmental and socioeconomic conditions be undertaken. Attention also must be paid to the quality and relevance of the data and information used for this purpose.

The value of local/traditional knowledge and customs, sometimes contained in the legends, oral histories and experiences of native peoples, should be considered. In some instances, they may be the only sources of available information on the changing relationships between humans and lakes. Further, if the necessary resources or equipment for accurate monitoring are not available, the acquisition of observational data on alternative indications of biological conditions and relevant local information should be pursued.

***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.***

Lakes provide a range of economic, cultural and ecological values. Healthy lakes are major water resources for meeting human needs, as well as natural resource engines for economic growth. Lakes also have a range of recreational, aesthetic and spiritual significance. Because lakes are able to accommodate a wider range of human and ecosystem water needs than either rivers or groundwater, conflicts over the use of lake resources may exist. Lake basins also may be subject to multiple jurisdictions at the local, regional, national and even international level, both upstream and downstream from a lake. Many often have differing, fragmented and even conflicting rights and obligations for the management and use of water and land resources. Effective lake management, therefore, requires the identification, analysis and reconciliation of competing users, as well as avoidance of water-related conflicts, particularly for international or transboundary lakes.

Many lakes have been used to meet human water needs for a long period, and the history of a given lake may be interwoven with that of the inhabitants of its drainage basin. Because a lake's ecological condition at any given instant is a snapshot of its natural and human historical development, its management for sustainable use requires consideration of the water needs of both present and future generations. This concept lies at the core of the notion of sustainable development, and provides the rationale for resolving conflicting water uses.

***Principle 6: Citizens and other stakeholders should be encouraged to participate meaningfully in identifying and resolving critical lake problems.***

Development and implementation of effective management efforts for the sustainable use of lakes ideally should involve all the "lake people." All citizens and stakeholders who wish to have meaningful roles to play in this process should be brought effectively into the information sharing, and the policy development and decision-making, arena to facilitate the development of sustainable solutions to critical lake problems.

In addition to government agencies, involving citizens and other stakeholders, such as non-governmental organizations, local authorities, business and industrial organizations, advocacy groups, and educational and research institutions, is essential for managing lakes for their sustainable use. Cooperative and collaborative arrangements for these multiple stakeholders, therefore, are fundamental in such efforts. Accountable governance, institutional and financial structures also must be in place, with all users and beneficiaries sharing in the burden of managing their resource base. Lake basins that cross or constitute international boundaries require additional management cooperation and collaboration.

***Principle 7: Good governance, based on fairness, transparency and***

***empowerment of all stakeholders, is essential for sustainable lake use.***

All lake management activities must be subject to a principle of fairness, in order to encourage citizens and other lake stakeholders to participate meaningfully in the process of policy development, decision-making and implementation. In fact, if it is perceived that any part of the process is not transparent, it will be difficult or impossible for citizens and other stakeholders to trust the lake management process, components or activities. The benefits of fairness are a balance in the policies and a resulting willingness of stakeholders to fulfill their roles in the implementation of the policies. Thus, citizens and other stakeholders must be empowered to play their significant roles. Employing participatory processes to develop and implement policies for the sustainable use of lakes and their resources is the most rationale means of insuring fairness, transparency and empowerment for the benefit of all citizens and other stakeholders in a lake drainage basin.

# *4. Implementing the World Lake Vision: Promising Actions and Strategies*

*"A vision without action is just a dream; an action without vision just passes time; a vision with an action changes the world."*
*…..Nelson Mandela*

The key to sustainable lake use lies in finding a balance between the water needs of humans and the ability of nature to meet these needs over the long term. To this end, the principles for action identified in the previous chapter provide valuable guidance to citizens, governments, decision-makers, managers, non-governmental organizations, scientists and other stakeholders involved in the myriad of issues associated with the sustainable use of lakes and their resources. Application of the principles must be accompanied by practical actions facilitating the timely, effective implementation of lake management goals. As noted in the introduction to this document, a vision without action is just a dream – making it a reality requires implementation of practical and appropriate actions.

There is no single action for the instant reconciliation of the impacts of unsustainable use of lakes and their resources. Rather, this chapter provides a menu of promising actions and strategies for applying the principles of the ***World Lake Vision*** for the purpose of developing individual lake visions. They can be undertaken by individuals, organizations and other stakeholders working at the local, national, regional and/or global levels – all have important roles to play in the process. The precise nature and mix of actions and programs for implementing individual lakes visions will depend on the local conditions, including such factors as the magnitude of the problem, the available human and financial resources, the extent of public and governmental support and interest, consideration of the consequences of doing nothing to address the problem and other scientific and social

factors. This tool box is intended to provide immediate help to those involved in problem solving for individual lakes, recognizing also that new approaches and methods to address threats to lakes continue to be developed and will be incorporated in the ***World Lake Vision*** as their value becomes evident.

Implementing the principles identified in the previous chapter, as well as the immediate actions and longer-term strategies outlined in this chapter, requires a systematic approach of the type outlined in Figure 2. Because it represents a cycle of steps to be undertaken, the entry point into this approach to develop an individual lake vision will depend upon the extent of knowledge and information available, community structure, and level of stakeholder participation. The development of needed political commitment to undertake activities and programs directed to sustainable lake use must also be undertaken early in the cycle. This may include the creation of appropriate agencies, institutions and organizations, both within government and the local community.

