

Transboundary Lake Basin Management: Laurentian and African Great Lakes



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ACRONYMS

BMU	Beach Management Unit
COM	Council of Ministers
EAC	East African Community
EC	Environment Canada
GCM	General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GLFC	Great Lakes Fishery Commission
GLWQA	Great Lakes Water Quality Agreement
GLRO	Great Lakes Regional Office
FFMP	Fisheries Framework Management Plan
IAGLR	International Association for Great Lakes Research
IJC	International Joint Commission
LaMP	Lakewide Management Plan
LTA	Lake Tanganyika Authority
LVBC	Lake Victoria Basin Commission
LVDP	Lake Victoria Development Program
LVEMP	Lake Victoria Environmental Management Project
LVFO	Lake Victoria Fisheries Organization
NTWC	National Taskforce on Water Hyacinth Control
PFOS	Perfluorooctanesulfonate
PLUARG	Pollution from Land Use Activities
RAPs	Remedial Action Plans
REGZ	Regional Economic Growth Zone
UNU	United Nations University
UNU-INWEH	United Nations University, International Network on Water Environment and Health
USEPA	United States Environment Protection Agency
SAP	Strategic Action Programme
WQ	Water Quality
WQB	Water Quality Board

PREFACE

The Great Lakes systems in Africa and North America are an invaluable resource for freshwater, biological diversity and natural beauty. Equally important is their role in sustaining human populations surrounding them. That multiple countries share these lake systems within their respective boundaries makes a great challenge for balancing human development needs against ecosystem protection and restoration. A number of multinational governance systems are designed to grapple with these challenges.

UNU-INWEH, as an honest broker of knowledge and information, took on the role to facilitate a dialogue amongst these Great Lakes' governance systems. This led to the creation of the Lake Twinning initiative with strong support from the Global Environment Facility and the United Nations Development Programme.

The Lake Twinning initiative revolves around the concept of sharing experiences between the lake governance commissions for the African and Laurentian Great Lakes. This joint collaboration has directly engaged five key lake commissions – the Lake Victoria Basin Commission, the Lake Victoria Fisheries Organization, the International Joint Commission, the Great Lakes Fishery Commission and the Lake Tanganyika Authority – and many national and international partners. Multi-stakeholder policy dialogues in Entebbe (Uganda) and Niagara Falls (Canada) have clearly demonstrated that such sharing can bring about significant improvements in management of these large lake systems. Such cooperation is directly linked to sustainable livelihoods for all, reduction of poverty in the riparian countries in Africa, and rich and robust ecosystems.

This report summarizes issues discussed during the dialogues – a summary for decision-makers provides key lessons learned up front. It comprises the following sections: an introduction, followed by discussions of the main drivers of change and stress in great lakes systems, transboundary governance, transboundary lake basin management regimes, and regional and trans-continental connections. Some annexes provide more details about the lakes and a summary of their existing governance structures.

We believe that this report offers useful and usable insights for governance of lake systems. This also provides us a stepping stone for future endeavour based on the Great Lakes' Twinning Framework developed within this initiative – something we are discussing with our partners.

Dr. Zafar Adeel, Director, UNU-INWEH

Transboundary Lake Basin Management: Laurentian and African Great Lakes



Lessons in Lake Twinning: A Synthesis of Dialogues on Transboundary Lake Management

The twinning of lake-governance systems offers unconventional learning opportunities. It allows twinned organizations to learn from each other's mistakes and use that information to explain to stakeholders why a management practice should not be tried. Similarly, they can learn from successes and use these to good advantage. Importantly, the notion of twinning fosters collaboration and information sharing among a wide range of professionals and stakeholders about science and management. Such cross-fertilization of ideas provides decision-makers a stronger base for sound political decisions.



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LESSONS IN LAKE TWINNING: A SYNTHESIS OF DIALOGUES ON TRANSBOUNDARY LAKE MANAGEMENT

Twinning helps organizations be more strategic in their initiatives and use of funds and staff. Organizations that engage in collaborative approaches to natural resource management have the benefit of leveraging resources with each other so that scarce time, staff, and funds can be put to best use. Research agendas can be developed in ways that seek solutions to shared problems, not simply focus on local or immediate needs.

SOME LESSONS LEARNED FROM THE LAKE TWINNING EXERCISE:

Institutionalizing science and policy linkages is vital for managers of large lake ecosystems with large watersheds that transcend multiple jurisdictional boundaries. There is clear recognition that science should not be confined to open waters but rather should encompass watershed and socio-economic issues that impact lake water quality and quantity. Socio-economic considerations should include full-cost accounting of shared costs and benefits of resource uses as part of better understanding of the ways and means of achieving sustainability. Institutional arrangements are needed to support development of linkages between science producers and decision makers, and to foster integrated water resources management practices that will catalyze implementation of basin-wide policies to sustain long-term resource protection. These should include a visioning process with the public and stakeholders to obtain buy-in and support for science-based management programs and policies.

African organizations can benefit from studying the North American approach of integrated multi-sectoral management of lake resources, and North American organizations can benefit from co-developing policy appraisal techniques with their younger sister organizations in Africa. The new governance structures being implemented in Lake Victoria provided a useful contrast to the century old structure in the Laurentian Great Lakes. The regular reporting to a tri-national ministerial committee

is instructive: something that North American governments and the IJC do not have.

Decision-making in African Great Lakes needs to be expanded to include a wider group of stakeholders. The decision making in North America appears to be a multi-organization and multi-stakeholder process, whereas the opposite is true for African Great Lakes where decisions are made and implemented by relatively much smaller groups. In particular, community engagement is a critical element. The East African lake commissions have just started a coordinated process through development of the shared vision, while the North America process was well entrenched through various voluntary associations and groupings, including academia. Consequently, public influence on policy seems to be more evident in North American lakes than in the East African, though first steps have been taken there.

The beach management units used in African Great Lakes offer a model that could possibly be explored for applicability to situations in the Laurentian Great Lakes. This model goes well beyond the Remedial Action Plan (RAP) program and connected to watershed and sub-watershed management with intense civic engagement supported by government technical expertise. Participants, through participation in the workshops, gained new overarching perspectives, knowledge, and understanding of global

OUTCOME OF THE LAKE TWINNING EXERCISE: A COOPERATION FRAMEWORK

The Lake Twinning dialogues provided the opportunity for continued comparative analysis of lake management between the North American and African systems. This has led to development a framework for cooperation and collaboration on Great Lakes systems through enhanced science and policy linkages. The following high-priority areas for joint research, studies, and investigations have been identified:

- **Climate change** (adaptation/mitigation), with a focus on modeling change in lake ecosystems, undertaking vulnerability mapping, and developing management strategies for adaptation.
- **Governance structure**, with a focus on comparative analysis of governance structures to facilitate policy, legal and institutional reform for transboundary waters management.



issues in fresh-water natural resource management. These will be important in identifying common theoretical and applied fisheries resource management concepts, defining ecosystem health for the management of large lake systems, and clarifying the relationship between the two.

The principles of Integrated Water Resources Management (IWRM) are being applied in both Great Lakes systems although to quite differing levels of implementation. In the East African region, this principle now forms the basis for administrative water resources management arrangements in the various countries; however this is not the case in North America countries, which base theirs on federal and state systems. The concept of adaptive management was welcomed and could be an added tool to IWRM for resources (fish and water) management in both systems.

Uncertainties regarding fish biomass and fish catches in the African Great Lakes are still too great to form the basis for adaptive management. Therefore the precautionary approach would still be the optimal way of addressing fisheries problems as too many livelihoods and investments are at stake. The (North American) GLFC considers that adaptive management has the potential to allow a greater understanding of how freshwater ecosystems respond to human actions, including fishing and land use

in the drainage basin. Adaptive management can lead to effective resource management approaches if there is sufficient scientific and political will to allow truly adaptive management regimes to occur.

It is critical to formulate an agreed methodology for assigning value to environmental benefits so that benefits can be shared fairly and conflict is avoided.

By this, riparian countries (or appointed bodies such as commissions) would inventory all the benefits generated for the entire basin, including use of water for drinking, hydro power, tourism fees, fishing permit fees, permits for aquaculture, bio-diversity fees, and cultural importance fees. Rates or fees should be set at the national levels but collected locally, which would encourage broader engagement.

Development of efficient mechanisms for information and data exchange is essential and forms the core of joint monitoring and assessment. Success in developing such mechanisms will require adoption of common terminology among riparian nations; harmonized or comparable methodologies for collecting data and information; uniform reporting procedures; and identifying targets for planning purposes across the riparian nations.

- **Human wellbeing**, with a focus on educating communities on the relationship between their actions and the health of lakes, and the linkages between the status of lakes (water quality) and human wellbeing. It was also suggested that joint research should be undertaken for natural resources evaluation to determine the economic value of the environmental services provided by the Great Lakes.
- **Public-private partnerships**, with a focus on systematic analysis of partnerships, engagement of the private sector, fostering public-private partnerships, and sustainability of these partnerships.
- **Gender equity**, with a focus on involving women when developing a new water management regime or water policies.
- **Ecosystem approaches and management**, with a focus on integrated management of land, water and living resources to promote conservation and sustainable use of resources. Some topics that need detailed research are groundwater aquifer management, invasive species, pollution control, water quality standards, and effective monitoring strategies for ecologically complex interactions.

SUCCESSFUL TWINNING: A MODEL

The Lake Victoria Fisheries Organization (LVFO) and the Great Lakes Fishery Commission (GLFC) have twinned for nearly two decades, to their mutual benefit.

Similarities and Shared Challenges

Lake Victoria and the Laurentian Great Lakes both have thriving freshwater fisheries and resident populations dependent on the resources for food and water. They are both integrated into global economic markets. Both regions face similar challenges such as sustaining fish stocks, dealing with changing water levels, managing habitat loss, preventing and controlling invasive species, integrating land use decisions into ecosystem management, and addressing negative externalities of globalization. With Lake Victoria shared by three countries and the Laurentian Great Lakes by two countries (including eight states, the Province of Ontario, and indigenous populations), sustainable management of the fisheries involves biological and political complexities.

How it is Done

The two organizations signed a memorandum of understanding that formally twins them and outlines areas for collaboration. It provides a formal, non-binding linkage between these two major fishery institutions and is designed to help them better understand the fisheries resource of large bodies of freshwater; improve interactions and outreach with the people who depend on the resources; enhance contributions to scientific and other forums; and encourage research and student mentoring.

Scientific Exchange

The LVFO and the GLFC have committed to the free exchange of social and natural science information, when appropriate, to improve their mutual understanding of the natural processes of large freshwater ecosystems and their fisheries. Both organizations have agreed to designate staff liaisons to keep the relationship fresh and consistent with the memorandum and have agreed to meet periodically to exchange information and conduct other business of mutual interest.

Collaboration Amongst Officials

Scientists in both organizations pledged to collaborate on scientific papers and presentations, with the goal of publication in respected journals or delivery at professional conferences. Professional staff members at the LVFO and the GLFC are active members of the scientific community. They are called upon regularly to contribute to the peer-reviewed literature and to present their research findings to the broader community during symposia and conferences. Papers and presentations are consistent with the research direction outlined in either organization's research programs or in the large lakes research theme to be developed jointly by the LVFO and the GLFC. The overall intent is to bring more transboundary, cross-continental thinking into the literature.

Identification of and Commitment to a Shared Research Agenda

The twinned organizations agreed to work together to develop a "research theme" for large freshwater lakes and their fisheries and to provide a set of research questions to guide solicitation and development of meaningful research projects. They have also agreed to encourage research by fostering student mentoring, supporting student exchange, providing student access to office space and archives, and making senior scientific staff available to mentor researchers.



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SECTION 1: INTRODUCTION

Natural resources do not recognize political boundaries. When natural resources cross borders, cooperation among countries and regions is essential for effective sustainable management. Without cooperation, the integrity of shared resources can be jeopardized by unsustainable use by one or other of the parties involved. The waters and fisheries of Great Lakes of the world provide enormous economic benefits for the peoples of surrounding countries and regions. Sustainable management of these resources requires informed and effective multi-jurisdictional, collaborative management.

To address threats to freshwater natural resources on multi- and trans-national scales, stakeholder organizations from North America and Africa developed the project *Regional Dialogue and Twinning to Improve Trans-boundary Water Resources Governance in Africa*, funded under the Global Environmental Facility (GEF) Medium Sized Projects (MSP).

