KNOWLEDGE INNOVATION SYSTEMS AND TECHNOLOGY DIFFUSION STRATEGIES FOR ECOSYSTEMS MANAGEMENT IN AFRICA — CASE STUDY: LAKE CHAD BASIN COMMISSION

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Introduction and Background

This article draws on the findings of a recent institutional assessment of the Lake Chad Basin Commission (LCBC), conducted between September 2005 and May 2006. The case highlights the role of human capital and institutions in shaping the evolution of systems of innovation in Africa.

The Lake Chad ecosystem once held the fourth-largest lake in Africa, and the lake was arguably one of the most prominent, important ecosystem features in the modern-era African landscape (see Figures 1 and 2). In 1964 it measured 25,000 square kilometers; however, persistent drought and water diversion schemes (Odada, Oyebande, and Oguntola 2003) have shrunk the lake to a mere 5 percent of its original size. Lake Chad currently ranks as Africa's fifteenth-largest lake. The Chad basin and its lake represent one the largest areas in the world at risk in terms of water and the environment that needs to be addressed for sustainable development, with an extraordinary effect on the lives and development

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potential of large social groups within at least six countries in the sub-Saharan African region.

Figure 1: A Chronology of Change (UNEP 2002)

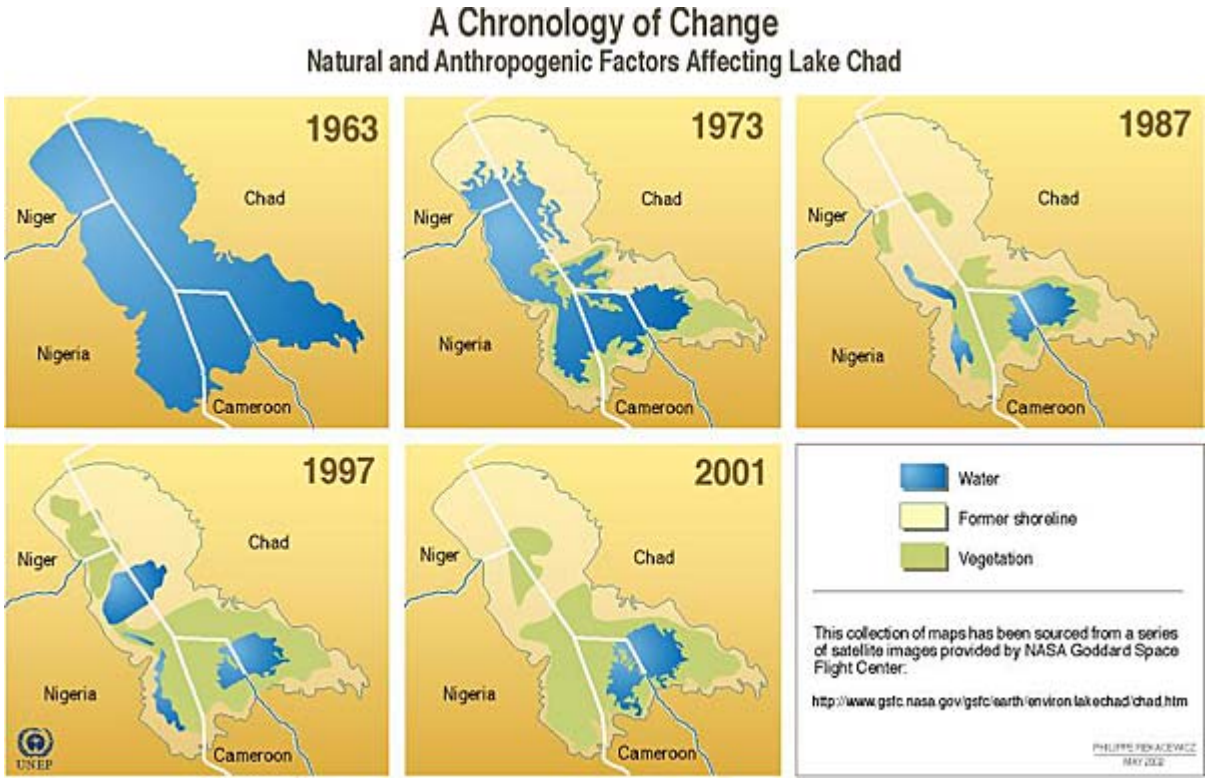

Figure 2: Location of Lake Chad (Source: University of Wisconsin-Madison, Devitt 2001)

Set against a challenging historical backdrop, this article reviews the unsuccessful efforts of the Lake Chad Basin Commission (LCBC) to manage the lake's natural resources; it considers reasons for this outcome, including institutional governance, technology diffusion and innovation, science, and issues surrounding the broader economic growth context (Lake Chad Basin Commission 2006).