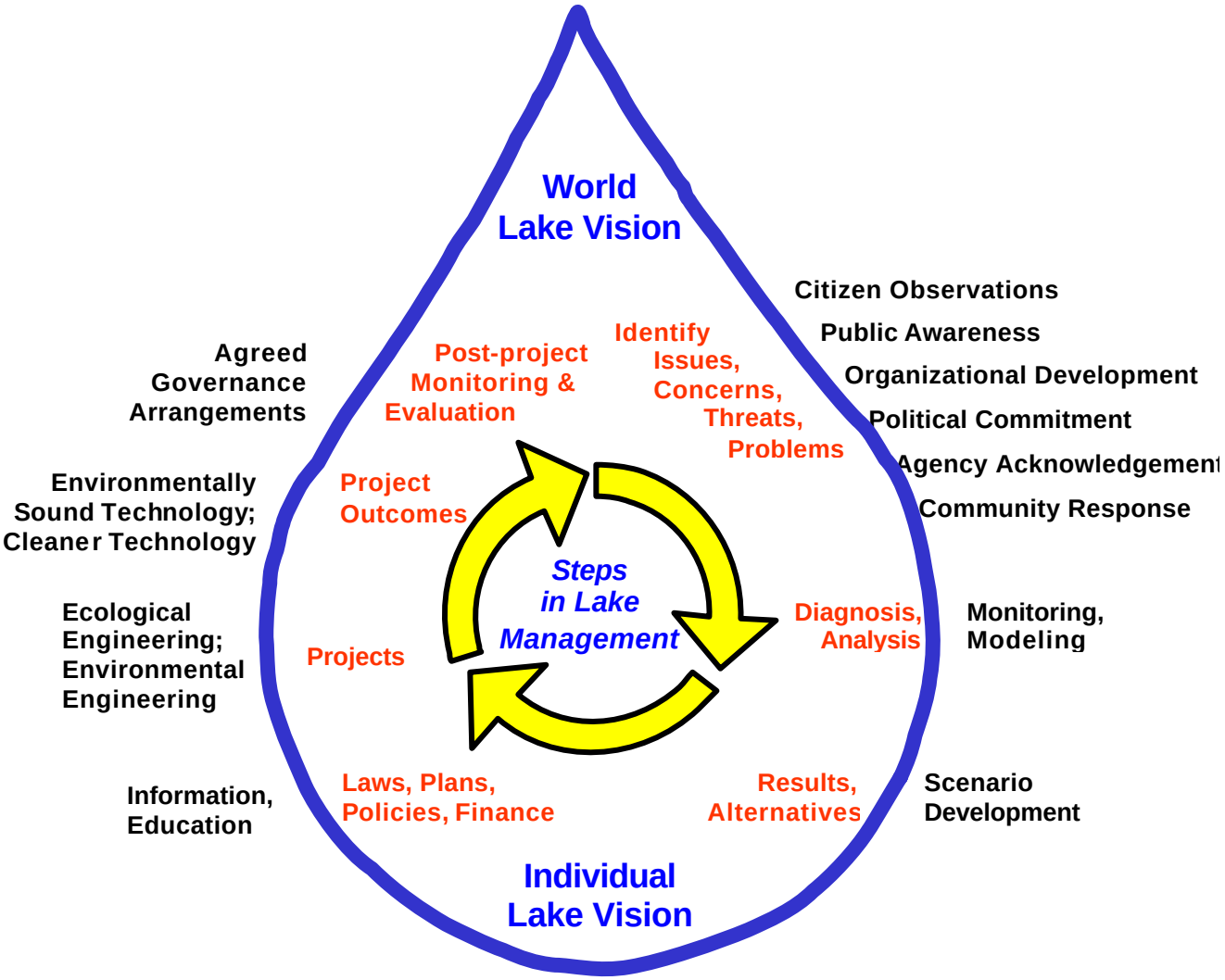



*Figure 2. Management cycle for developing, implementing and refining individual lake visions.*

In facilitating the sustainable use of water resources, it also must be recognized that no action is always negative - even for situations where comprehensive lake management programs may not be possible for financial, technical or other reasons, implementing at least some action is still likely to be beneficial. In identifying the actions and opportunities below, therefore, no order of priority is implied with the order of the listing.

## Immediate actions for addressing major threats facing lakes

Interactions between humans and their water and land resources are critical factors influencing the health of lakes. Decisions and actions regarding the utilization of land and water, therefore, will largely determine the type and magnitude of threats to lakes. Each threat and its underlying causes have particular attributes to be considered. Further, many different entities, including citizens, governmental agencies, decision-makers and managers, non-governmental organizations, the private and agricultural sectors, educational and research institutions, and the media, have a role to play in addressing threats to the sustainable use of lakes and their resources. Following the general order of the threats to lakes identified in Chapter 2, therefore, this section identifies a number of actions that can be employed to address these threats.

### *Managing Water Withdrawals and Diversions*

?? ***Develop accurate water budgets for individual lakes and their drainage basins*** – Developing an accurate water budget is a major step to managing water withdrawals from lakes and their tributaries, identifying both the available water resources, and the various demands for it in meeting water needs throughout the drainage basin. The latter should include the quantity of water needed to preserve life-supporting or economically-important ecosystem functions. Development of an accurate water budget is a critical step in prioritizing water uses on a drainage-basin scale, with the goal of developing a realistic management framework for sustainable lake use.

*Drainage Basin Water Budget: Lake Titicaca (Bolivia, Peru)*

*In developing a water balance for Lake Titicaca, the Autonomous Binational Authority of Lake Titicaca (ALT) discovered that the maximum usable water flow in the lake's drainage basin was significantly less than the estimated water demands. The development of the water budget highlighted the fact that the lake's water transfer and irrigation projects must be strictly prioritized on the basis of environmental, social, economic and hydrological criteria, if the use of Lake Titicaca's water is to remain within sustainable limits. Unfortunately, there are few examples of such useful assessment activities.*

?? ***Implement technical water conservation measures to reduce water use*** -- Water diversions from lakes and their tributaries are a direct result of growing water needs for irrigation, industrial and municipal use. Only by reducing the quantities of water used by these three major sectors, therefore, can we preserve adequate supplies of water for meeting beneficial human water uses and maintaining lake ecosystems. The vast

majority of water on a global scale is used for agricultural irrigation. Further, much of the water used for crops and plants is evaporated directly back into the atmosphere, thereby not being returned to the water systems from which it was taken, reducing the potential for immediate downstream water reuse. The largest potential water savings, therefore, can be obtained by implementing more efficient irrigation techniques (e.g., drip irrigation, micro-irrigation systems), changing cropping practices or products, although these techniques sometimes require significant monetary investments. Substantial water savings also are possible by implementing more efficient industrial and domestic water-use, upgrading urban water delivery systems that lose large amounts of water through leakage, and using low-flow or dry toilets in individual households. Additional water savings can be realized with the implementation of other innovative water conservation approaches, including reuse of gray water and of treated water from municipal wastewater treatment plants, rainwater harvesting, etc.

?? ***Recognize the social and economic value of water in making water management and allocation decisions*** – Where appropriate, charging an equitable price for water service and treatment is one of the single most important steps for addressing the sustainable use of lakes and other water resources. Studies around the world have demonstrated that the prices charged for freshwater resources can be highly flexible, and can result in significant water savings. Charging even small fees for irrigation water, for example, can create a strong motivation to reduce excessive water consumption and wastage. Further, some communities provide a basic allocation of water for use by low-income persons as a means of insuring adequate sanitation and preservation of public health. Experience also has demonstrated that, in the absence of adequate revenue from water charges, municipal water enterprises are seldom able to deliver piped water to poor areas, to reduce their often-significant unaccounted-for water losses, or to provide for treatment of wastewater prior to its discharge back into the environment.

Also to be considered is the economic value of preserving aquatic ecosystems. Many aquatic ecosystems, including lakes, provide valuable services to humanity, including food production, waste assimilation, nutrient recycling, flood control, water storage, etc. Further, they provide these services free-of-charge to humanity. Noteworthy is the fact that these costs would otherwise have to be met by humans. On a global scale, it is estimated that the economic value of these "free" ecosystem services totals in the trillions of dollars on an annual basis. This economic reality provides another incentive to actively pursue the sustainable use of lakes and other aquatic ecosystems.

?? ***Apply the lessons learned from past experiences in the future construction and operation of dams*** – Civilizations and societies have constructed dams from ancient times to store water for meeting their drinking, irrigation and sanitation needs. In more recent decades, dams also have been constructed for such purposes as food production, flood control, hydropower generation, recreation and other beneficial human purposes. Additional new reservoirs will likely be constructed in some countries, particularly developing nations, in the future. Nevertheless, the construction of dams and the accompanying land-clearing operations and activities can cause changes to water quality, biological communities and landscape properties, both upstream and downstream of a

lake. Thus, the environmental and socioeconomic lessons learned from past construction of reservoirs can provide valuable information and guidance to planners and decision-makers regarding the potential impacts that may be encountered in constructing new reservoirs. In its global evaluation of the developmental effectiveness of large dams, for example, the World Commission on Dams proposed guidelines regarding dam projects, including important aspects of needs assessments, evaluating alternatives, and dam project preparation, implementation, operation and decommissioning. Other subsequent evaluation efforts also are ongoing. It also is critical that decisions about the use of water resources be taken in a transparent and participatory manner, facilitating a full consideration of alternatives and a balancing of environmental and economic developmental goals.

## *Preventing and Controlling Water Pollution*

?? ***Implement wastewater treatment within lake drainage basins*** -- The construction of adequate wastewater treatment facilities continues to be a top priority. Experience around the world suggests that large wastewater treatment systems generally are the most effective approach in urban areas with large populations and water usage. In addition to improving local hygienic conditions, upgrading existing wastewater systems to remove the largest quantities of biologically-available phosphorus and other pollutants in wastewater is also an important measure. In sparsely-populated areas, small community-based projects for meeting local sanitation needs, including the use of constructed wetlands, can be just as effective, less expensive and more practical than large infrastructure projects. Depending on the specific circumstances, septic tanks or low water volume toilets may be the most appropriate actions in other areas. Ecological sanitation that separately recovers urine and feces for fertilizers also may be a promising approach for reducing water pollution in some regions.