Lake Twinning is part of this MSP and is intended to facilitate policy, legal and institutional reform for trans-boundary waters management, through comparative analysis of African and Laurentian Great-Lakes systems; to enhance regional and national capacities for integrated management of shared water resource systems; and to strengthen participatory planning to help establish self-sustaining regional water institutions in Africa. The project involves more than 15 institutions, including the International Joint Commission (IJC), Great Lake Fishery Commission (GLFC), Lake Victoria Fisheries Commission (LVFC), Lake Victoria Basin Commission (LVBC), Lake Tanganyika Authority (LTA), United Nations University-INWEH, UNDP, UNOPS, and McMaster University.

Discovering and documenting the benefits of twinning the Laurentian and East African Great Lakes was a central theme of the project.

It was recognized that those responsible for managing transboundary lakes face common challenges, including water quality issues, fluctuating water levels, fisheries management (resource management), and control of invasive species. It was also realized that there would be significant differences between lakes, including geography, hydrology, history and governance. Nonetheless, sharing experiences in managing large lakes will help decision makers and other stakeholders find a faster route to more effective management strategies.



SECTION 2: MAIN DRIVERS OF CHANGE/STRESS IN GREAT LAKE SYSTEMS

The main drivers identified are the following: land use, invasive species, toxic chemicals, climate change and water exploitation. Each is described briefly below.

LAND USE

The catchments of all the Great Lakes have experienced land-use changes in response to population increase, with consequent demands for agricultural production and other resources. Clearing of land for agriculture, lumbering, and human settlement results in increased surface run-off and increased sediment and nutrient input to the lakes. Charcoal harvesting is a major cause of deforestation in the African Great Lakes. Extensive watershed deforestation in most of the African region has been clearly evident in the last few decades, and dates back to as early as the late-18th to the early-19th centuries in the northern part of the Lake Tanganyika catchment. Historical land-use changes in the catchments of the Laurentian lakes are well documented. Land use in the catchments of the Laurentian lakes involves large-scale farming, which uses significant quantities of fertilizers, pesticides and herbicides, some of which are transported into the lakes through surface runoff. In contrast, land use in the catchments of the African Great Lakes is mainly subsistence farming, which

High levels of nutrients, for example phosphorus and nitrogen, increase eutrophication and proliferation of weeds, such as water hyacinth.

uses bush burning to clear the land. Bush burning, together with wind-bound dust, has been suggested as a major source of atmospheric phosphorus input to the African Great Lakes.

Impacts of land-use changes include:

- **lake water quality:** increased urbanization and growth along the lakes have intensified agricultural expansion and industrial growth, resulting in increased runoff with sediments, pollutants, and pesticides. This has greatly influenced the water quality in lakes, usually for the worse;

- **deforestation** has led to loss of biodiversity, increased soil erosion, and impacts on precipitation and lake levels;
- **increased eutrophication:** in the African Great lakes, point sources of phosphorus from urban centres have been identified as contributing to eutrophication of the nearshore areas;
- **more frequent algal blooms** in lakes as a result of excess nutrients.



INVASIVE SPECIES

Laurentian and African Great Lakes have one or more invasive species, introduced intentionally or accidentally. (See Table 1 for a list of some of these). Today, the Laurentian lakes harbour more than 185 non-native species, many of which entered the lakes accidentally. Major invaders include the alewife, round goby, zebra and quagga mussels, spiny water flea, fishhook water flea, Eurasian ruffe, and, among the worst, the sea lamprey. Three species of Asian carp—the silver, bighead, and black—currently loom. The rate of introduction into the Great Lakes has not slowed in recent years, about one new species every nine months. Species originate from the far reaches of the globe. Ballast water (water taken on board to stabilize the vessel) is a major source of new invasive species, and the regulatory regime to manage ballast is inadequate to protect the Laurentian lakes. Canals and waterways are another vector, as are recreational activities, aquaculture, and the trade of live organisms (for the live seafood industry, pet trade, ornamental gardens, food, etc.). Many scientists believe that the Great Lakes harbour many more exotic species than is known. A coordinated, basin-wide effort to monitor new species has not been established; hence, a definitive picture of the situation is not available. To date, decision makers have given much attention to large or prominent organisms such as sea lampreys, Asian carp, and round gobies; however, the introduction of micro-organisms and pathogens is an increasing concern for human and ecosystem health.

Invasive species are economically and ecologically costly. According to the International Association for Great Lakes Research, a small portion of the aquatic invasive species actually becomes established, and only a small portion of the established species (perhaps 15%) becomes harmful and spread. However, the small number of harmful invaders has been costly to the region. Although economic damage is hard to

In Africa, invasive wetland species have been introduced as decorative plants and animals, for horticulture, aquarium, and other uses.

quantify, the consensus is that the cumulative economic costs over the past century have been in the hundreds of billions of dollars. The ecological damages are significant, even if not precisely measurable.

Invasive species can rarely be eradicated but they can be controlled. Control is always expensive and time-consuming but can result in sustained ecosystem integrity. A recent preliminary survey on invasives in the African Great Lakes region reported the occurrence of 37 species. Out of these, 20 are plants, 5 vertebrates, 9 insects, 1 is an invertebrate and 2 are micro-organisms.

Some of the major invaders are water hyacinth, red water fern, water lettuce, Nile cabbage, waterfern, giant sensitive plant, parrot feather, aquatic herb, pickerel weed bulrush, Nile perch, tilapia, and common carp. Water hyacinth has also spread to smaller water bodies. One of the newer invasive species that has not yet invaded all the African Great Lakes is the Louisiana crayfish, originating from the southern United States of America.

This species is hard to control and can destroy native wetland vegetation, such as water lilies and submerged vegetation.

To prevent large-scale damage to the Laurentian lakes and to other waters of the U.S. and Canada, governments must view the problem from a global perspective and understand that all of the many possible vectors for invasive species must be addressed.

Decision makers in the Laurentian lakes and the African lakes have responded to aquatic invasive species in different ways. In the Laurentian lakes, officials have understood the adverse economic and ecological impacts of aquatic invasive species and have taken the view that prevention, not adaptation, is paramount. Many states, the Province of Ontario, and the federal governments of the U.S. and Canada prohibit the use or movement of most harmful invasive species. Moreover, intentional introductions of new species—once viewed as acceptable—are today seen by most management agencies as too risky to attempt. In the African lakes, on the other hand, exotic species have been seen as an economic driver. In Lake Victoria, the two main exotic species—Nile perch and tilapia—are now dominant in the ecosystem and serve as the foundation of the lake's fishery. People and industries have become dependent on these two species for income and sustenance. In Africa, an effort has been made to share the list of invasive species, which has created a platform for building local, national, and regional management strategies and linkages. However, gaps are still apparent and there is a need to strengthen linkages among community groups, non-governmental organizations and governments. Overall, one might conclude that exotic species are an economic and ecological sink in the Laurentian lakes and an economic (though not an ecological) driver in the African lakes.

TOXIC CHEMICALS

The presence of toxic contaminants in lakes is a major problem and an important management issue. The accumulation of toxins in the Great Lakes is largely the result of industrial and agricultural build-up along lakeshores over the past hundred years. With early industrialization and farming, few, if any, regulatory requirements protecting lake quality were in place; consequently, many toxins were added to the lake systems. During the 20th century, many new chemicals were used in agricultural production, and were later discovered to have severe effects on the ecosystem. Mineral-based industries were situated on the lakes because of the ease with which materials could be transported. An unfortunate side effect of those locations has been that wastes have been intentionally and accidentally dumped into the lakes. While there has been significant progress in the control of such point-source pollution (where polluters can be directly identified), non-point source pollution (where the sources are diffuse or even unknown) remains much more difficult to control or regulate.

More than 360 chemical compounds have been found and identified in the Laurentian Great Lakes including persistent toxic chemicals, alkylated lead, benzo(a)pyrene, DDT, mercury and mirex, which are dangerous to human health and aquatic ecosystems. Contaminants of greatest concern in the Laurentian lakes are heavy metals (e.g. mercury), persistent organic pollutants, PCBs, dioxins/furans, chlorinated pesticides, and toxaphene. Monitoring of many of these chemicals has been conducted since the 1970s and indicates that many of the monitored chemicals are declining in concentration. Despite this decline, these chemicals still pose risks to Great Lake ecosystems and to humans. Furthermore, a number of chemicals are now emerging as a cause of concern including perfluorooctanesulfonate (PFOS), which is commonly used in flame-retardants, as well as various pharmaceutical compounds including antibiotics, steroids, synthetic hormones, and endocrine disrupters such as surfactants and musks. Indeed, the focus is shifting from industrial point sources to dispersed release of chemicals and substances in consumer products, cosmetics, personal care products and pharmaceuticals. These new threats require new analyses and risk management approaches. In addition to chemicals, pathogens such as bacteria, protozoa, fungi, and viruses can cause disease in humans, animals, or plants.

In Lake Victoria, pollution from diffuse sources (such as silting and agrochemicals) and point sources, (such as industrial waste water effluent, solid wastes and domestic sewage) is a major problem. Major contaminants causing concern

are lead and mercury. Because of the importance of the fishery to both domestic consumption and export, exposure to mercury is a primary concern for populations who are dependent on fish and have low tolerance: for example, pregnant and nursing mothers. Fortunately mercury is still relatively low in fisheries of the African lakes, but vigilance is required to prevent future contamination as societies develop industrial capacities. Currently biomass burning is likely the major source of mercury to the African lakes. Other contaminants come from industries such as tanneries, breweries, sugar refineries, pulp and paper operators, soft drink and food processing factories, oil and soap mills, and mining companies.

Despite the fact that different chemicals and different routes of entry are involved in each case, the common element for the Laurentian lakes and African lakes is the ongoing need for surveillance and monitoring.

CLIMATE CHANGE

The effects of climate change on ecosystems of the African Great Lakes and Laurentian Great Lakes are projected to increase in severity. In the Laurentian Great Lakes, climate change is reported to have led to an increased annual average temperature, resulting in shorter winters, shorter duration of ice cover, increased evaporation, and heavy winter precipitation of rain and snow. In the African Great Lakes, climate change has been associated with increased water column stability leading to changes in nutrient cycling and biogeochemical cycles. The periodic hypolimnetic anoxia in Lake Victoria has partly been blamed on climate change, and in Lake Tanganyika warming during the past century has been associated with increased density gradients, which has slowed vertical mixing and reduced primary production. Increased modelling, monitoring, and analysis of the effects of climate change on Great Lakes ecosystems are required to help in decision making and policy formulation.

Effective management of lake water quality is challenging due to fluctuating water levels, climate change issues, and gaps in data.

Climate questions in the context of the Great Lakes have shifted from *whether they are warming to how much they will warm and what will be the impacts.* The world's lakes are warming, and the size of Great Lakes does not protect them from related impacts. Significant warming trends over the past century have now been reported not only for the Laurentian Great Lakes, but also for the three largest African Great Lakes, Tanganyika, Malawi, and Victoria.

The significant warming of the African lakes might be considered surprising because they are already quite warm, and atmospheric temperature changes have been greater at higher latitudes and considered to be rather minor at low latitudes. Most global climate models are in agreement that the atmosphere will continue to change due to anthropogenic CO₂ increasing over the next century at even faster rates than realized in the past century; and that warming may be of similar magnitude at both high and low latitudes.

Concern about the warming of African lakes focuses on impacts on productivity because these lakes host some of the largest fisheries in the world; and also on the stability of water levels, because the lakes are in delicate hydrologic balance, with gains and losses of water directly across their surface dominating their water budgets. The issue of climate impacts on productivity is complicated by the fact that the lakes are suffering anthropogenic eutrophication due to increasing nutrient inputs from their catchments. Current high nutrient loading may be reinforcing or may be counteracting some of the possible impacts of climate on lake productivity. The issue of water balance is difficult to resolve because future projections of gains and losses in the water budget can be no more certain than the future projections of precipitation and winds over the lakes, and so far there is no agreement on projections of precipitation and winds over the lakes among various General Circulation Models (GCMs) available for such projections.