I believe that the LCBC's underperformance is rooted in historic and economic structural barriers that must be tackled through local interventions and a consideration of the wider context of economic modernization programs.[1] This study supports a framework for considering ecosystems and sustainability issues in Africa and highlights the paramount role of institutions in creating a supportive "innovation system," including prerequisites such as human capital, technology, and the ability to diffuse the technology for ecosystem management.

This article begins with a look at the literature concerned with "innovation systems" and the African development context in general. The next section provides a description of the Lake Chad management case, including its history, the achievements, and the limitations. The article then discusses the obstacles for the Lake Chad Basin Commission in effectively managing the natural resources, including a look at the preconditions necessary for a trans-boundary lake governance system to be effective, including economic regional integration, education, and infrastructure. The article next evaluates two international examples that highlight favorable characteristics to consider during the Lake Chad governance reform process: the USA Land Grants Model and the Great Lakes Ecosystem Management approach. The article concludes by looking at the lessons to be learned for LCBC reform.

Literature Review: Key Findings

The literature highlights the paramount role that institutions play in supporting the development of innovation systems and technology diffusion in Africa (Oyelaran-Oyeyinka and Barclay 2003; McCormick 1998; Mani and Bartzokas 2002). The readings showed, for example, that an organization's ability to manage multidisciplinary and complex problems is dependent on the existing knowledge, human capital, and ability to use and diffuse technology. A study by Oyelaran-Oyeyinka and Barclay (2003) provides a useful framework for considering innovation systems and learning processes in Africa's development context, including: (1) consideration of the role of institutions in shaping growth and development in Africa, and (2) "systems of innovation evolution," making the explicit link between science and technology, human capital, and economic growth (see below for the European Union's (EU) definition of an innovation system). The literature has generated the following questions in relation to the subject:

- Can complex technologically intensive problems, such as are contained within the realm of the ecosystem management approach, be managed without a supportive knowledge and innovation system, human capital, and the organizational capacity to diffuse technology?[2]

- Can historic institutional underperformance, as demonstrated by the current challenges of development in Africa, be sufficiently reformed in order to elicit a knowledge-based response and provide services inherent in Integrated Water Resources Management?[3]

- What are the preconditions needed to develop a learning or innovation system and how do prerequisites such as literacy, economic stability, and natural endowment impact this goal?

- Without political and economic stability, is public investment in human capital development for institutional reform effort undermined by these larger systemic gaps?

Economic Evolution Theory — Growth and Sustainable Development

Evolution theory provides a model of industry evolution concerned with innovation and global imitation (Nelson and Winter 1982). This theory questions how new innovations emerge and to what extent these new innovations are accepted by the economic environment (selection/diffusion). Finally, it questions the consequences of this upon the economic system at large (Fagerberg 2002).

Table 1 provides the basic assumptions of the theory. In the context of the current topic, it provides a useful framework to view, broadly, barriers to Africa's sustainable development.

Table 1: Main Assumptions — Economic Evolution Theory (Nelson and Winter 1982)

- Firms' (organizations') behavior is conditioned by their rule-based decision process and inertia;
- Specific *research and development (R&D)* investment is necessary for innovation;
- The competitive advantage of firms (organizations) is based on their innovative capacity;
- The selection of firms (organizations) is determined by their innovative capacity;
- Innovative behavior of firms (organizations) hence determines the structure of the industry and its evolution.

Innovation Learning Systems

The European Union defines an innovation system as "a network of firms and other economic agents who, together with the institutions and policies that influence their innovative behavior and performance, bring new products, new processes and new forms of organization into economic use" (UNU-INTECH 2004)[4]. M. Goedhuys (2005) expands, arguing that the "innovation systems approach" includes elements such as a learning process, interaction, and investment by the actors in the system, both the firm (organization) and other economic agents (UNU-INTECH 2004). Her thesis suggests that a firm's quest for new knowledge involves efforts aimed at internal learning such as "investing in research and development (R&D), education and training, new equipment, connectivity and communication" (Goedhuys, 2005, 7). Further, the changes often involve "investment and risk" and require a "financial commitment" (Malerba 1992 and Lazonick 2004 as quoted in Goedhuys 2005).