?? ***Limit or ban the use of phosphate-based detergents –*** Because phosphorus in detergents typically is in a chemical form that algae and other aquatic plants can readily use, thereby promoting lake eutrophication, the phosphorus content of industrial and residential detergents is regulated in many industrialized countries. Many lakes in developing countries, however, still receive substantial phosphorus loads from detergents. Manufacturers in many parts of the world have successfully replaced phosphorus with less environmentally-harmful ingredients, and many successful models for implementing phosphate detergent bans or limits are available to countries currently lacking them. Accordingly, management plans for sustainable lake use should include comprehensive phosphorus reduction strategies, combined with monitoring programs that identify baselines and track changes in nutrient pollution loads and levels over time, as well as information programs to inform consumers of appropriate alternatives.

?? ***Protect forests and vegetation in the drainage basin*** -- A key to reducing excess sediment and pollutant loads to lakes is to protect natural vegetation, often in the form of forests, savannahs and prairies along inflowing tributaries, from development pressures. The presence of vegetation and other substantial ground coverage reduces the velocity of water flowing over the land surface, as well as promoting the removal of some types of

water pollutants before they can reach lakes and their inflowing tributaries. Reforesting or revegetating cleared areas, therefore, are important preventative measures for enhancing the sustainable use of lakes and their resources. Maintenance of a mosaic landscape through protection of natural wetlands and other natural buffer areas is a good practice for protecting waterways in urban and rural areas. Protection of forests and woodlands enhances the production of water from water source areas.

?? ***Implement best management practices to control erosion*** -- Best management practices for agricultural areas, construction sites, eroded land surfaces and other areas with bare soil surfaces are well described in the literature. Most are effective in reducing soil erosion, primarily by slowing the velocity of water movement and promoting the sedimentation of soils and particles carried in it prior to their entrance into lakes and their inflowing tributaries. Prominent examples include constructed waterways, and water and sediment control basins with grassed waterways.

?? ***Adopt best management practices for reducing agricultural and urban runoff*** -- Storm-generated runoff and drainage from agricultural and urban areas (nonpoint sources) are major sources of nutrients, toxic contaminants, sediments and microorganisms. Best agricultural management practices for reducing nonpoint source nutrient loads include reduced fertilizer use, abatement of fertilizer and livestock manure runoff, grassed waterways, no-tillage/low-tillage plowing methods, etc., all of which reduce the quantity of nutrients reaching lakes and their tributaries. Better fertilizer management practices can reduce costs to farmers without reducing yields, creating a win-win opportunity. Better management of the quantities and timing of pesticide applications, or implementing organic farming, also can reduce lake pollution. Best management practices for urban areas include street sweeping, litter management and solid waste disposal, stormwater detention basins, buffer zones, grassed waterways, and constructed wetlands, all of which can reduce pollutant loads. Although not necessarily significant on an individual household level, it is clear that the cumulative effect of many households employing similar measures can be substantial on a drainage basin scale.

| *Promoting Pollution Prevention Practices:*<br>*Great Lakes Binational Toxics Strategy (USA, Canada)* |
|---|
| *Acting collaboratively to protect the water quality and biota of the North American Great Lakes, which contain about 20% of the world's liquid freshwater, and the health of its drainage basin citizens, the United States and Canada developed a Great Lakes Binational Toxics Strategy in the 1990s. The strategy included programs for working with industry to replace toxic chemicals with less toxic substances, ultimately phasing out chemicals that pose unreasonable risks to human health and the environment, and those that are toxic, persistent and can accumulate in the tissues of living organisms, including human. An international, multi-stakeholder review of the effectiveness of this program undertaken in the year 2000 indicated that it was contributing significantly to the reduction and elimination of such chemicals in the Great Lakes Basin Ecosystem. This binational effort provides a useful model for other countries pursuing the same goals elsewhere in the world.* |

?? ***Promote pollution prevention practices for persistent toxic substances, especially those that can accumulate in living organisms*** -- Primary emphasis should be directed toward pollution prevention, taking into account environmental risk assessment and the entire life cycle of the polluting chemicals, in contrast to the necessity for costly clean-ups after pollution has occurred. Viable alternatives exist for many known uses and sources of persistent organic pollutants, and all should be thoroughly explored prior to using these chemical products. Other significant actions for reducing the generation of toxic and environmentally-persistent agro-chemical residues include the promotion and use of cleaner production and technologies, emission inventories, product labeling, use limitations, economic incentives, and the adoption of Integrated Pest Management practices. Particular attention should be given to controlling or eliminating those chemicals and other pollutants that can accumulate in the tissues of living organisms, thereby posing both human and ecosystem health problems. Further, requiring polluters to pay for all negative impacts resulting from their actions, the so-called "polluter-pays principle," can help realign distorted incentives, and also generate financial resources for environmental projects to prevent lake degradation. At the same time, the application of this principle should not be considered a substitute for a more comprehensive pollution control program.

?? ***Develop and implement land use plans to limit the use, generation and transport of water pollutants*** -- With increasing population and the associated agricultural production, urbanization, and industrialization, human demands for land resources also are increasing. Thus, it is imperative that attention be focused on the formulation of effective land use planning and "sustainable growth" processes that integrate developmental goals and environmental needs. Sensible land use planning is essential to conserve critical lake drainage basin habitats, for sustaining ecosystem services, and for minimizing unnatural or altered water runoff to lakes, all of which can ultimately affect beneficial lake uses. Providing accurate and timely information to local and regional decision-makers about the importance of lakes and their resources, and about effective planning principles to protect lake drainage basins, is an important means whereby corporations, non-governmental organizations, and individuals can help shape local and regional land use choices.

| *Managing Water Resources Development: Lake Biwa (Japan)* |
| --- |
| *The Lake Biwa Comprehensive Development Project was implemented for Lake Biwa during the period 1972-1997. It was implemented via national legislation facilitating special financial arrangements between national, local, upstream and downstream governments. It comprised 22 water resource development programs for the lake, Japan's largest, including meeting downstream needs of the Osaka-Kobe region. It also included projects directed to the socioeconomic development of the region upstream of the lake, including flood control, water treatment works and construction of sewerage treatment facilities. During this period, the lake has shown environmental improvement in some areas, with an example being the relative control of eutrophication at the same time that the drainage basin population increased by 50%.* |

?? ***Develop, implement and enforce appropriate pollution control plans, standards and regulations*** – Appropriate regulatory frameworks, and the enforcement of relevant requirements, including prohibition of toxic contaminants and other aquatic pollutants and appropriate application of the polluter pays principle, remain effective measures not only for limiting the degradation of lake ecosystems, but also for encouraging the widespread adoption within societies of environmentally-sound practices and technologies. Pollution control plans can encourage timely actions, which can also limit the costs and difficulties of implementing future remedial programs required to mitigate the consequences of environmental contamination. Such plans can include the application and enforcement of necessary regulations, limiting the potential for pollution through requiring appropriate siting and construction of infrastructure structures, and coordinating the activities of various segments within civil society, including individuals, governmental agencies, communities, and non-governmental organizations. Indeed, experience throughout the world continues to indicate that a small investment made in a timely manner can result in substantial savings over time.