Greater effort is needed to forecast hydrodynamic and ecological responses to climate change in the African lakes. This uncertainty is compounded by the rudimentary nature of GCMs when extrapolated to mesoscale applications needed to assess future impacts on the Great Lakes and their catchments. Broadly, the effects of changes in climate on the aquatic resources of the African lakes include the following:

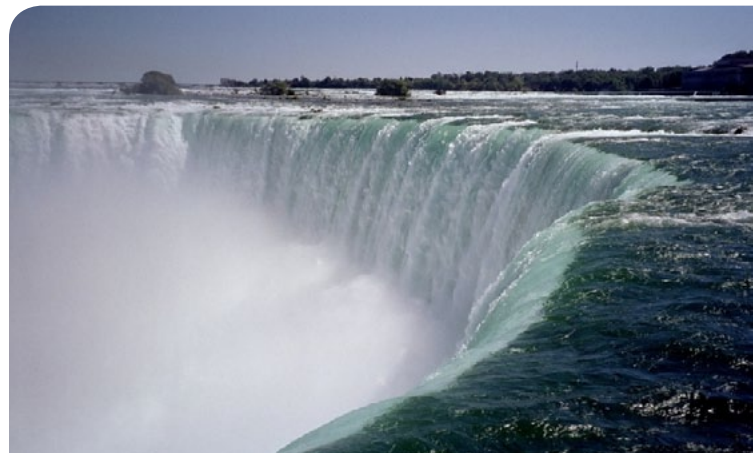
- **in permanently stratified deep lakes,** deep waters are warming, but not as rapidly as surface waters;
- **increasing strength and duration of seasonal hydrodynamic stability in the Great Lakes** may be reducing internal nutrient loading and pelagic primary productivity, as well as causing spreading anoxia;
- **other anthropogenic impacts,** especially eutrophication from increasing nutrient loading and increased fisheries effort, in the near term, may override climate impacts, specially in shallow

waters/lakes, e.g. Victoria. These lakes are nearly hydrologically closed at present, and direct surface exchange of water (precipitation and evaporation) dominates water balance, so lake levels are quite sensitive to atmospheric aridity;

- **changing water levels will be perhaps the greatest societal risk over the next 100 years** and can be exacerbated by societal responses if the climate becomes more arid and more water is withdrawn for irrigation. Contemporaneous challenges of lower primary productivity, lower lake levels and warmer temperatures would be new stresses for species-rich littoral communities of these lakes. Dramatic effects, based on analogous situations, can be anticipated but not predicted with certainty for the future.

Improving climate prediction for the African lakes will require improved GCM capability to predict changes in precipitation, winds and temperature. It will also require greater spatial resolution to account for the complex topography of East Africa.

Climate change is affecting chemical, biological, and physical aspects of the Laurentian Great Lakes. Future effects that have been identified include the impact of climate change on lake levels, which are predicted to decline even further than their current low levels. Another significant effect will be the impact of warming on biological community structure, including fish communities and algal communities. Changes in either fish-predator species or algal assemblages will further impact other trophic levels through top-down and bottom-up effects. Finally, warming of the Great Lakes will result in greater evaporation of semi-volatile compounds from the water column, which will cause sediment reservoirs to leach back to the water column. Thus, rather than sequestering contaminants in sediments, semi-volatile compounds will reverse their movement and re-enter water and air.



WATER EXPLOITATION

As the population continues to increase within lake basins and beyond, water demand for domestic, industrial, agricultural purposes and for hydroelectric power generation will continue to increase. Despite the large size of the lakes, increase in water use can result in a decline of lake levels, with consequent negative effects on lake ecosystems and economic activities. Additionally, part of the water abstracted from the lakes for domestic and industrial use is normally returned back to them, together with pollutants associated with use, including nutrients, chemicals and organic pollutants; it can be expected, therefore,

that increased water use will translate to increased pollution. The African Great lakes are particularly vulnerable to increased water use since their water balance is dominated by atmospheric exchange (precipitation and evaporation) and are sensitive to water level changes. In Lake Victoria, for example, the recent decline in lake levels has been blamed partly on increased water abstraction by Uganda for hydropower generation on the River Nile downstream. Climate change is also expected to increase water scarcity in the East African region,

leading to increased demand for water.

	Species	Origin & Impacts
Victoria	Nile perch (<i>Lates niloticus</i>) Nile tilapia (<i>Oreochromis niloticus</i>)	<i>Origin:</i> Deliberate introductions from Lake Turkana and lower Nile in 1950s and early 1960s to boost fish catches <i>Impacts:</i> Now dominant since 1980s but accompanied by loss of numerous native fish species, and major trophic and water quality changes
	Water hyacinth (<i>Eichhornia crassipes</i>)	<i>Origin:</i> Accidental introduction via River Kagera <i>Impacts:</i> Blockage of water ways, fish landing sites, water intakes and power generating stations, and deterioration of water quality
Tanganyika	Water hyacinth (<i>Eichhornia crassipes</i>)	<i>Origin:</i> Accidental introduction as decoration flower by traders <i>Impacts:</i> mainly fish landing sites and deterioration of water quality
	Red water Fern (<i>Azolla filiculoides</i>) Water lettuce (<i>Pistia stratiotes</i>) <i>Potamogeton</i> sp. (<i>P. crispus</i> ?) <i>Hydrilla verticellata</i>	<i>Origin:</i> Tropical America
Laurentian lakes	Sea lamprey (<i>Petromyzon marinus</i>)	<i>Origin:</i> Probably from lower basin through Erie Canal. <i>Impacts:</i> A fish parasite responsible for decimation of predatory fish e.g. Trout and Burbot

Table 1: Some invasive species in the Laurentian and African Great Lakes

<p>Alewife (<i>Alosa pseudoharengus</i>)</p>	<p><i>Origin:</i> Uncertain but either introduced accidentally in 1870s or migrated earlier through Erie Barge canal systems <i>Impacts:</i> Associated with major changes in plankton community and other ecosystem features</p>
<p>Rainbow smelt (<i>Osmerus mordax</i>)</p>	<p><i>Origin:</i> Introduced in Cristal Lake, Michigan (1912) and observed in Laurentian lakes by 1936 <i>Impacts:</i> None but has developed into a major component of the fish community</p>
<p>Dreissenid mussels: -Zebra mussels (<i>Dreissena polymorpha</i>) -Quagga mussels (<i>D. bugensis</i>)</p>	<p><i>Origin:</i> Possibly through ballast water in sea going ship from Europe <i>Impacts:</i> Clogging water intakes, encrusting boat hulls and other structures, replacing benthic invertebrates and depressing zooplankton abundance due to high filtering rates and change of phosphorus cycle in the lakes</p>
<p>Cladocerans: -Water flea (<i>Bythotrephes longimanus</i>) -<i>Cercopagis Pengoi</i></p>	<p>Minor impact on lake ecosystems mainly affecting trophic transfer from zooplankton to fish</p>

Table 1: Some invasive species in the Laurentian and African Great Lakes (cont'd)



Section 3: TRANSBOUNDARY GOVERNANCE: TOOLS AND CHALLENGES

Effective transboundary lake basin governance is founded on a shared desire to respond to environmental, socio-economic, legal, and management challenges and help deal with conflict. Transboundary lakes, by definition, cross national boundaries; consequently, management and use of natural resources are subject to the policies and laws of more than one political jurisdiction. Because resources are shared, actions in one jurisdiction can affect others. Effective management requires cooperation and harmonization of water and environmental management policies. In the case of the Laurentian lakes, where Canada and the U.S have put in place management structures to address environmental and policy issues,

harmonization is clearly evident. In the African Great Lakes region, cooperation is newer. Differing political structures among the riparian countries of Lake Victoria, for instance, have been a major hindrance to management of lake ecosystems, particularly following the breakup of the East African Community in 1977.

Over time, East African countries have made cooperative efforts, culminating in establishment of regional structures and authorities for Lake Victoria management: the Lake Victoria Fisheries Organization (LVFO) in 1994 and the Lake Victoria

Basin Commission (LVBC) in 1995. In Lake Malawi and Lake Tanganyika, various political issues still hinder cooperation in managing the lakes. The Lake Tanganyika Authority (LTA), established in 2008, is intended to facilitate harmonization in management of lake ecosystem and resources through the *Lake Tanganyika Convention and the Strategic Action Programme*. Section 3 will focus on the responses to drivers of change, discussed in Section 2, and will discuss major challenges to effective transboundary governance.

Transboundary governance of the African Great Lakes was established to address environmental, socio-economic, legal, and management challenges facing all the riparian states.

RESPONSES

Responses to deal with the transboundary lake basin problems may be legal instruments such as binding or non-binding agreements among one or more jurisdictions sharing the lake, or legal treaties among different riparian states;

institutions (commissions or organizations) established to deal with either specific issues such as water quality, fisheries (such as GLFC, LVFO) or to look at the transboundary basin itself (such as LTA); policies for more integrated approach across lake basins, including shared data and monitoring; and mechanisms for sharing benefits and costs. For the most part, policies and instruments to deal with transboundary lakes are responsive in nature: for example, transboundary governance institutions were established in the Laurentian Great Lakes in response to high-profile crisis situations. The *Boundary Waters Treaty* of 1909, which established the International Joint Commission, was developed to respond to water quantity disputes involving hydropower development, and to water quality

problems that had resulted in human disease and death. The Great Lakes Fishery Commission was established in 1955 by the *Convention on Great Lakes Fisheries* of 1954 in response to the sea lamprey crisis, in which invasive species devastated the commercial fishery for top predator fish species.

LEGAL INSTRUMENTS: BINDING AND NON-BINDING AGREEMENTS

Agreements among jurisdictions sharing natural resources can be binding or non-binding. Binding agreements require parties to relinquish some of their sovereignty, something independent entities are loath to do. Compliance is often high in these hard agreements, as participants only sign binding agreements with which they know they can comply. Non-binding arrangements

among sovereign governments are common and have varying levels of effectiveness. Routinely, governments discuss shared matters with each other and seek, in less formal ways, to harmonize regulations, share information, and establish reciprocal practices. Non-binding agreements are often more flexible in dealing with compliance, generally rely on consensus, and are more ambitious because signatories are more likely to be innovative if they know they will not be held, legally, to the agreement.

TREATIES

Transboundary lake basin management is a pressing environmental and political issue. International legal instruments can establish sustainable use of freshwater along lakes, prevent conflict over water, and lead to effective cost-sharing arrangements. Legal instruments, such as treaties and legal documents, are more formal arrangements between different jurisdictions and more binding than agreements that have no formal structure for implementation, enforcement and monitoring.

The governments of the Great Lakes of Africa have responded in the last fifteen years to water quality, water quantity and fisheries challenges by negotiating and enacting national and regional laws to mitigate problems. In Lake Victoria, the 2000 *Treaty for the Establishment of the East African Community* (EAC), and more specifically, the 2004 *Protocol for the Sustainable Development of Lake Victoria Basin* (LVB), are the legal instruments negotiated and agreed by partner governments for regulating the water quality and quantity of Lake Victoria. Although the Protocol stipulates the response method agreed by countries to deal with land-based drivers of deteriorating water quality and quantity, the actual regulation and enforcement are carried out based on existing water and environment national legislations; this is consistent with the principle of subsidiarity espoused in the treaty. It is worth noting that regional governments are harmonizing their laws and regulations for the purpose of creating a level ground for investment and operations.

As well as these legal documents, the Council of Ministers of EAC periodically issues specific directives to fast track implementation of some of the aspects of the Protocol. The ministerial directives of April 2006, on development of investment and action programs to address declining water levels, and the directive to prepare a new water release policy, stemming from a meeting at Jinja, Uganda, are a response to managing water quantity in Lake Victoria. Actions toward achieving this are underway. The 2000 directive of the Council of

Ministers for EAC to develop a comprehensive strategy for control of water hyacinths and other invasive weeds in Lake Victoria was the cornerstone for several interventions undertaken by partner states to remove and reduce the invasive weed infestation in Lake Victoria and other inland lakes of East Africa. It resulted in water quality improvements. The three Partner States, Kenya, Tanzania and Uganda, signed the Convention establishing the Lake Victoria Fisheries Organization as a legal instrument for cooperating on management of the fisheries resources and the health of the Lake Victoria.

In the Laurentian lakes, two treaties, several interstate agreements, and an agreement between the Province of Ontario and the Canadian federal government are in place to legally bind the jurisdictions. The 1909 *Boundary Waters Treaty* was established by Canada and the United States as a mechanism for the two nations to manage their shared waters. The primary focus of the treaty was water quantity, though provisions in the agreement also noted the pledge of the two nations not to pollute common waters. The 1909 *Boundary Waters Treaty* created the International Joint Commission (IJC). The *Convention on Great Lakes Fisheries* of 1954 was signed by Canada and the United States to formalize an effort between the two nations to control the invasive sea lamprey and take steps to improve and perpetuate fishery resources. The Convention established the Great Lakes Fishery Commission and, among other things, asked the commission to develop working relationships among all of the fishery jurisdictions on the lakes. The United States Constitution authorizes the formation of “interstate compacts,” which are legally binding agreements among the states; no commensurate authority exists in Canada. Scores of interstate compacts exist in the Laurentian region, binding two or more states to narrow or broad behavior ranging from issues of radioactive waste to water management. The most recent interstate compact—the Laurentian Great Lakes-St. Lawrence River Basin Water Resources Compact—was formally ratified in late 2008. That agreement governs diversion of Laurentian Great Lakes water, requiring permits for any significant withdrawal. In Canada, the Canada-Ontario Agreement is a formal arrangement between the federal government and the province over numerous issues of shared jurisdiction between the two levels of government. The agreement delineates which level is responsible for certain activities relating to the Laurentian Great Lakes.

In the United States and Canada, both federal governments responded in the 1970s and beyond to major environmental threats with a suite of laws, creating the modern legal framework for environmental policy. Pollution problems were most visible to the public in the 1950s and

1960s, leading to public outcry and political action in the 1970s, and to development of a large number of environmental laws and regulations in the U.S. and Canada. Most of that legislation is extant today with additions concerning toxic substances in the 1980s. In Canada, most of the regulatory authority rests with the Province of Ontario, with the federal government playing a coordination role. In the U.S., most of the regulatory authority is with the federal government, with funding and directives to the states for implementation.

POLICIES AND INSTITUTIONS

To deal with transboundary lake basin management issues, riparian countries can form joint organizations or commissions for both regulatory (IJC, LVBC, LTA) and resource management (fisheries) purposes (GLFC and LVFO).

Effective management starts at the national level with coordination among different water management institutions. This is complemented by transboundary-level institutions such as a commission, which is a joint body among riparian states. These transboundary institutions should involve local institutions, research institutions, private sector stakeholders, NGOs and international organizations. Such institutions lead to integration at the vertical and horizontal level. Joint bodies can serve various functions such as:

- **Executive functions:** i.e., activities related to implementation of joint agreements or treaties, such as developing joint monitoring programmes and establishing regimes for water reservoirs and other water management facilities;
- **Coordination and advisory functions:** commissions can undertake joint activities such as data collection, data sharing, identifying pollution sources, and providing a platform for exchanging information. These institutions should investigate bringing research communities together to integrate science and policy, and should encourage establishment of research institutions such as a Council of Great Lakes Research and Water Quality Boards;
- **Dispute resolution function:** settling differences and disputes among riparian nations. This might involve setting up trust-building workshops, developing infrastructure involving all the parties so that benefits can be shared, and setting up a mechanism to resolve disputes.

Decision making in North America appears to be a multi-organization and multi-stakeholder process while in the African Great Lakes region decisions are made and implemented by a relatively smaller group of individuals and/or organizations. These commissions and their broad functions are noted in Annex B.

In the Laurentian Great Lakes, there are many other government and non-governmental institutions that have evolved in response to specific issues and needs. Some institutions are bi-national, such as the Great Lakes and St. Lawrence Cities Initiative (a consortium of riparian mayors) and Great Lakes United (an environmental non-governmental organization). Many others are based in the U.S. or Canada but often conduct cross-border projects, such as Nature Conservancy (U.S.) and Nature Conservancy Canada. A host of special interest groups and manufacturing/trade associations, and aboriginal peoples (Tribes in the U.S. and First Nations in Canada) maintain environmental and fishery governance mechanisms.

BENEFITS SHARING

A transboundary water system is a common pool of resources, which means that if one riparian nation uses it the benefits available to other riparian countries decrease. To overcome this issue of common pool resources and property rights, some have suggested a shift in focus from dividing the volumes of water each country can use to sharing the values of water: i.e., in terms of hydro-power, economic, social and environmental benefits. The idea behind this approach is that nations can then focus on optimizing benefits rather than on dividing water and dealing with conflict.

MAKING NON-BINDING AGREEMENTS WORK

Non-binding transboundary agreements on environmental issues benefit from a strong mandate. Agreements such as the Great Lakes Water Quality Agreement (GLWQA), the Joint Strategic Plan (JSP) for the Management of Great Lake Fisheries, and the Protocol for Sustainable Development of the Lake Victoria Basin pledge to uphold obligations, and to communicate between commissions, governments, resource managers, policy makers and the public to keep everyone informed about progress and keep everyone engaged as they work towards their shared goals. Participants also need to learn from experiences of what has worked and what had not worked, and, in the latter case, to make corrective actions or chart a new course. Common features to help make agreements work include respect for the process

at the highest level among all parties involved; commitment to reach a consensus; and financial/funding support from all the participating countries.

Twinning can be a valuable tool to exchange information on success and failures, allowing one participant to learn from the other's experience. For example:

EUTROPHICATION IN NORTH AMERICAN LAKES

Success in addressing eutrophication stands as an extraordinary example of interjurisdictional cooperation fostered by science and impartial fact-finding.

A major achievement of the International Joint Commission was the study it undertook in 1960 to study pollution in Lake Erie and elsewhere in the lower lakes. These IJC activities were a result of the highly influential 1964 request by Canada and the United States, termed a “reference.” The results of this study led to the signing of GLWQA in 1972.

Scientists associated with the IJC found that excessive phosphorus loads from anthropogenic sources were resulting in severe eutrophication of Lake Erie and Lake Ontario. At the time of the signing of the GLWQA a particularly important reference on Pollution from Land Use Activities (PLUARG), was issued to the IJC. The 1978 final report was the culmination of a five-year comprehensive study of non-point source pollution in the Great Lakes. PLUARG found that the Great Lakes were being polluted from non-point sources by phosphorus, metals, industrial chemicals and pesticides. The problem of pollution from non-point sources, including intensive agricultural activities and atmospheric deposition, was identified as a significant source of pollution to the basin and was identified as one of the most important issues to be addressed by GLWQA. This experience illustrates that consensus between the two nations is important when starting an investigation into a problem and looking for a cooperative solution; and also that a dedicated institution to deal with the issue is an important component for success in transboundary lake basin management

TOXIC CHEMICALS

As a consequence of increased knowledge about the dynamics and effects of toxic chemicals, the GLWQA codified the use of an ecosystem approach to achieve the objective that discharge of all persistent toxic substances be virtually eliminated. An important achievement of the IJC was the introduction and delineation of concepts such as the ecosystem approach, and the virtual elimination of inputs of persistent substances, though often

politically sensitive and difficult to put into operation. In time, these concepts were included in the amended GLWQA. Factors that appear to have contributed to this breakthrough include the rising concern about toxic contamination; identification of atmospheric deposition and hazardous waste disposal sites, such as Love Canal, as sources of toxic chemicals to the lakes; and a new understanding about contaminated sediment and how toxic substances cycle within the ecosystem. The IJC's Virtual Elimination Task Force was constituted in July 1990 to “investigate the requirement of the amended Great Lakes Water Quality Agreement to virtually eliminate the input of persistent toxic substances into the Great Lakes Basin Ecosystem.” In 1993 the Task Force Final Report presented a conceptual framework for a virtual elimination strategy, presented its evaluation of the various elements comprising the strategy, and examined the application of the strategy to three examples —PCBs, mercury, and chlorine as a feedstock — from which general principles can be gleaned to apply to other persistent toxic substances. The IJC in the 1990s was at the forefront of international efforts to deal with the discharge of toxic chemicals into the lakes. Much of their work set the context for the 1997 Great Lakes Binational Toxics Strategy of Canada and the United States.

REMEDIAL ACTION PLANS

Remedial Action Plans (RAPs) promise a way in which resource users, regulators, and those interested in restoring the local ecosystem can collaborate towards a common purpose. They promise to empower local stakeholders to determine their own solutions to ecological degradation, and open new venues for collaboration.

Under the amended GLWQA 43 hot spots were identified along Laurentian Great Lakes.

These spots were highly contaminated and needed action in remediating the situation for both ecosystem and human health. In 1983 the Water Quality Board (WQB) determined that classifying Areas of Concern was difficult due to the lack of specificity of the criteria for classifying the areas and the guidelines to be used for their evaluation. This led to difficulties in data interpretation for the purpose of defining the problems and deducing trends in environmental quality. To overcome these difficulties, the Board developed a procedure for data assessment and identification of Areas of Concern. The unique experiment in place-based remediation and protection called for in the 1987 Protocol emerged directly from recommendations of the Water Quality Board.

Empowering local stakeholders to determine their own solutions to ecological degradation and open new venues for collaboration has proven to be a valid approach to ecosystem revitalization.

The Agreement calls for federal governments, in cooperation with state and provincial governments, to ensure the public is consulted throughout the development and implementation of the Remedial Action Plans. Despite organizational and fiscal resource hurdles, several RAPs are being applied and, as a result, there are notable advances in remediation and prevention programs. Essential elements that characterize successful initiatives include true participatory decision making, a clearly articulated and shared vision, and focused and deliberate leadership. The first comprehensive review of progress in developing and implementing RAPs was released by the IJC in 2003.

WATER QUANTITY

Success in water level management in Laurentian Great Lakes can be attributed to (a) the independence of the IJC members, (b) public engagement, (c) transparency of process, (d) commitment to consensus, and (e) joint fact finding. The geographical realities are such that North American ecology naturally spans North/South as opposed to East/West. By definition, thus, the environment is not reflective of political boundaries. The IJC governs use of transboundary water disputes by (a) regulating the construction/operation of dams or protective works and/or any activity that involves water use, and (b) making suggestions, conducting investigations, and resolving disputes over water usage. Of the 56 disputes submitted to the IJC since its inception in 1909, 55 have been resolved unanimously. Past water issues between Canada and the U.S. have set precedents for resolving future disagreements.

WATER HYACINTH IN LAKE VICTORIA

Success in controlling water hyacinths in Lake Victoria has been a result of a combination of actions, both natural and human induced. It is apparent neither one of them could have succeeded independently. The key lessons learned from the entire process of controlling the weed were (a) science is needed to inform any management decisions, (b) the public expected immediate results in weed removal (but were disappointed), (c) a coordinated approach among all the countries of the LVB was the only way to tackle transboundary challenges, and (d) a regional mechanism was crucial in coordinating the national actions to solve issues with a regional dimension.

Water hyacinth will continue to pose a threat to the lake's ecosystem, and a re-emergence of the plant has been observed locally as well as in NASA satellite images,

proving that without a diligent approach, this plant will continue to be a menace.

A recent cause of the hyacinth's resurgence was, in part, due to heavy rains carrying agricultural run-off and nutrient-rich sediments into the lake, feeding the water hyacinth and creating another outbreak. The inability to control hyacinth in a riverine environment adds to the challenges in controlling water hyacinth in the lake. Uganda has rejected chemical control methods after public hearings.

MOVING FROM PLANNING TO IMPLEMENTATION

Transboundary commissions provide an excellent forum for planning, but responsibility to implement programmes generally rests with governments and other cooperators. In the Laurentian Great

Lakes, implementing plans works best when there is both "top-down and bottom-up" connectivity and communication among commissioners, high-level government officials and resources managers, and the technical staff responsible for the "on-the-ground" research. The JSP is a good example of how on-the-ground research influences sound management for effective functioning. The JSP is a central guide for fisheries management for the Laurentian Great Lakes and led to the creation of Lake Committees. In addition, both the IJC and GLFC have a long history of public participation in their activities, which is often instrumental in assuring accountability and translating public pressure into political will for implementing transboundary plans of high priority.

In the African context, over a thousand Beach Management Units are community run, governing bodies that manage the fishery and share policy development, enforcement, and research duties with each national government's fisheries department. The BMUs create and enforce their own by-laws for sustainable fisheries management, serve as resource-data collection points for better fisheries management and monitoring, and increase member's capacity to manage financially. BMUs were created to standardize rules and roles of fishers throughout Lake Victoria's fisheries. The LVFO, departments of fisheries, research institutes and BMUs are all designed to transcend resource issues across national borders and to overcome the differences in fisheries management that come with varying degrees of decentralization between the lake's three governments.