## *Achieving Sustainable Fisheries Management*

?? ***Establish and implement a management program for sustainable fisheries*** -- In the same way that water budgets help prioritize water uses and protect aquatic ecosystem functions, preparing similar budgets for the plant and animals species harvested from lakes also is essential. Programs for protecting lake fisheries over the long term should involve application of comprehensive fisheries management protocols, including collaborative actions among governmental authorities, fishermen and the fishing industry in conducting studies of fish biology, identifying sustainable catch limits, and managing fisheries with such measures as fishing permits and fees, net or gear size requirements, harvesting seasons and limits, fishing technologies and harvest area restrictions. Measures to protect the shoreland ecosystems, involving local communities, commercial fishing operations, and other stakeholders, should be included in a sustainable fisheries management program. Certain zones can be reserved for selected fisheries, particularly traditional or indigenous fisheries. Development and enforcement of equitable, sustainable fishing regulations also is critical, but presently insufficient for many lakes. Further, provision of alternative employment opportunities for off-peak fishing periods (e.g., ecotourism) should be considered in a fisheries management program.

*Sustainable fisheries are essential for the livelihood of many indigenous communities.*

Fisheries managers also must work to minimize the catch and waste of non-target species and to reduce the negative impacts on associated species, particularly endangered species, juveniles and spawners. They should harmonize fishing regulations between different jurisdictions using the same lake. Local fisheries management councils, or partnerships between stakeholders and authorities, can contribute to the development and implementation of fishing regulations and management measures.

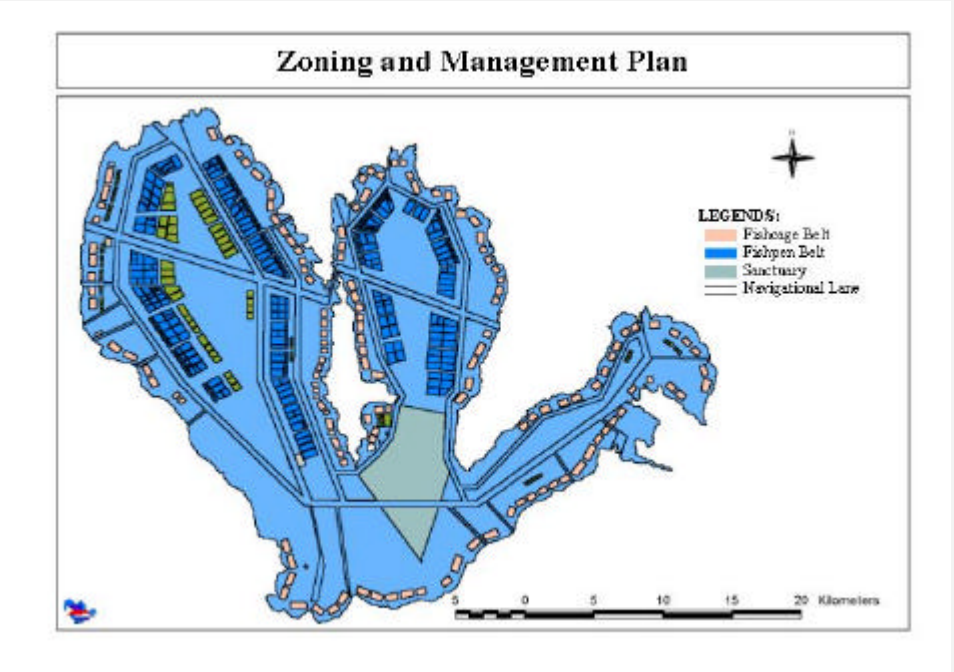
## Conserving Lake Biodiversity

?? ***Protect and restore biodiversity in lakes*** – Restoring and protecting aquatic biodiversity requires that attention be given to all the previously-identified threats to lakes. Careful evaluation of the endemic species in specific lakes also is important for efficient and effective conservation, and should go beyond the relatively common practices of fish and bird counts. Mapping the ranges and breeding areas for key species, and studies of life histories and relationships with other species, will help prioritize areas for special protection. Designation of special protected areas at the local, national and/or global levels can offer at least partial protection to aquatic organisms in lakes and their inflowing tributaries. As discussed further below, comprehensive efforts also must be made to control the introduction and spread of invasive species, which is second only to habitat destruction as a cause of biodiversity loss.

?? ***Establish protected areas within lake drainage basins*** -- It is important that local, provincial and national governments, as well as international agreements and programs (e.g., Ramsar Convention, Convention on Biological Diversity, International Union for the Conservation of Nature (IUCN) protected areas program, UNESCO Biosphere Reserve and World Heritage Site Programmes), work expeditiously to insure that critical areas within the lake drainage basin landscape mosaic are identified and protected. Such protections should be maintained over the longer term, and be sensitive to the traditional

uses of such areas by indigenous peoples. Establishment of active use areas as buffers around protected areas has proven effective in the management of such areas. Private reserves, created by individuals or non-governmental organizations, also are appropriate protection measures in some areas. In addition to major tributaries, known spawning or breeding grounds for key species, including springs, floodplains, steep slopes and surrounding forest, are critical areas requiring protection. Further, once they are under protection, the effective and wise use of lands and aquatic systems, in partnership with stakeholders, are essential.

*Achieving Sustainable Fisheries: Fishing Zones in Laguna Lake (The Philippines)*




*The Laguna Lake Development Authority developed a Zoning and Management Plan (ZOMAP) in Laguna de Bay to address the conflict between open water fishermen and aquaculture operators, and the declining fish catch due to over-utilization of the lake's natural food sources for fish. The fish pen belt and fish cage belt were demarcated with specifications on the distance between the structures and the maximum allowable area for each owner. From a lake area of 900 km$^2$, a total area of 100 km$^2$ and 50 km$^2$ were allocated for fish pens and fish cages, respectively.*

## Controlling Invasive Species

?? ***Prevent the introduction of invasive species –*** The introduction of invasive species can have serious ecological and economic consequences. Programs aimed at preventing invasive plant or animal species from establishing a foothold can be created by governmental agencies and lake users and organizations. Monitoring of key habitats within the lake and its nearshore areas for species known to be invasive in a specific region, or in similar habitats, also can be undertaken by governmental agencies and

citizen volunteers. Policymakers can assist in this process by requiring extensive environmental impact and risk assessment as part of any planning process in which the introduction of non-native species is being considered, whether for economic, recreational or aesthetic purposes. Programs for effectively reducing the accidental introduction of invasive species into lakes from such sources as the ballast water of ships, transfer of water between drainage basins, etc., are also currently being explored in several global fora.

?? ***Eradicate or control established invasive species in lakes and their drainage basins –*** It is difficult to control invasive species once they have become established, particularly if they have gained an economic importance. Current methods for controlling invasive plant species include mechanical and hand harvesting, biological control following appropriate evaluation and assessment to prevent unwanted introductions of additional non-native organisms, chemical treatment, and educational programs to reduce their unintentional spread by lake users. Some invasive organisms, such as water hyacinth, flourish because of high nutrient loads entering lakes. Thus, strategies to reduce the nutrient loads reaching lakes can also help reduce their spread. Methods for controlling invasive or unwanted introduced animal species include mechanical and hand harvesting/clearing of targeted species, selective chemical treatment, biological control, installation of physical controls/barriers, lake water level drawdown, and educational programs. Many of the control strategies for both invasive plants and animals can be implemented through local coalitions, including governmental agencies, scientists and non-governmental organizations.

## *Preventing Health Risks*

?? ***Coordinate lake management actions with public health authorities –*** Properly-operated municipal wastewater treatment plants are a primary means of preventing the spread of human waterborne diseases. Other possibilities include ecological sanitation, septic tanks and simplified toilets, especially for preventing diseases spread by human wastes, and the use of small community-based projects for meeting local sanitation needs. Shoreland management actions that encourage human settlements in areas with environmental conditions suitable for reducing health risks, and appropriate designation of areas for swimming, other full contact recreation and fishing, are useful tools in limiting the spread of disease. Because of the fact that waterways are major pathways for transmitting disease, as well as the habitat of disease vectors, coordinating lake protection programs with those of public health authorities is another logical and useful partnership in many locations. Further, in undertaking activities such as promoting immunizations, health centers can distribute literature and information on protecting citizens from disease vectors such as mosquitoes, through such simple measures as limiting the availability of stagnant water in containers, ditches, pits and other uncovered water-holding or conveyance systems. Special attention should be given to the sanitation problems associated with human settlements on or over the water or along the shoreline.

## *Controlling Litter and Garbage*

?? ***Undertake anti-litter campaigns*** -- Indiscriminately discarded refuse can ultimately find its way into lakes and their tributaries, particularly after precipitation events. Undertaking local anti-littering campaigns, therefore, provides a mechanism for protecting lakes from garbage and trash. Careful siting of refuse disposal points, the use of sanitary landfills constructed to provide treatment of leachates and gases, and implementation of street sweeping and refuse collection programs, for example, are often used to control environmental pollution from litter, debris, and discarded human materials. Implementation of waste collection and recycling programs, composting and bio-gas production, also may be beneficial in reducing or reusing potential pollutants. Such programs also enhance human health by limiting opportunities for disease vectors to successfully reproduce.

## *Establishing a Management Mechanism for the Sustainable Use of Lakes and Their Resources*

?? ***Establish a mechanism for managing water resources in a sustainable manner*** -- To insure the equitable and sustainable use of lakes, it is essential that they be jointly assessed and managed by the stakeholders sharing them, based on an agreed and collaborative mechanism. A primary goal is to harmonize the interests between and among lake stakeholders, whether local, regional, national or international, while also maintaining the integrity of the lake ecosystem. Whether on an international or local basis, different jurisdictions can be expected to operate under different organizational structures, operating procedures, and legal and policy frameworks. As a result, hostilities and/or competition between adjoining political entities are not uncommon. Further, international lake drainage basins often contain communities speaking different languages, greatly complicating attempts to form coalitions and develop common understandings and visions. Nevertheless, every effort should be made to encourage dialogue among lake users, rationale and equitable bases for lake management activities, and development of a shared lake vision and action plan between different communities, jurisdictions or countries using the same lake.

?? ***Encourage creation of partnerships to resolve lake problems*** – Partnerships between the citizens and government officials can be very helpful in identifying and solving lake problems. The management of lake problems may be accomplished at the drainage basin level through establishment of formal or informal partnerships. Where feasible, public awareness and feedback can be an important component of effective, sustainable solutions to lake problems. If the public can be persuaded of the severity of a lake problem (and its human, ecosystem and economic consequences if left untreated), it may more readily appreciate the need to develop and implement effective lake management programs. One result can be the development of a proprietary interest by the public in the work involved in addressing lake problems. It also can make the public more amenable to the associated expenses of such activities.

The development of partnerships between government authorities, citizens and the private sector is an area requiring much greater effort. The private sector has technical and managerial skills that can enable it to produce more goods and services using less water.

Private sector companies have the human and financial resources to invest in more "eco-efficient" technology that can protect water, use water more efficiently, recycle water for reuse inside plants and factories, and clean water before it is returned to rivers and lakes for common usage. Thus, if governments set appropriate developmental, financial and regulatory framework conditions, it is possible that the economic and technical power of the private sector could be unleashed to tackle pressing problems facing lake and their resources. The World Business Council for Sustainable Development is an example of a business association focusing on the sustainable use of water and other natural resources.

?? ***Consider creation of new and alternative employment opportunities*** -- Encouragement of alternative employment opportunities (e.g., eco-tourism) can provide economic incentives for communities and individuals within lake drainage basins and along lakeshores. Such opportunities can include adopting environmentally-sound technologies, such as using locally-grown organic products, introducing recreational management programs based on consideration of a lake's carrying-capacity, restricting the numbers of visitors to sensitive sites, and providing appropriate informational materials regarding areas frequented by tourists and others. In tourist or urban areas, provision of public transportation can alleviate traffic and minimize environmental impacts of human economic activities on lakes. In addition to helping reduce stresses on lake environments, such measures can be self-sustaining in some cases, an example being the generation of revenues from tourism activities. Tax relief provides a further opportunity to encourage the adoption of alternative technologies and employment.

?? ***Coordinate lake management and poverty alleviation programs*** – Experience around the world indicates that the basic survival needs of people must be satisfied before they can be expected to focus on lake management issues, or on environmental problems in general. Conversely, the sustainable use of lakes and their resources will contribute directly to alleviating poverty. The provision of environmentally-sustainable economic opportunities, therefore, provides a primary mechanism for encouraging the sustainable use of these resources for meeting beneficial human needs.

## Longer-term strategies for addressing major threats facing lakes

In contrast to the toolbox of immediate actions that can be used to address threats facing lakes, this section of the ***World Lake Vision*** identifies a range of broader strategic approaches directed to the goal of sustainable lake use. As longer-term initiatives, these strategies typically require sustained action over a period of year or even decades. Many span national boundaries, and might also be best implemented at the regional level. Nevertheless, many also are equally applicable at the local and community level. Their specific level of implementation will depend on the nature of the individual lake problem(s), and the capability of the relevant lake stakeholders to address them. This may include the level of the individual, communities and governments, non-governmental organizations, business and agricultural sectors, and/or scientific professionals and academicians. It is noted that action by governments commonly involves both a political process, requiring that legal and institutional frameworks be put

in place, that relevant actions by established governmental agencies and units be implemented, and that the actions are subsequently enforced.

*Managing lakes for their sustainable use requires the cooperation and involvement of all lake stakeholders, particularly the citizens inhabiting their drainage basins..*

## *Monitoring and Assessing the Health of Lakes and Their Drainage Basins*

?? ***Implement and maintain lake monitoring and assessment activities*** -- The ***World Lake Vision*** encourages new or continuing monitoring and assessment of the state of lakes and their drainage basins, and the dissemination of the results to all lake stakeholders. It is a demanding task to select ecological and water quality indicators for lake health assessment and to establish and maintain a corresponding monitoring program. It requires continuing and concerted efforts to acquire the necessary data and information for making informed lake management decisions. Ideally, all water development projects should include both pre-project and post-project monitoring activities, as a means of both refining individual projects and for identifying case studies and lessons learned for future projects. Monitoring activities can be undertaken by individuals, governmental agencies, non-governmental organizations, corporations, and academic institutions at all levels. Monitoring and assessment programs should be specifically designed to recognize and incorporate the hydrological, biological, chemical and physical similarities and differences between natural and artificial lakes (reservoirs). Where feasible, effective monitoring programs conducted by trained citizens can provide accurate, long-term data about the health of a lake and its drainage basin. If properly organized and supervised, citizen monitoring is a relatively simple, low-cost approach for collecting essential lake data and information. Citizen monitoring can be done in collaboration with, or independent of, monitoring and assessment activities undertaken by professionals in governmental agencies, non-governmental organizations and academic/research institutions. Citizen involvement also has the added benefit of increasing awareness and participation in lake management programs.

*Data obtained from accurate, long-term monitoring are essential for making sound lake management decisions.*

?? ***Disseminate and utilize the results of lake monitoring and assessment activities –*** In addition to promoting monitoring efforts and activities for acquiring data for evaluating the state of lakes and their resources, including the use of multidisciplinary, integrated management models, the ***World Lake Vision*** also promotes the widespread dissemination of the results of such activities, both to inform lake stakeholders and to guide lake management actions. Its widespread dissemination facilitates the sharing of lake knowledge and better understanding of the state of lakes and the processes that fundamentally control their conditions.