For successful implementation of programmes, in addition to institutions/commissions, effective policies or laws are needed. A classic example is the case of invasive species where the failure is because of lack of policies and laws to deal with accidental introduction of invasive species, and because of the fact that no one institution has responsibility to address the issues, making it no one's responsibility.

SUCSESSES AND FAILURES IN RESOURCE MANAGEMENT (FISHERIES)

Fisheries management in African fresh water lakes has been informed by the underlying concepts of decentralization and co-management. Decentralization proposes that “democratic local institutions can better discern and are more likely to respond to local needs and aspirations because they have better access to information, due to their close proximity, and are more easily held accountable to local populations.” The concept of co-management further strengthens participation of local institutions and populations through mechanisms that ensure participation in the decision-making process on protecting and using natural resources. Co-management allows information generated by the users to assist in scientific advisories, as well as in policy considerations. Both co-management and decentralization move away from failed centralized efforts to manage natural resources, often called “command-and-control.” Extensive research has revealed that the centralized approach in developing countries has failed to sustainably manage the fishery, creating distrust of the government and of centralized fisheries management by the people who depend on the resource for their livelihood. Daily dependence on natural resources in most developing nations requires greater local knowledge for their management as they vary spatially and temporally, “making them less amenable to central standardization.”

The Lake Victoria fishery is one of the most productive in the world. The major success of Lake Victoria is not sustainable fisheries management, at least not as yet, but rather establishment of governance institutions for the fisheries resource. The most notable example is the creation and work of the Lake Victoria Fisheries Organization (LVFO), the fisheries management arm of the East African Community (EAC). For Lake Victoria, a well-defined institution with supporting organizations has been created to harmonize fisheries management around this common property lake. The LVFO is structured with committees and processes related to specific goals outlined by the LVFO’s guiding documents. LVFO uses working groups to inform the scientific community and directors from the parent countries about scientific findings. LVFO is the only organ of the EAC with grassroots (in village) institutions, including 1,069 Beach Management Units (BMU).

The GLFC’s strategic vision takes the ecosystem concept as the informing principle of fisheries management and research. The commission developed the Ecosystem Health of Large Lakes research theme to explore the ecosystem concept within and beyond the geographical boundaries of the Laurentian Great Lakes. This research theme included establishing an international forum for exchanging information

about issues affecting fisheries and the health of large lakes across a spectrum of systems under a range of environmental stresses. The objective is to develop robust metrics to assess the state of ecosystem health and to guide corrective actions to reduce the risk of deterioration and assess the effect of restorative actions.

The overlying challenge is how to measure “ecosystem health” in ways that will be useful in communicating research and monitoring information to resource managers and policymakers. At the first Great Lakes Fishery Commission/Board of Technical Experts Workshop on Ecosystem Health of Large Lakes of the World, metrics were developed that show promise in detecting trends in large lakes ecosystems. Useful metrics include trophic structure, exploited species, habitat changes, and catchment changes. Challenges include appropriate scales for measurement, cross-lake differences in monitoring methods and frequency, and costs and logistics for conducting large lakes assessments.

To complement the ecological aspect of large lakes, the GLFC established the Human Dimensions of Great Lakes Fisheries Management research theme to recognize humans as a central component in the ecosystem. These two research themes reflect global efforts to manage natural fresh-water resources sustainably. They also illustrate an understanding that the commonalities between fresh-water governance structures, successes, and failures can improve resource governance of the Laurentian Great Lakes.

With one or two exceptions, governments have failed to institute meaningful policies to manage invasive species on the Laurentian Great Lakes. While the sea lamprey control program, begun by the Great Lakes Fishery Commission in 1958 and continuing to this day, and the alewife control program (which consists of stocking native and non-native predators) have succeeded as after-the-fact control measures, none of the other invasive species established in the Great Lakes is being managed. Prior to some recent encouraging, targeted initiatives (e.g. the formation in 2006 of a U.S./Canadian Great Lakes Seaway Ballast Water Working Group, subsequent efforts to harmonize approaches, and Canada’s ratification in 2010 of the International Convention for the Control and Management of Ships’ Ballast Water and Sediments) and actions (in 2009 and 2010 100% of vessels bound for the Seaway from outside of the Exclusive Economic Zone received ballast tank exams on each Seaway transit and were obliged to follow defined protocols based on the findings), comprehensive policies to prevent introduction of invasive species into the Laurentian Great Lakes have generally been nonexistent. The failure to deliver on invasive species policy for so long is particularly puzzling, given the widespread

consensus that invasive species must be stopped. Moreover, the problem is manageable, with known vectors and many opportunities for intervention. Normally, such consensus and manageability would make development and implementation of an effective environmental policy relatively straightforward; however, an effective invasive species policy remains elusive. This policy failure most probably occurred because of four main factors: basic disagreement on approaches, lack of political will to regulate affected industries, lack of consensus on science and technology, and inadequate funding.

LINKING WATER QUANTITY, WATER QUALITY, LANDUSE AND FISHERIES ISSUES

Better linking of water quantity, water quality, fisheries, land use and watershed issues is a challenge in lakes. Although scientific synergies are often obvious, governance mechanisms were not designed to integrate these issues. This is true even within the IJC, where although there has been considerable interaction between the IJC and GLFC staff, there are only a few instances of jointly conducted projects or activities.

LINKING LAKES AND WATERSHEDS

The four major bi-national agreements on the Laurentian Great Lakes all address the lakes, but make little mention of the surrounding watersheds, where most of the environmental perturbations affecting the lakes originate. The IJC,

through the *Boundary Waters Treaty*, is involved with water quantity issues on tributaries and the connecting channels, but for water quality the focus is on the international boundary. The Great Lakes Water Quality Agreement, for the most part, addresses open waters, and the Convention on Great Lakes Fisheries emphasizes “fish stocks of common concern” that are primarily open water species. The IJC is engaged in a watershed initiative under the auspices of the *Boundary Waters Treaty* so that the ecosystem, rather than just hydrology, is being considered in water levels and water flow decisions. The advisory boards under the Great Lakes Water Quality Agreement are engaged in activities in nearshore waters of the Great Lakes and are discussing scientific and governance issues concerning better linking between the lakes and watersheds. The GLFC, among other things, is involved in dam removal projects on tributaries to improve lake-tributary-watershed connectivity. The LVBC’s mandate covers both the watershed and the lake itself; thus, a holistic approach is adopted in dealing with catchment and lake ecosystem linkages.

CRITICAL IMPROVEMENTS NEEDED

1. A holistic/integrated approach: to address all the critical issues discussed above an integrated approach to deal with the transboundary water issues is important: attempting to address one issue at a time might complicate other issues.
2. Information exchange, joint monitoring and assessment mechanisms. To share information there is a need to work toward:
 - a. common terminology among riparian nations
 - b. harmonized or comparable methodology for collecting data and information
 - c. uniform reporting procedures
 - d. targets for planning purposes across the riparian nations.
3. Participatory approach: stakeholders, including industry, local authorities, government representatives, research institutions, farmers and local citizens must be involved to understand the problem and determine the suitability of specific actions to ensure that the decision reached is accepted by all and will facilitate implementation.



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4. Assigning value to environment: environmental costs should include market cost, non-market and economic valuation and benefits, and introduction of benefit (cost) sharing approaches. Riparian countries (or appointed bodies such as commissions) will need to focus on making an inventory of all the benefits generated for the entire basin and sharing the benefits fairly. The benefits can include use of water for drinking, hydro power, tourism fees, fishing permit fees, permits for aquaculture, bio-diversity fees, cultural importance fees (people might be willing to pay for preservation). It is also important to note that the rates or fees for the benefits generated by transboundary lake basins should be set at the national levels (preferably by a discussion among all the riparian nations) but the fees should be collected locally by local managers (this will increase the collection rate). Also if the benefits collected are spent locally, it encourages local managers to collect more, users to pay more.
 5. A strong political will and commitment is needed for better transboundary lake basin management.
 6. International community commitment is needed in terms of financial, technical and human capacity building.

SECTION 4: TRANSBOUNDARY LAKE BASIN MANAGEMENT REGIMES

The framework described below facilitates effective transboundary lake-basin management. It can be modified to fit local conditions and circumstances and includes the following elements: management regime, operational framework and resources management.

1. MANAGEMENT REGIME

- a. A forum is needed to support discussion among transboundary nations with the aim of developing joint agreements, plans, and cost/benefit sharing arrangements. The forum should comprise a network of different actors such as governments, non-governmental organizations, scientists, and policy makers. The network can be built at various levels:
 - i. commissions are formal arrangements among transboundary riparian nations and are effective in bringing all concerned parties together. A commission should be interdisciplinary and inter-sectoral in nature so that participants can focus on bridging science and policy issues (or using science to make management decisions). To work effectively, commissions should have decision-making and enforcement power but should report to a multinational panel of ministers for accountability purposes and for dealing with sovereign issues. Again, this is the “ideal” situation; to achieve it countries must deal with the issue of sovereignty before agreeing to this model. Commissions can work towards protection or restoration of water quality in lake(s), and can manage infrastructure issues;
 - ii. a network to involve community and non-governmental organizations is a more informal arrangement to work with communities to address on-the-ground issues and to feed into formal decision making.
- b. A legal framework or structure will be needed within all riparian nations and might involve international agreements (binding or non binding) to address issues. It should include several of the following:
 - i. principles of equitable and reasonable utilization, which can include clauses on thresholds of allowable harm, minimum allocation for vital human needs, and minimum required levels of water for proper functioning of lake ecosystems;
 - ii. obligation to cause no harm (this is especially true for upstream countries who should agree to work together to keep water clean for downstream countries);
 - iii. a duty to notify and exchange information, especially in case of a disaster. In case of upcoming floods, or accidental discharge into lakes, a clause in the agreement is needed that calls upon a country to notify other riparian states so that they can take appropriate action to protect citizens as well as the environment;
 - iv. a communications system across different national legal, institutional frameworks, culture and languages is essential for treaties and agreement to work;
 - v. dispute resolution mechanisms are an integral part of any agreement or legal

- framework and are needed to establish whether a committee (with members from all countries) or a commission will deal with complaints or disputes arising among riparian nations once an agreement has been made on sharing water and benefits.
- c. Policies are needed that reflect what governments want to achieve and what steps are to be taken to achieve stated goals. Policies can take the form of a formal or an informal document to be updated periodically. The general recommendation for a transboundary lake basin arrangement is to have some kind of common environmental management policy that is holistic, encompasses the health, agriculture, education, fisheries, socio-cultural issues of the entire lake basin into policy making, and, in all likelihood, is based on an integrated water resources management approach. Essentially, the common environmental policy should integrate environmental management into all development activities, including urban development. The common environmental management policy should also encapsulate strategies for addressing transboundary pollution: i.e. set standards for water quality; set up rules for monitoring and enforcement and enhance both; establish and accredit laboratories; strengthen regulations for mandatory effluent treatment from municipalities and industry; improve farming practices through training; and provide better technologies.
- d. An information management system is needed for sharing data and information among the riparian countries and can be achieved by:
- i. joint monitoring programs;
 - ii. joint training and capacity building exercises to promote use of common language, common parameters in data collection and data analysis, and use of a common data base;
 - iii. use of remote sensing, real time monitoring or other technologies to collect data from sensitive areas;
 - iv. access to degree programs and training
- programs to build capacities in nationals of all the riparian countries.
- e. A financing system for transboundary lake basin management involves costs for:
- i. protecting public goods: for example, floods protection measures and nutrient management;
 - ii. regulating public goods: for example, enforcing fisheries quotas;
 - iii. producing market good: for example, hydropower;
 - iv. maintaining commissions: for example, management and administrative costs. Mechanisms need to be in place to sustain the commissions or the institutions for transboundary lake basin management. Initial investment from donors and international community will be needed but for long term sustainability and ownership of the process, the governments involved must make an equitable contribution towards the commission.
- f. cooperation among riparian countries sharing the lake is vital and involves building trust among participating countries. This is a difficult task but can be achieved by first working on technical projects together, slowly evolving a political infrastructure, and building in mechanisms for financial compensations if a win-win solution cannot be reached (so the party losing can be financially compensated).