## *Developing the Capacity of Individuals and Organizations to Manage Lakes for Their Sustainable Use*

??***Create web-based information, online databases and other readily-accessible materials about management of lakes and their resources*** – The ***World Lake Vision*** promotes the establishment and maintenance of electronic fora or other appropriate communication systems to disseminate information and facilitate dialogue about individual lakes, regions and issues of global concern among lake practitioners. One mechanism proving to be beneficial for this purpose is the World Wide Web. Where Internet access is readily available, many lake organizations are moving toward electronic dissemination of materials through electronic-mail (e-mail) lists, web-based electronic forums, and online databases and instructional programs. Other Internet possibilities include access to a clearinghouse for information and notices of relevant events, and to experts or organizations for answering questions regarding sustainable lake use. Although not an exhaustive list, examples of some non-governmental organizations with relevant Internet-based lake monitoring and management information and data, such as

the International Lake Environment Committee Foundation (ILEC), LakeNet, Living Lakes and the Inter-American Water Resources Network (IWRN), are given in Annex 2. Some professional associations and societies dealing with scientific and technical aspects of lake science and management, such as the North American Lake Management Society (NALMS), also maintain websites. A primary goal of these and similar organizations is to facilitate information sharing, training and exchange of experience among technical and non-technical lake management practitioners alike.

Where electronic communication possibilities are difficult to implement, printed newsletters, reports, and mailings based upon traditional postal mailing lists can be an equally effective means of sharing lake data, information and experiences. Typical sponsors of such initiatives include government agencies, non-governmental organizations and academic institutions.

?? ***Establish science and education centers for the compilation, analysis and dissemination of information on lake resources and management issues*** -- The ***World Lake Vision*** promotes the establishment of science and education centers for individual lakes or lake regions. These centers can focus on identifying, compiling, documenting and disseminating information, data and experiences on specific lakes, their problems and their sustainable use. This information ideally should include the economic, ecosystem and cultural importance of specific lakes and their resources, their direct and indirect uses and values, promising tools and strategies for their management, and the lessons learned (successes and failures) from specific case studies. In undertaking these activities, these centers will enhance capacity building in managing lakes for their sustainable use. They also can provide valuable region-specific information. Knowledge and experience gained from studies of lakes in the mid-latitudes, for example, are not necessarily appropriate for assessing and managing tropical lakes, nor are the scientific principles of the former necessarily directly applicable to the latter. Various scientific and educational centers have been established for some lakes, such as the Lake Biwa Museum (Japan), Balaton Limnological Research Institute (Hungary), and Leahy Center of Lake Champlain (USA). These and similar centers throughout the world have demonstrated and promoted the benefits of advancing scientific, educational and community development goals for lakes and their drainage basins. Thus, they serve as models for establishing centers for other lakes, whose sponsorship typically includes private foundations, corporations, government agencies, non-governmental organizations and academic institutions.

?? ***Create more training programs and knowledge transfer opportunities for lake management*** –Capacity building can take place at the individual or group level (covering skills and knowledge requirements), at the institutional or organization level (covering operational and administrative aspects), and at the strategic level (covering legal, political and economic frameworks). In fact, effective training, focusing on building coalitions, managing projects, and increasing monitoring and evaluation skills, is urgently needed in many lake drainage basins for local and national governmental and non-governmental staff. Mismanagement of lakes, arising from the lack of trained staff in many countries, hinders efforts to use lakes in a sustainable manner, or enforcing environmental and other regulations dealing with lake resources.

The ***World Lake Vision*** strongly supports the development of appropriate human resource capabilities to correct such deficiencies, including region-specific training. Inclusion of a component directed to effective capacity-building activities in all water resource investments can provide a means of promoting such training at the international level as well. Several training programs are available free-of-charge, or at very low cost, for almost every aspect of lake management. Examples include courses organized by the International Lake Environment Committee Foundation and the North American Lake Management Society (Annex 2), which are generally oriented toward water professionals and their institutions.

*Educating children about water-related issues is a beneficial long-term measure for achieving sustainable lake use.*

?? ***Implement a public education and awareness program about lakes and their drainage basins*** – Some corrective lake management actions can be as simple as informing lake drainage basin inhabitants about how they can change their work routines or personal habits to reduce or alleviate problems associated with the unsustainable use of lake resources. Use of the educational system, the media, non-governmental organizations, and the religious community can be especially helpful in carrying out this task, providing practical information, guidance and inspiration regarding sustainable lake use. They can help shape positive public attitudes about the threats facing lakes, and the need for their participation in implementing practical solutions to them. Greater public awareness of lake issues is usually facilitated by making details of lake problems and corrective programs readily available to the public. This type of communication also can serve as a type of government feedback to the public, in the form of answers to public questions about individual lakes and their drainage basins.

?? ***Establish exchange programs, "sister lake" partnerships and lake networks*** – Another effective way to share knowledge and experience is by "twinning" individuals, non-governmental organizations and government agencies working on similar lake management issues. There are successful examples of such partnerships that have existed for many years (e.g., the partnership between Lake Toba in Indonesia and Lake Champlain in the United States). At the larger scale, networks such as Lake Net and

Living Lakes can provide a means of fostering goodwill and cooperation among the network members, and facilitating technical and scientific exchanges. These exchanges can take place at any level.

?? ***Establish a grant, mini-grant or other financing program*** -- Developing and supporting small projects and local groups in lake drainage basins is an excellent way to demonstrate or to pilot lake management and conservation measures for lakes and their drainage basins. It also facilitates capacity-building for individuals and non-governmental organizations, an example being the support given by the Laguna Lake Development Authority and the private sector to the local River Rehabilitation and Protection Councils. Many local governments support this type of action through revenue sharing, provision of trust funds, tax incentives, revolving loan funds, micro-banks, and similar mechanisms.

## *Identifying Lake Stakeholders in the Drainage Basin and Facilitating Their Active Involvement*

??***Develop lake-based partnerships*** – To raise awareness of, and bring attention to, the continuing overexploitation and degradation of lakes and their resources, the ***World Lake Vision*** encourages the establishment of comprehensive, practical and, if appropriate, non-traditional stakeholder partnerships at the drainage basin, national and global levels. Stakeholders include all user groups and parties having interests in using specific lakes and their resources, including individuals, government agencies, non-governmental organizations, private sector corporations and agricultural operations, and academic/research institutions. Because stakeholder participation in developing and implementing individual lake visions and action plans is of critical importance in such endeavors, greater efforts are needed to identify and overcome the challenges associated with establishing such partnerships.

?? ***Provide technical and financial assistance, and allow time for involving stakeholders*** -- An important step in the pursuit of sustainable lake use is to make stakeholder involvement a condition of receiving financial assistance or, alternatively, to require that community assistance projects include a participatory approach. Such involvement typically can include individuals, non-governmental organizations and private sector corporations. In contrast, however, technical and financial assistance programs are often provided by government agencies. Universities and research institutions also can offer scientific and technical expertise. Many community assistance projects include a participatory component, but unfortunately do not provide adequate training or allow sufficient time to facilitate stakeholder involvement. Where funds are lacking, however, using simple, low-cost methods to bring stakeholders together provides a means of initiating their involvement. The World Bank and other organizations have developed guidance materials for a participatory rural appraisal technique, as a means of involving citizens and stakeholders in identifying and inventorying local lake resources. The technique was successfully applied in five communities on Lake Toba in Indonesia, for example, to inventory resources, identify issues and develop community-based action plans. Wider use of such techniques is recommended. On an institutional level, some financing options commonly used to share the financial burden among all users and

beneficiaries of lake resources include pollution charges such as the polluter pays principle, catchment, fish, marina and sporting levies, and water tariffs. In addition, tax relief and similar economic incentives can prove useful.


## Implementing and carrying forward the *World Lake Vision*

?? ***Broadly disseminate the World Lake Vision –*** The proponents of the ***World Lake Vision*** should disseminate it to as many stakeholders in as many lake drainage basins, and in as many countries, as possible. This can be done in a number of ways, including publication of the ***World Lake Vision***, developing instructional and descriptive brochures based upon it, disseminating these materials to relevant institutions, non-governmental organizations and others, and conducting workshops and short courses at the national, regional and local levels on critical lake problems, their social and ecological implications, and their possible solutions.

?? ***Use existing regional and global treaties, conventions and protocols to coordinate and implement the World Lake Vision*** -- Some international agreements relevant to protecting and restoring lake ecosystems include the (1) Ramsar Convention on Wetlands of International Importance, (2) Convention on Biological Diversity, (3) Convention to Combat Desertification, (4) United Nations Convention on the Law of the Sea and its protocols, (5) Convention on Transboundary Watercourses and International Lakes, (6) World Heritage Convention, (7) Framework Convention on Climate Change, and (8) Rotterdam Convention for the Prior and Informed Consent. The latter convention procedure for certain hazardous chemicals and pesticides in international trade (IINC/PIC), together with the existing Basel and Stockholm Conventions, can provide a comprehensive and systematic approach to controlling chemical hazards to lakes and other aquatic ecosystems. Thus, countries that have not yet ratified these conventions should be urged to do so, thereby allowing the conventions to enter into force at the

earliest opportunity. International agencies also should work to insure, with appropriate funding assistance, that all countries have the technical and financial capacity to implement the convention's demanding procedures. Countries are likewise encouraged to implement their obligations within the context of such treaties and their associated rules, protocols, and procedures.

?? ***Involve lake stakeholders in developing and implementing local lake visions and action plans*** -- The ***World Lake Vision*** promotes individual lake visions and long-term action plans applicable at the level of the drainage basin. These individual lake activities should follow the principles outlined in the ***World Lake Vision***. They should consider not only the local causes of lake degradation and loss of lake uses, but also those that may be regional, international or even global in nature, including excessive water diversions and withdrawals, water quality degradation, unsustainable fisheries practices, loss of aquatic biodiversity and habitats, long-range transport of airborne pollutants, invasive species, and impacts of climate change such as flood control and drought management. Because lake degradation not only threatens the long-term sustainability of lakes and other aquatic ecosystems, but can also interfere significantly with beneficial human water uses and related economic development activities, securing political and financial support for local lake visions and action plans is both a tremendous challenge and opportunity. Doing so obviously requires the establishment of an appropriate institutional framework, and of partnerships necessary to involve stakeholders in lake management efforts, and in facilitating planning and implementation processes.

?? ***Launch a world lake management initiative*** – During the course of preparing the ***World Lake Vision***, it became clear that some institutional mechanism was essential if the ***World Lake Vision*** was to be promoted and effectively implemented. One significant opportunity for achieving this goal, consistent with the desire to carry the ***World Lake Vision*** forward as a living document to guide the development, sustainable use and protection of these vital global water resources for meeting human and ecosystem water needs, is to establish a global lake alliance, as previously called for in the 9th World Lakes Conference. An organization of this type could take many forms, one example being a virtual alliance comprised of water resources professionals, individuals and other interested entities. In fact, the organizations whose representatives served on the ***World Lake Vision*** Committee, as identified in the Internet web page http://www.worldlakes.org/vision.html, provide a good approximation of such an alliance. Whether this entity ultimately is a governmental, non-governmental or international organization, the ***World Lake Vision*** can be maintained, updated and periodically revised through such a mechanism as a useful and living document to guide actions and programs for the sustainable use of the world's lakes.

*In the century that lies ahead, humanity faces the challenge of developing a civilization fit for a finite planet, and one equipped to deal with a mounting scarcity of essential resources such as freshwater. The world's lakes, which are a primary source and storehouse of the world's easily-accessible freshwater, will be a critical arena in this great transition to a society which sustains itself without degrading and depleting its own natural foundation. Many of these lakes are already in jeopardy. The World Lake Vision*

*aims to illuminate this growing crisis, to articulate principles to guide this transition toward managing lakes for their sustainable use, and to provide a practical blueprint for insuring the long-term health of lakes and the integrity of the freshwater required by human societies for their survival and economic development, and for maintaining life-supporting ecosystems. Indeed, if we are able to use lakes in a sustainable and responsible manner, there is much hope we can meet the needs of the human and natural communities that depend on them for clean freshwater resources, the key to life.*

# *ANNEXES*

## Annex 1

### Glossary of Terms

?? *Algae* -- Microscopic-sized, free-floating aquatic plants, whose dense growth can result in "algal blooms," degraded water quality and interference with beneficial water uses.

?? *Aquatic ecosystems* -- Referring to the totality of the living organisms and non-living components of an aquatic system, such as lakes, rivers or ponds.

?? *Best management practices* -- Technically- and economically-feasible measures and activities for reducing environmental contamination or degradation, based on the local conditions and capabilities for addressing the problems.

?? *Biodiversity* – Biological diversity commonly refers to the magnitude and range of different species and biological communities living in aquatic and terrestrial ecosystems.

?? *Buffer zones* -- A transition zone between terrestrial and aquatic ecosystems, meant to protect the aquatic system from land-based pollution runoff, and often containing vegetation or grass meant to slow water velocity and/or trap sediments and pollutants.

?? *Climate change* -- Referring primarily to the process of global warming.

?? *Disease vectors* -- Organisms whose life cycles involve some contact with water systems, and that are capable of carrying or transmitting diseases.

?? *Drainage basin* -- The total land area from which water drains into a river system.

?? *Ecotourism* -- Tourism activities based on the conservation, preservation and exhibition of terrestrial and aquatic ecosystems.

?? *Environmental audits* -- A process to assess the nature and extent of environmental concerns at existing facilities, plants and other potential pollution sources.

?? *Environmentally-sound technologies* -- Measures and procedures that are less polluting, use resources in a sustainable manner, recycle more wastes, and handle residues in an environmentally acceptable way.

?? *Emissions* -- Discharges, including pollutants, into receiving waters, the atmosphere and/or onto the land surface.

?? *Eutrophication* -- The nutrient enrichment of lakes and reservoirs, resulting in excessive growths of algae and aquatic plants, degrading water quality and interfering with beneficial human water uses.

?? *Groundwater aquifer* -- The underground basin containing abundant water that has percolated or otherwise entered it from the land surface.

?? *Integrated water resource management* -- Management of water systems for their sustainable use, including identification and reconciliation of scientific, technical, social and economic factors.

?? *Invasive species* -- Non-native organisms entering a given ecosystem in which they did not previous exist.

?? *Lake drainage basin* -- The total land area from which water drains into and flows from a central lake system.

?? *Littoral zone* -- The portion of the lake near the shoreline, in contrast to the open waters of the lake.

?? *No till/low till plowing* – Agricultural practices that eliminate or minimize the need to disturb the land surface by plowing.

?? *Nonpoint sources* -- referring to diffuse pollution sources resulting from storm-generated land runoff, and whose entry point into receiving waters cannot be readily identified or quantified.

?? *Persistent organic pollutants* – Organic chemicals that are stable and persist over long periods of time, that tend to accumulate in the tissues of humans and other organisms, and in lake bottom sediments, and that can cause cancer, tumors and/or birth defects.

?? *Point sources* -- Referring to pollution sources that enter receiving waters at identifiable points, via distinct pipelines or channels, and from which pollutant loads can be readily quantified with traditional hydraulic techniques.

?? *Rainwater harvesting* -- The process of gathering and storing precipitation for use at later times.

?? *Stakeholders* -- Referring to the range of persons having an interest in using, protecting and/or sustaining lakes, their drainage basins and their resources.

?? *Sustainable approach* -- A process or approach whereby the long-term use, rather than rapid or unbridled depletion, of a natural resource is the goal.

?? *Water budget* -- A calculation of all the water inflows and water extractions in a given drainage basin.

?? *Water column* -- Referring to the water in lakes, from its surface to the bottom.