2. OPERATIONAL FRAMEWORK

The act of setting up a commission does not guarantee it will be successful. On the operational level four types of resources are needed: technical; science and research; regulatory instruments; and communications channels. Technical resources support the science, and strong science is needed to feed into resource management and policy making. Science conducted in vacuum, even when published in peer-reviewed scientific journals, is often ineffective in influencing resource management and policy decisions so institutional arrangements are needed to ensure strong links are made between science and policy. This is particularly important

for managing large lakes ecosystems with large watersheds and multiple jurisdictional boundaries. There is also growing recognition that the science should not be confined to open waters but should encompass watershed and socio-economic issues that impact lake water quality and quantity. Socio-economic considerations should include full-cost accounting of shared costs and benefits as part of the process for achieving sustainability. Institutional arrangements to foster integrated water resources management (IWRM) catalyze implementation of basin-wide policies to sustain long-term resource protection and restoration for sustainable uses. A visioning process with the public and stakeholders will encourage “buy-in” and support for science-based management programs and policies.

3. RESOURCES MANAGEMENT

A resources management plan articulates steps to manage common resources such as fisheries. Where poverty, large markets, inadequate regulation, poor institutional and legal arrangements, and low civic awareness prevail, management of fisheries to prevent over fishing can be difficult. Options include:

- a. set and implement fishing quotas;
- b. review and update existing fisheries policies, laws and regulations;
- c. strengthen monitoring and enforcement of regulations and restrictions (financing options might be needed to begin enforcement) and place more emphasis on educating user groups as to the need and purpose of the regulations;
- d. explore innovative funding arrangements for local management of fisheries resource: for example, allow BMUs to recover cost for landing services or even own quotas that can be leased from the BMU communities;
- e. involve communities in setting fishing quotas and updating policies, since enforcement becomes relatively easier when the community has a sense of ownership of new laws, policies and regulations;
- f. educate people about linkages between healthy lakes, sustainable fisheries,

- g. curb illegal gear use for fishing, explore provision of credit to fishermen, and train them for alternative livelihoods to enable them to look into other economic opportunities;
- h. plan to prevent and/or control invasive species.

SECTION 5. BUILDING REGIONAL AND TRANS-CONTINENTAL CONNECTIONS

Newer organizations and commissions may benefit from studying the North American approach of integrated multi-sectoral management of lake resources, while North American organizations can benefit from co-developing policy appraisal techniques for their younger sister organizations in Africa. Twinning can cut down the learning curve, by many years or even decades. Twinning can be helpful when discussing governance structures, but caution is needed when replicating (or twinning) science results without considering the local factors of the lakes.

TWINNING: WHAT IS NEEDED TO MAKE IT WORK?

Twinning is a way for two or more organizations to enter into a well-structured relationship that allows commissioners, scientists, politicians, and others affiliated with the organizations to exchange knowledge and experiences.

Twinning bridges organizations and fosters collaboration among a wide range of professionals and stakeholders. At the top level, twinning allows senior officials to discuss broad strategies. Among staff and scientists, twinning enables organizations to exchange research results and technical expertise, and potentially develop shared research agendas. Among elected officials, twinning offers an opportunity to broaden perspectives and learn how other regions of the world operate in a governance and political context. This knowledge can be used in building new institutions for transboundary management or adapting older ones. Information generated through a collaborative process—information that relies on broad perspectives and broadly applied science—also helps make policies more defensible to politicians, commissioners, scientists, and staff.

Successful twinning arrangements should be based on the needs, wishes, and potentials of the twinned organizations, and may change over the course of time. Organizations that opt to enter a twinning arrangement do so voluntarily and because the arrangement enhances their ability to fulfill established missions. If the act of twinning were to be burdensome or inappropriate because of incommensurate missions, organizations would simply avoid the exercise. Those choosing to twin should focus on issues of mutual interest and responsibility, and use the relationship to learn from each other and broaden each others' horizons. The

twinning arrangement should change over time to reflect what organizations have learned from each other and to allow organizations to jointly explore new avenues of interest. Ultimately, twinning is only as useful as the twinned organizations believe it to be, and the arrangement should only and always seek mutual benefit.

The action of twinning can come in many forms and can range from formal and binding to less-formal and voluntary.

Twinning can be a series of meetings, workshops, or other gatherings to build communities of practice and to share science. It can also be a more formal arrangement, underpinned by a mutual agreement, binding or non-binding. Twinning agreements can include pledges of in-kind contributions or joint initiatives with co-mingling of funds. Overall, twinning arrangement should reflect the types of issues that benefit from collaboration and should clearly outline commitments necessary to achieve those objectives.

A key element of a twinning arrangement is a mutual pledge to collaborate.

Common elements include:

- **committing to exchange information** about environmental protection, sustainable development, and management of natural resources;
- **helping to gain a better understanding** of how an institution might best function within its own domain (e.g., how best to share information among member states);

- **providing better focus** on issues of common interest/benefit to people living within basin areas;
- **refining research focus**, methodologies, and transfer to practitioners and politicians;
- **building professional capacity** and creating more opportunities for training; and
- **implementing measures to prevent**, control, monitor, and reduce pollution.

Twinning can occur between organizations of a particular region or across continents — similar mandates and shared challenges outweigh considerations of distance. Twinning achieves strong mutual benefits when the twinned organizations (1) commit to invest in research and development; (2) are willing to enter into strategic partnerships; (3) are flexible and adapt/adopt management strategies based on success stories; (4) seek innovative management approaches; (5) exchange information and expertise; and (6) have strong political commitment to the organization and to twinning.

Commitment to invest in research and development. Organizations depend on sound information to manage natural resources and meet local and global challenges. The information they need flows not only from academic research, but also from management-driven research that seeks answers to real problems. Investment in knowledge creation, knowledge transfer, and development of innovative approaches will ensure that results of all kinds of research are available to decision makers so that policies are based on a solid foundation.

Willingness to enter into strategic partnerships. Many of the challenges facing riparian countries have a global dimension; thus, organizations operating in different continents have some responsibility in the international pursuit of sustainable development and management of lake ecosystems. Such responsibilities can be fulfilled by entering into partnership arrangements. Obligations and expectations of each partner must be clearly articulated and practical linkages established with institutions of higher learning and institutions with similar mandates at international, regional, and national levels. Strategic partnerships must be able to promote dialogue and cooperation to share and replicate innovation and best practices through counter-part exchange.

Flexibility to adapt and /or adopt management strategies based on success stories. It is important for organizations to be

flexible and, when necessary, adapt or adopt management strategies that enhance their abilities to achieve goals and objectives. Through twinning, African and North American large-lakes organizations have an opportunity to communicate experiences so they can adapt and/or adopt the strategies that have been successful and avoid those that have not.

Commitment to adopt innovative resource management approaches. Organizations should adopt ecosystem-based approaches to address the many challenges that result from various land uses and consequent fragmentation of landscapes. Such approaches should be driven by explicit goals, based on research information and understanding of ecological interactions and processes. Traditionally, management efforts have been organized around particular uses (such as fisheries) resulting in separate governance regimes for each use. Over time, it has become ever more apparent that such a sectoral approach results in conflicts among users. The shift away from management of individual resources to a systems approach is evidenced in the broader perspective endorsed by a number of studies and expert commissions. As well as adopting ecosystem management approaches, organizations must have a means of applying the lessons learned to adaptive management approaches. To carry this out successfully, organizations must be willing to acknowledge best practices and uncertainties in resource management, and endeavor to reduce those uncertainties.

Commitment to exchange information and expertise. A strong commitment to research and development benefits practitioners in a particular region, but, given that many regions face similar problems, research in one region of the world could be applicable to other regions. Organizations must make deliberate efforts and structured arrangements to share information on successes and challenges in resources management. On-the-job training sessions, workshops, and counterpart-exchange programs are all vehicles for sharing expertise.

Political commitment and resource allocation. Working across boundaries is difficult, and thinking beyond local needs is not always an easy choice for politicians, particularly if such larger scale thinking requires an agreement that could limit sovereignty. Political commitment and resource allocation are required to make real progress in addressing complex, trans-boundary challenges. With political support and encouragement, and an appreciation for collaboration, it is possible to harness the capabilities of many organizations in a coherent manner, although economic disparities may make this more challenging for the African Great Lakes.

LINKAGES BETWEEN SCIENCE AND POLICY AND BETWEEN MANAGERS AND STAKEHOLDERS

Twinning can help organizations forge better links between science and policy and thus generate better decisions. Most decisions made at the highest levels of Great Lakes' organizations are based on advice provided by field researchers, technical committees, and scientists, but often are made without benefit of an evaluation of their scientific efficacy. Certainly, inadequate or a complete lack of scientific information can inhibit such evaluations, but even where good independent scientific information is available, decisions are sometime made based on strong vested interests, political, and bureaucratic factors. Good governance requires that mechanisms are put in place to link scientific information to political decision making. Through twinning, organizations that share information and expertise are able to give decision makers a stronger base for sound political decisions. For example, if organizations can share information that transcends purely local interests, policy makers can be better persuaded to make more consistent and coherent decisions.

With a better understanding of management challenges and scientific realities in other regions, twinned organizations have an enhanced ability to interact with stakeholders and communicate more defensible policies.

With the knowledge gained from other regions, backed by solid research and analysis, officials from twinned organizations can interact with stakeholders with more authority, knowing that a broader perspective has been incorporated into the organization's processes. Indeed, the better the information, the more defensible the action.

Access to information that reflects broad consensus among professionals from various regions improves an organization's ability to educate stakeholders about science and management. Organizations need a capacity to provide solid, timely information to stakeholders—those who depend on the resource for food, income, recreation, or myriad other benefits. Twinned organizations share experiences and these can be communicated to stakeholders to demonstrate how or why successes from a far-away region might be tried in the local region. Twinned organizations can also learn from others' mistakes and use that information to explain why a management practice should not be tried. Organizations with shared social, biological, or political conditions could benefit from joint educational programs. For example, large lake ecosystems often have many biological characteristics in common or face similar threats such as invasive species, climate change, and poor land-use practices. Joint educational programs

not only save staff time and other costs, but also broaden thinking so that stakeholders better appreciate that local issues have global implications, and vica versa.

LEVERAGING RESOURCES

Twinning helps organizations be more strategic in their initiatives and use of funds and staff. Organizations that engage in collaborative approaches to natural resource management have the benefit of leveraging resources with each other so that scarce time, staff, and funds can be put to best use. Research agendas can be developed in ways that seek solutions to shared problems, not simply focus on local or immediate needs.

Twinned institutions have the ability to draw upon each other's "bench strength," instead of having to develop and maintain individual capacity. Exchanging information and expertise helps twinned organizations build capacity and, by learning from others, those affiliated with twinned organizations become more professional and better trained, ultimately improving the overall ability of the organization to deliver its mission. As an example, scientists who pledge to work together to produce articles for peer-reviewed publications (an element of the memorandum of understanding between the Great Lakes Fishery Commission and the Lake Victoria Fisheries Organization) benefit professionally from the collaborative process.

FRAMEWORK FOR COLLABORATION UNDER LAKE TWINNING

Based on the common interests expressed by all five lake commissions, several areas for joint research, studies, and investigations have been identified.

- **Climate change** (adaptation/mitigation), with a focus on modelling change, undertaking vulnerability mapping, and developing management strategies for adaptation.
- **Governance structure**, with a focus on comparative analysis of governance structures to facilitate policy, legal and institutional reform for transboundary waters management .
- **Human wellbeing**, with a focus on educating communities on the relationship between their actions and the health

of lakes, and the linkages between the status of lakes (water quality) and human well being. It was also suggested that joint research should be undertaken for natural resources evaluation to determine the economic value of the environmental services provided by the Great Lakes.

- **Public-private partnerships,** with a focus on systematic analysis of partnerships, engagement of the private sector, fostering public-private partnerships, and sustainability of these partnerships.
- **Gender equity,** with a focus on involving women when developing a new water management regime or water policies. The role of women in education is also important.
- **Ecosystem approaches and management,** with a focus on integrated management of land, water and living resources to promote conservation and sustainable use of resources. Some topics that need detailed research are groundwater aquifer management, invasive species, pollution control, water quality standards, and effective monitoring strategies for ecologically complex interactions.