?? *Transboundary* -- A lake or other water system shared and/or used by two or more countries.

# Annex 2

## Examples of Sources for Additional Information Relevant to the Management of Lakes and Their Resources

**Reports and Publications**


Cosgrove, W.J. and F.R. Rijsberman. 2000. *World Water Vision. Making Water Everybody's Business*. World Water Council, Earthscan Publications Ltd, London, United Kingdom. 108 p.

Grey, D., E. Gilgan-Hunt, N.P. Sharma, D. Torbjorn and V.Okaru. 1996. *African Water Resources: Challenges and Opportunities for Sustainable Development*. World Bank Technical Paper No. 331, Washington DC, United States of America. 144 p.

International Lake Environment Foundation. *Guidelines of Lake Management Series*, volumes 1 through 10. ILEC, Shiga, Japan.

International Lake Environment Foundation. *Lake Data Book Series*, volumes 1 through 5. ILEC, Shiga, Japan.

Reimold, R.J. 1998. *Watershed Management. Practice, Policies and Coordination*. McGraw-Hill, New York, United States of America. 391 p.

United Nations. 1993. *Report of the United Nations Conference on Environment and Development*. Resolutions Adopted by the Conference. United Nations Report A/CONF.151/26/Rev.1, Volume 1, Rio de Janeiro, 3-14 June, 1992. 486 p.

United Nations Environment Programme and Wetlands International. 1997. Wetlands and Integrated River Basin Management. UNEP (Nairobi, Kenya) and Wetlands International-Asia Pacific, Kuala Lumpur, Malaysia. 346 p.

United Nations Environment Programme. 1999. *Global Environment Outlook 2000. Past, Present and Future Perspectives.* Earthscan, London, United Kingdom. 398 p.

United Nations Environment Programme. 2002. *Global Environment Outlook 3. Past, Present and Future Perspectives.* Earthscan, London, United Kingdom. 446 p.

United Nations Environment Programme-International Environmental Technology Centre. 1999. *Planning and Management of Lakes and Reservoirs: An Integrated Approach to Eutrophication*. UNEP-IETC Technical Publication Series 11, Shiga, Japan. 375 p.

United Nations Environment Programme, Shiga Prefectural Government, International Lake Environment Foundation. 2002. *Proceedings of International Symposium on Building Partnerships between Citizens and Local Governments for Sustainable Lake Management*. UNEP-IETC Freshwater Management Series No. 3, Shiga, Japan. 157 p.

Watson, R.T., M.C. Zinyowera, R.H. Moss and D.J. Dokken. 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability.* Cambridge University Press, Cambridge, United Kingdom. 517 p.

World Commission on Dams. 2000. *Dams and Development. A New Framework for Decision-Making*. Earthscan, London, United Kingdom. 404 p.

World Meteorological Organization. 1992. *The Dublin Statement and Report of the Conference*. International Conference on Water and the Environment: Development Issues for the 21st Century, World Meteorological Organization, Geneva, Switzerland. 55 p.

Zalewski, M. 2002. *Guidelines for the Integrated Management of the Watershed—Phytotechnology and Ecohydrology.* United Nations Environment Programme-International Environmental Technology Centre, Freshwater Management Series No. 5, Shiga, Japan. 188 p.

**Web-based Resources**

Global Water Partnership (http://www.gwpforum.org)
Inter-American Water Resources Network (http://www.iwrn.net)
International Association for Great Lakes Research (http://www.iaglr.org)
International Association of Theoretical and Applied Limnology (http://www.limnology.org)
International Lake Environment Committee Foundation (http://www.ilec.or.jp)
International Network of Basin Organizations (http://www.inbo-news.org)
International Water Association (http://www.iwa.org)
International Water Resources Association (http://iwra.siu.edu)
Lake Champlain Basin Program (http://www.lcbp.org)
LakeNet (http://www.worldlakes.org)
Living Lakes (http://www.livinglakes.org)
North American Lake Management Society (http://www.nalms.org)
Peipsi Center for Transboundary Management (http://www.ctc.ee)
United Nations Education, Scientific and Cultural Organization, International Hydrological Programme (http://www.unesco.org)
United Nations Environment Programme (http://www.unep.org)
World Water Council (http://www.worldwatercouncil.org)

# Annex 3

## *World Lake Vision* Committee and Drafting Committee Members

**Individuals**

| | |
|---|---|
| Tatuo Kira (Chairman) | International Lake Environment Committee Foundation |
| Chris H.D. Magadza (Vice Chairman) | University of Zimbabwe (Zimbabwe) |
| Walter Rast* (Chair, Drafting Committee) | Southwest Texas State University (USA) |
| Motokazu Ando | Tokyo University of Agriculture |
| David Read Barker | LakeNet |
| Adelina C. Santos-Borja* | Laguna Lake Development Authority |
| Aitken Clark | Living Lakes |
| Denis Fourmeau | International Network of Basin Organizations |
| Liza Gonzalez | Ministry of Environment & Natural Resources, Nicaragua |
| Buzz Hoerr | Lake Champlain Basin Program |
| Shinji Ide | Kosho Net |
| Libor Jansky | United Nations University |
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| Yukiko Kada | Kyoto Seika University/ Lake Biwa Museum |
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| Aurora Michel | Sociedad Amigos del Lago de Chapala A.C. |
| Masahisa Nakamura* | Lake Biwa Research Institute |
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| Eric Odada* | University of Nairobi/ Pan-African START Secretariat |
| Mario Francisco Revollo* | Binational Autonomous Authority of the Lake Titicaca |
| Vicente Santiago | UNEP-International Environment Technology Centre |
| Dongil Seo* | North America Lake Management Society Chungnam National University |
| Payaman Simanjuntak* | Lake Toba Heritage Foundation |
| Juan Skinner | Lake Atitlán Sustainable Management Authority |
| Jeff Thornton* | Southeastern Wisconsin Regional Planning Commission International Environmental Management Service Limited |
| Maciej Zalewski | International Center for Ecology/ Polish Academy of Sciences |

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***Drafting Committee Members***

# Annex 4

## Other individuals and organizations contributing to World Lake Vision

**Individuals:**

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**Organizations:**

Environment Canada, Government of State of Michigan (USA), Great Lakes Commission (USA), International Association for Great Lake Research (IAGLR), International Environmental Management Services Ltd (IEMS), Third World Water Forum Secretariat, Global Water Partnership

# Annex 5

## World Lake Vision Meetings and Consultations

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|---|---|---|
| 2001 | Sept. 4-6 (Shiga, Japan) | Workshop: Toward a World Lake Vision |
| 2002 | July 26-28 (Shiga, Japan) | Task Force Meeting |
| | Aug. 1-4 (Shiga, Japan) | World Lake Vision Preparation Meeting (1st Draft) |
| | Aug. 27 (Johannesburg, South Africa) | World Lake Vision Meeting (Proposal of Vision) |
| | Sept. 26-28 (Shiga, Japan) | World Lake Vision Committee Inaugural Meeting<br>World Lake Vision Workshop (2nd Draft) |
| | Oct. 15-19 (Cleveland, USA) | World Lake Vision Consultation Meeting (3rd Draft) |
| | Dec. 15 (Shiga, Japan) | World Lake Vision Symposium |
| | Dec. 16-18 (Shiga, Japan) | World Lake Vision Workshop (4th Draft) |
| 2003 | Feb. 24-25 (Shiga, Japan) | World Lake Vision Committee Meeting<br>(Final Draft) |
| | March 20 (Shiga, Japan) | The 3rd World Water Forum (Official Launch of the World Lake Vision) |

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Photo Credits: The photographs contained in this document were provided by members of the World Lake Vision Committee or others associated with the development of the World Lake Vision. Their contributions are gratefully acknowledged.

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**Supporting Organizations for the World Lake Vision**