SECTION 6: AN EXAMPLE OF SUCCESSFUL TWINNING

The Lake Victoria Fisheries Organization (LVFO) and the Great Lakes Fishery Commission (GLFC) have twinned for nearly two decades, to their mutual benefit. Lake Victoria and the Laurentian Great Lakes both have thriving freshwater fisheries and resident populations dependent on the resources for food and water. They are both integrated into global economic markets. Both regions face similar challenges such as sustaining fish stocks, dealing with changing water levels, managing habitat loss, preventing and controlling invasive species, integrating land use decisions into ecosystem management, and addressing negative externalities of globalization. With Lake Victoria shared by three countries and the Laurentian Great Lakes by two countries, eight states, the Province of Ontario, and indigenous populations, sustainable management of the fisheries involves biological and political complexities.

The LVFO and the GLFC have signed a memorandum of understanding that formally twins the two organizations and outlines areas for collaboration. The existing memorandum of understanding between the LVFO and the GLFC is the second iteration of a collaborative agreement first signed in 1995. The current memorandum was signed in September 2008 and provides a formal, non-binding linkage between the two major fishery institutions on their respective water bodies. The purpose of the twinning agreement is to improve ties between the two organizations so that both organizations may better understand the fisheries resources of large bodies of freshwater; may improve interactions and outreach with the people who depend on the resources; may enhance contributions to scientific and other forums; and may encourage research and student mentoring.

The twinning arrangement focuses on issues of shared concern between the twinned organizations. The LVFO and the GLFC have long recognized that they face similar challenges in managing the fisheries of their lakes, advancing the scientific research that underlies policy decisions, and maintaining effective governance institutions to advance harmonious relationships among member states and with stakeholders. To help them better achieve their missions, the two organizations identified three main areas of focus for a memorandum of understanding: a mutual commitment to scientific exchange, collaboration among officials of the organizations, and identification of and a commitment to shared research agendas.

1. **Scientific Exchange:** The LVFO and the GLFC have committed to the free

exchange of social and natural science information. Large freshwater ecosystems, regardless of geographical location, often have much in common. The LVFO and the GLFC, through the memorandum, have acknowledged the importance of science and the need to share it, whenever appropriate, to improve their mutual understanding of the natural processes of large freshwater ecosystems and their fisheries. Both organizations have agreed to designate staff liaisons to keep the relationship fresh and consistent with the memorandum and have agreed to meet periodically to exchange information and conduct other business of mutual interest.

2. **Collaboration Among Officials:** Scientists with the LVFO and the GLFC have pledged to collaborate on scientific papers and presentations, with the goal of publication in respected journals or delivery at professional conferences. Professional staff with the LVFO and the GLFC are active members of the scientific community. They are called upon regularly to contribute to the peer-reviewed literature and to present their research findings to the broader community during symposia and conferences. Through the memorandum, the two organizations have expressed the importance of professional collaboration. Papers and presentations should be consistent with the research

direction outlined in either organization's research programs or in the large lakes research theme (see #3 below) that is to be developed jointly by the LVFO and the GLFC. The overall intent is to bring more transboundary, cross-continental thinking into the literature.

- 3. Identification of and Commitment to a Shared Research Agenda:** The LVFO and the GLFC have agreed to work together to develop a "research theme" for large freshwater lakes and their fisheries and to provide a set of research questions to guide solicitation and development of meaningful research projects. The two organizations have also agreed to encourage research by fostering student mentoring, supporting student exchange, providing student access to office space and archives, and making senior scientific staff available to mentor researchers.

ANNEXES

ANNEX A: LAKE SYSTEMS

	Victoria	Tanganyika	Superior	Michigan	Huron	Erie	Ontario
Altitude (m)	1,134	774	183	176	176	173	74
Surface Area (km ²)	68,800	32,600	82,100	57,800	59,600	25,700	18,960
Maximum depth (m)	79	1,470	405	281	229	64	244
Mean depth (m)	40	580	147	85	59	19	86
Volume (km ³)	2,760	18,900	12,100	4920	3540	484	1640
River Inflows (km ³ /yr)	20	14	50	36	165	196	229
River outflow (km ³ /yr)	20	2.7	71	47	170	196	230
Rainfall (km ³ /yr)	100	29	65	47	51	24	17
Evaporation (km ³ /yr)	100	50	48	42	40	24	13
Retention time (years)	23	440	107	59	16.4	2.2	6.7
Drainage area (km ²)	195,000	220,000	127,700	118,000	134,100	78,000	64,030
Population	30,000,000	6,200,000	607,121	10,057,026	2,694,154	11,682,169	8,150,895
Population density	153.8	28.2	4.8	85.2	20.1	149.8	127.3

Table 2: Physical characteristics and population of African Great Lakes and Laurentian Great Lakes¹⁰

¹⁰ Data for Rift Valley lakes from Bootsma & Hecky (2003) and data for the Laurentian Lakes from Evans (2005) and Bootsma & Hecky (2003) (hydrology data)

AFRICAN GREAT LAKES

The African Great Lakes, situated in the highlands of eastern Africa are headwaters to three great rivers of Africa, the Nile, the Congo and the Zambezi, and receive inflows from a total of 10 different countries. Tanzania borders three of the lakes, the Democratic Republic of the Congo four, Uganda three, with Malawi, Mozambique, Zambia, Burundi and Kenya sharing one of the lakes. Rwanda and Burundi are in the catchments of three and two lakes respectively, and the lakes contribute downstream flows to an additional two arid countries, Sudan and Egypt.

The management challenge for African lakes is made more complex by the need for economic growth and development to alleviate poverty and improve personal and national incomes. Regional poverty is usually considered a negative in terms of supporting costs of resource management; however, rapid development of the Lake Victoria fishery has had the positive effect of drawing riparian countries together to ensure sustainability of that large, shared aquatic resource. On the other hand, rapid economic growth may also occur in exploitative sectors and can lead directly to negative impacts on these large lakes.

LAKE VICTORIA

Lake Victoria has a multimillion dollar fishery industry and is an important source of water and fish protein to riparian countries. Approximately 35 million inhabitants live within the Lake Victoria basin, a third of the population of the East African Community Partner States (Uganda, Kenya, Tanzania, Rwanda and Burundi). Lake Victoria and its entire basin face key environmental, management, and socio-economic challenges. Environmental challenges stem, in part, from excessive nutrient loading from domestic and industrial wastewaters, solid wastes, sediments from soil erosion in the catchment areas, as well as from agricultural wastes and atmospheric deposition. Phosphorous sediments, for example, have doubled over the past 100 years and have been linked to massive increases in algae populations and fish kills. Increased fishing pressures and the introduction of exotic fish species have put pressure on the fisheries. The proliferation of water hyacinth, an invasive plant species, also poses challenges for environmental management in the region. Various mitigation strategies have been implemented to control the plants, including introduction of predatory weevils, manual extraction methods, and use of wave action to reduce numbers. While these measures have been somewhat effective, areas around the lake still have high numbers of the hyacinths.

Ongoing management challenges are closely linked to the rich natural resources found within the lake basin. These resources, especially the fishery, attract many stakeholders with diverse interests. Lack of coordination among the various individuals, associations and organizations operating within the basin have led to duplicated and often ineffective management programmes to address problems arising from resource use and extraction. The overall ineffectiveness of efforts to address these challenges has caught the attention of the riparian countries and alerted them to the need for cooperative management through an ecosystem approach.

Many of the socio-economic challenges in the Lake Victoria basin are directly linked to poverty, especially among the many rural communities occupying the basin and relying heavily on subsistence production. Mortality rates among such communities are high, due to water-borne diseases like malaria and typhoid. Bilharzias are also quite common. A high incidence of HIV and AIDS in the region, with a prevalence of more than 40% in the basin, puts an enormous socio-economic burden on basin communities.

LAKE TANGANYIKA

Lake Tanganyika is shared among four riparian countries: Tanzania, the Democratic Republic of Congo, Zambia and Burundi. The main industries in the basin include agriculture, raising livestock, and natural resource extraction. Lake Tanganyika has had less human impact than the other lakes in the East African region; however, population in the region is high, and is growing rapidly, so it is possible that the situation could change quickly without intervention. The lake holds on to water for more than 400 years; there is, thus, a great incentive to protect the lake from contamination because it will stay in the system for a long time.

Many of the challenges that face the lake basin are intricately linked with the high level of poverty, industry and historical conflict throughout the region. Lake Tanganyika is specially challenged by the impacts of high population and by unsustainable fishing practices. Fisheries make up the most significant source of animal protein for human consumption in the region, and are therefore very important for health and well being in the basin. Another significant threat to the lake is sediment influx, particularly from areas in the lake basin in which heavy deforestation is occurring. Threats faced by Lake Tanganyika include:

- overexploitation of biological resources
- siltation, because of deforestation
- untreated wastewater discharges
- runoff from agricultural areas
- increases in population density, and urbanization and industrialization of the basin
- tourism pressures
- climate change

LAURENTIAN GREAT LAKES

The North American, or Laurentian, Great Lakes are Lake Erie, Lake Huron, Lake Michigan, Lake Ontario and Lake Superior. More than 30 million people live in the Laurentian Great Lakes basin area and a significant amount of economic activity, including industry and agriculture (25% of

Canadian agriculture and 7% of American farm production) is based in the region. The health of the Laurentian Great Lakes is threatened by effects of pollutants from runoff, waste discharge from municipalities and industries, and leaching of toxic chemicals from industry throughout the basin. In part due to the enormous area the Laurentian Great Lakes basin covers, climatic conditions, geography, soil properties and human impacts vary across the system. Individual lakes also differ in size and volume, and are therefore affected differently by several key challenges facing the basin, including excess nutrients, agricultural runoff, chemical contamination, climate change, exotic species, changes to the biological communities, and habitat destruction through developments and urban sprawl.

Size alone does not provide protection from environmental degradation driven by rapid economic development. In fact, it was rapidly expanding economies, leading to excessive demands on shared resources, that brought commissions into being, as with the African commissions; and it is continuing economic expansion with sometimes negative impacts that have driven concern over the sustainability of water quality and fisheries resources. The longer history of the North American commissions gives them a reservoir of experience, both successes and failures, in managing shared resources that can be used to accelerate the capacity of emerging African international organizations. There are lessons that can be transferred about effective organizational structures and management practices that may have value to the new African agencies.

THE GREAT LAKES WATER QUALITY AGREEMENT

The Great Lakes Water Quality Agreement, signed by the U.S. and Canada, outlines and affirms the commitment of both countries to ensure the quality of the Laurentian Great Lakes, in terms of chemical, physical, and biological properties. The agreement is a reaffirmation of the commitments made by the two countries to protect shared waters under the *Boundary Waters Treaty* of 1909. The agreement was amended in 1987 with the signing of a protocol that introduced provisions to create RAPs, and Lakewide Management Plans (LaMPs). RAPs originally focused on 43 Areas of Concern, which have since been reduced to 42. The Plans take an ecosystem approach, with broad local community involvement. LaMPs put a focus on maintaining the quality of open waters, with a specific focus on critical pollutants. The IJC is responsible for overseeing the progress of these efforts in both countries, which in turn are responsible for regularly reporting their progress.

In 2009, Canada and the United States committed to amend the GLWQA to address concerns and new challenges of both countries, First Nations, provinces, non-government organizations, and other stakeholders.

LAKE SUPERIOR

The drainage basin of Lake Superior encompasses part of four U.S. states, Michigan, Minnesota, Wisconsin, and part of Ontario, Canada. It is considered the healthiest of the Great Lakes, largely because of its relatively undeveloped shoreline and low human population throughout the basin. This allowed the lake to remain relatively unexposed to the human impacts experienced by other Laurentian Great Lakes. The Lake Superior LaMP is considered unique because it includes the 1991 Binational Program to Restore and Protect the Lake Superior Basin, a measure that involves the ambitious Zero Discharge Demonstration Program for critical pollutants, intended by the International Joint Commission to be a model for lakewide management for the other Laurentian Great Lakes.

LAKE MICHIGAN

Lake Michigan is the only Laurentian Great Lake situated entirely within the United States, with a drainage basin that includes parts of Illinois, Wisconsin, Michigan, and Indiana. The lake is unique because of the dramatic difference in climatic and environmental conditions across the basin. This characteristic of the lake has led to a diversity of plant and animal species throughout the region. It has also meant that human impacts differ significantly between the northern reaches of the basin, and the southern areas. In the north, the population is sparse and the basin remains relatively undeveloped, covered primarily with forested areas. Further south, however, human populations become very dense, and shoreline development with both residential and industrial areas, increases significantly. Major industries in the basin include production of agricultural and industrial products such as metals, petroleum and coke. Development of the basin has led to significant alterations of the ecosystem and has resulted in the designation of 11 areas in the basin as Areas of Concern.

LAKE HURON

Lake Huron is the largest of the Laurentian Great Lakes and has a drainage basin covering portions of Michigan, U.S., and Ontario, Canada. The lake contains Manitoulin Island, the single largest freshwater lake in the world. The basin is heavily forested, and the region relies heavily on local natural resources for extraction and recreational tourism. The Lake Huron Binational Partnership is a unique program that addresses pollution reduction and habitat protection around the lake, including in the five Areas of Concern, two of which have been delisted. The Partnership uses existing institutions and networks in order to pursue on-the-ground work.

LAKE ERIE

Lake Erie is the most biologically productive of the Laurentian Great Lakes. Due to its southerly location, the lake's drainage basin is heavily developed for industry, agriculture, and urban areas. Lake Erie is also the most densely populated of all the Great Lakes, with 12 million people residing in the basin. It is heavily impacted by urban sprawl, industrial pollution, and shoreline development, climate change, exotic species, and habitat destruction. Although the lake is small in comparison to the other Great Lakes, it has 8 areas designated as Areas of Concern, second only in number to Lake Michigan.

LAKE ONTARIO

Lake Ontario's drainage basin includes portions of Ontario, New York, and Pennsylvania. It is also situated downstream from each of the other Great Lakes and thus is impacted by the flow and deposition of contaminants from upstream. The lake has experienced considerable degradation through habitat loss, toxic pollution, and artificial lake level management. Seven Areas of Concern have been identified across Lake Ontario including Hamilton Harbour, Toronto Harbour, Port Hope, Bay of Quinte, Oswego, Rochester Embayment, and Eighteenmile Areas of Concerns.

ANNEX B: GREAT LAKES GOVERNANCE STRUCTURES SUMMARY

Commission	Year Established	Governance Structure	Functions	Public Involvement	Related Policies and Agreements	'Riparian' Countries
International Joint Commission www.ijc.org	1909 <ul style="list-style-type: none"> Established under <i>Boundary Waters Treaty</i> 	<ul style="list-style-type: none"> Six Commissioners, 3 selected by U.S. president, 3 selected by Canadian government Decisions made through consensus-building The Great Lakes Water Quality Board is the principal advisor to the IJC related to the GLWQA 	<ul style="list-style-type: none"> Provides non-binding recommendations to government for the prevention of disputes Can be employed as a final court of arbitration on boundary water issues between U.S. and Canada Implements GLWQA Pushes for establishment of watershed councils 	<ul style="list-style-type: none"> Biennial public meetings Sponsors conference and meetings open to public Seeks public input for major decisions 	<ul style="list-style-type: none"> Great Lakes Water Quality Agreement (1972) 	USA, Canada
Great Lakes Fishery Commission www.glfco.org	1954 <ul style="list-style-type: none"> Established under the <i>Canada/U.S. Convention on Great Lakes Fisheries</i> 	<ul style="list-style-type: none"> Eight government-appointed commissioners, 4 U.S (plus one alternate), 4 Canada Executive functions conducted with 17 secretariat staff Both sections consult with advisors, drawn from a cross section of interests and required to maintain close contact with their constituents. 	<ul style="list-style-type: none"> “Coordinates fisheries research, controls the invasive sea lamprey, and facilitates cooperative fishery management among the state, provincial, tribal, and federal management agencies.” 	<ul style="list-style-type: none"> Developed a communications framework to facilitate 2-way communication between commission and partners, including the public Formal Committees of Advisors established 	<ul style="list-style-type: none"> Great Lakes Fisheries Act of (1956) (though with significant non-federal responsibilities) Great Lakes Fisheries Convention Act (1956) Joint Strategic Plan for management of Great Lakes Fisheries (1997) 	USA, Canada
Lake Victoria Fisheries Organization www.lvfo.org	1994	<ul style="list-style-type: none"> Council of Ministers (COM) is the supreme organ of LVFO consisting of Ministers responsible for fisheries in member countries Management and scientific committees report to the Executive Committee Executive Committee reports to Policy Steering Committee, which reports to the COM 	<ul style="list-style-type: none"> Part of the East African Community's Lake Victoria Development Program LVFO uses working groups to inform the scientific community and directors from the parent countries. Provides advice and honest information to governments. Objective: “harmonize national measures for sustainable use of the lake’s fisheries resources and to develop and adopt conservation and management measures accordingly.” 	<ul style="list-style-type: none"> LVFO works with stakeholders in co-management. Community work achieved through grassroots institutions in communities, including beach management units (BMUs) LVFO established to empower stakeholders & improve governance 		Uganda, Tanzania, Kenya

<p>Lake Victoria Basin Commission www.lvbcom.org</p>	<p>2005</p> <ul style="list-style-type: none"> Formed by the East African Community Council of Ministers 	<ul style="list-style-type: none"> Policy and steering committee represents all national government agencies with responsibilities for fisheries Implements Lake Victoria Development Program (LVDP) 	<ul style="list-style-type: none"> “Policy and Steering Committee reports to its Council of Ministers, which represents all national government agencies with responsibilities for fisheries” Goals: a healthy lake ecosystem, integrated fisheries management, coordinated research programmes, effective information generation and exchange and strong institutional/ stakeholder partnerships. 	<ul style="list-style-type: none"> LVDP emphasizes poverty eradication and community participation 	<ul style="list-style-type: none"> Lake Victoria Development Programme EAC, Protocol for Sustainable Development of Lake Victoria Basin 	<p>Tanzania, Uganda, Kenya, Rwanda Burundi - check</p>
<p>Lake Tanganyika Authority www.lta-ait.org</p>	<p>2008</p> <ul style="list-style-type: none"> Established under Convention on the Sustainable Management of Lake Tanganyika 	<ul style="list-style-type: none"> Main organs: the Conference of Ministers, the Management Committee and the Secretariat Management Committee is assisted by national Technical Committees. 	<ul style="list-style-type: none"> Responsibilities: to coordinate basin management, represent member states on lake matters, and serve as a forum for regional cooperation, integration and development. 	<ul style="list-style-type: none"> Lake Tanganyika Fisheries Framework Mgmt Plan (FFMP) Lake Tanganyika Strategic Action Programme (SAP) Convention ensures: “Individuals and communities living within the basin have the right to participate at the appropriate level in decision-making processes...” States are also responsible for ensuring that an appeal process is in place Convention also outlines extent to which information must be made publicly available 	<p>Burundi, Democratic Republic of Congo, Tanzania and Zambia</p>	

Table 3: Summary of Governance Structures

ANNEX C: POLICY AND SCIENCE WORKSHOPS OF THE LAKE TWINNING PROJECT

FIRST SCIENCE AND POLICY LINKAGE WORKSHOP, Entebbe, Uganda

This was the first of two policy workshops specifically addressing issue linkages between Lake Victoria, East Africa, and the Laurentian Great Lakes. It was held in Entebbe, Uganda from 24 to 26 September 2008. The meeting was largely by invitation and included participants from North American and African trans-boundary lake commissions, governments, universities, and research institutions.

SECOND SCIENCE AND POLICY LINKAGE WORKSHOP Niagara Falls, Canada

Objectives of the Niagara Falls meeting, June 14-15 2009, were to discuss a number of issues of common interest, expanding upon materials covered in the Entebbe meeting. These issues included ecosystem management, climate change, public/private partnerships, and governance. The meeting facilitated continuation of comparative analysis of lake management between the North American and African systems: to facilitate the translation of science into policy and resource management, to finalize a framework for cooperation on Great Lakes systems through enhanced science and policy linkages, and to organize and ensure sustained communication mechanisms.

The Lake Twinning Workshops were based on the shared management issues confronting the Laurentian Great Lakes and Lake Victoria and Lake Tanganyika in East Africa.

Because of shared issues, commissions and organizations dealing with lake management in the different lake systems have many similar priorities and objectives. Managers of both the Laurentian and African Great Lake systems are able to benefit from sharing their respective successes and challenges.

The Lake Twinning Project is part of a Medium Sized Project “Regional Dialogue and Twinning to Improve Transboundary Water Resources Governance in Africa” funded by Global Environmental Facility. The main purposes are to facilitate policy, legal and institutional reform for transboundary waters management through comparative analysis between African and Laurentian Great-Lakes systems; to enhance regional and national knowledge and capacity for management and planning of shared water resource systems; and to strengthen planning processes in shared water resources management, facilitating self-sustaining regional water institutions in Africa. This project is ultimately expected to lead to development of a framework for collaboration on Great Lakes systems through enhanced science and policy linkages. That framework will form the basis for longer term partnership between the commissions.

SOME LESSONS LEARNED

- **Whereas decision making** in North America appears to be a multi-organization and multi-stakeholder process, the opposite is true for African Great Lakes where decisions are made and implemented by relatively much smaller groups. In terms of human wellbeing, differences could be described as leisure versus survival. On the leisure side ecological and biodiversity values can be maintained, whereas on the survival side, care for the environment is less important, resulting in pollution and overexploitation.
- **For African Great Lakes**, the ways in which trans-boundary issues are addressed determines the willingness for shared water and living resources management, whereas for Laurentian Great Lakes the issues are dealt with from a holistic perspective, and equally shared by the partners, whatever the size of their “interest.”
- **With respect to community participation** in management of lake resources, the extent of involvement was different between the two. The East Africa ones had just started a coordinated process through development of the shared vision, while the North America process was

well entrenched through various voluntary associations and groupings, including academia. Consequently, public influence on policy seems to be more evident in North American lakes than in the East African, though first steps have been taken here.

- **The principles of Integrated Water Resources Management (IWRM)** are being applied in both systems although again to the differing levels of implementation. In the East African region, this principle now forms the basis for administrative water resources management arrangements in the various countries; however this is not the case in North America countries, which base theirs on federal and state systems. The concept of adaptive management was welcomed and could be an added tool to IWRM for resources (fish and water) management in both systems.
- **However, with regard to adaptive management** in the case of African great lakes, uncertainties regarding fish biomass and fish catches are still too great to form the basis for this type of management. Therefore the precautionary approach would still be the optimal way of addressing fisheries problems as too many livelihoods and investments are at stake. The North American Commission (GLFC) feels that adaptive management has the potential to allow a greater understanding of how fresh-water ecosystems respond to human actions, including fishing and land use in the drainage basin. Adaptive management can lead to effective resource management approaches if there is sufficient scientific and political will to allow truly adaptive management regimes to occur. It is necessary to properly define adaptive management and how it can be successfully implemented, so that it can be used as an effective tool for its intended purpose.
- **Finding effective means to link science and policy** is vital to managers of large lake ecosystems with large watersheds that transcend multiple jurisdictional boundaries. There is growing recognition that science should not be confined to open waters but rather should encompass watershed and socio-economic issues that impact lake water quality and quantity. Socio-economic considerations should include full-cost accounting of shared costs and benefits of resource uses as part of better understanding of the ways and means of achieving sustainability. Institutional arrangements are needed to support development of linkages between science producers and decision makers, and to foster integrated water resources management practices that will catalyze implementation of basin-wide policies to sustain long-term resource protection. These should include a visioning process with the public and stakeholders to obtain buy-in and support for science-based management programs and policies.
- **African organizations can benefit from studying the North American approach of integrated multi-sectoral management of lake resources, and North American organizations can benefit from co-developing policy appraisal techniques with their younger sister organizations in Africa.** The new governance structures being implemented in Lake Victoria provided a useful contrast to the century old structure in the Laurentian Great Lakes. The regular reporting to a tri-national ministerial committee is instructive: something that North American governments and the IJC do not have.
- **The beach management units used in African Great Lakes offer a model that could possibly be explored for applicability to situations in the Laurentian Great Lakes.** This model goes well beyond the Remedial Action Plan (RAP) program and connected to watershed and sub-watershed management with intense civic engagement supported by government technical expertise. Participants, through participation in the workshops, gained new over-arching perspectives, knowledge, and understanding of global issues in fresh-water natural resource management. These will be important in identifying common theoretical and applied fisheries resource management concepts, defining ecosystem health for the management of large lake systems, and clarifying the relationship between the two.

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