Diffusion of Innovation Theory

E.M. Rogers (1983) argues that "technology and innovation are the basic engines of economic growth." He coined the Diffusion of Innovation (DOI) theory in order to improve our understanding of the "patterns of adoption, explain the mechanism, and assist in predicting whether and how a new innovation will be successful." DOI provides a suitable framework for considering ecosystems management, agricultural development, and related sustainability issues in Africa (Rogers 1983). According to a task force formed within the USA House Subcommittee on Technology and Environment to study these issues, technology and tools for ecosystem management are extensive and still evolving.[5] This was

also illustrated by the case of the Lake Chad Basin Commission. For example, LCBC managers initiated the South Chad Irrigation Project more than thirty years ago in order to support changes to unsustainable irrigation practices, however, the project failed, and nothing has been done to use or diffuse technology into the problem since (Bomford 2006).

According to Roger Clark (1991), "DOI theory is concerned with the manner in which a new technological idea, artifact or technique, or a new use of an old one, migrates from creation to use" and that "technological innovation is communicated through particular channels, over time, among the members of a social system." Juma expanded and added the concept of sustainability. For example, he argued, that "it is important to frame agricultural sustainability in the context of innovation systems" (Juma 2006a). He rejects the classical view that "agriculture is a separate sector requiring unique policy interventions, decoupled from the wider process of economic learning." According to him, agriculture requires the intensive use of new technology (2006c).

Role of Institutions — Innovation Systems Evolution

Oyelaran-Oyeyinka and Barclay (2003) argue that combining the literature on systems of innovation and institutional development with evolution theory highlights the role of institutions and human resources in the prediction of growth in Africa. However, the "systemic nature of institutions" has not been considered broadly as it relates to Africa's development issues. Oyelaran-Oyeyinka and Barclay provide explanations regarding African's poor economic performance including: (1) structural and institutional factors (also see Easterly and Levine 1995); (2) the poor technological and managerial capacities resulting in a failure to effectively transfer technology and underutilization of human capacities (see also Enos 1992; Lall 1992, 1993); (3) policy issues; and (4) long-term historical factors (see

also Engerman and Sokoloff 1997).[6] It does not, however, consider the role of institutions in shaping patterns of development (Oyelaran-Oyeyinka and Barclay 2003, 9). Therefore, the paramount role of institutions in transmitting science, technology, and human technical experiences to sustainable development initiatives in Africa is apparent.

Role of Policy

According to Goedhuys (2005), innovation system approach acknowledges that policy plays an important role in setting the parameters within which actors make decisions about three key elements in an innovation process: learning, investment, and linkages, (UNU-INTECH 2004). Applying this theory to the Lake Chad Basin Commission reform exposes that institutional underperformance is theoretically linked to the lack of preconditions necessary for organizational learning and technological innovation, including technology, infrastructure, and the human capacity to diffuse and use knowledge in a dynamic problem solving or innovation process (World Bank 2005).

The Lake Chad Crisis

The Problem

"It will be a puddle. You'll get crops and drinking water out of it, but you'll have no ecosystem left to speak of" (Coe and Foley 2001).

Lake Chad is disappearing for two reasons: (1) natural — increasing drought and climatic change conditions, and (2) human factors — lack of regulation and massive bad irrigation practices. It is estimated that about one-third of the stream flow today is being diverted from the Chari River before its flow even reaches Lake Chad. Between 1983 and 1994, irrigation water use increased fourfold (Glantz 2004). About 50 percent of the

decrease in the lake's size since the 1960s is attributed to human water use, with the remainder attributed to shifting climate patterns (Devitt 2001; Coe and Foley 2001).

Achievements

On 22 May 1964, the LCBC was established by the Fort Lamy (N'djamena) Convention and Statutes by the governments of Cameroon, Chad, Niger, and Nigeria. In 1994, the Central African Republic was admitted as the fifth signatory. Sudan was admitted during the tenth Head of State summit held on 28 July 2000, increasing the LCBC jurisdiction from 966,955 square kilometers to 1,035,000 square kilometers (Lake Chad Basin Commission 2003). The Fort Lamy Convention recognizes the sovereign rights of each member state over basin water resources within its own territory but forbids unilateral exploitation of lake water where such use detracts from the interests of other states. Member states are required to abstain from measures likely to alter the water budget, water quality, integrated water and resources management health, or water access by other member states. The convention recognizes the right of member states to plan projects within the conventional basin in consultation with the LCBC.[7]

Limitations

Despite the LCBC's broad mandate, which includes trans-boundary water and land, economic integration, peace and security issues, the existence of institutional legal frameworks has not translated into effective action. For example, years after the creation of the LCBC, national water policies within member states still remain deficient or nonexistent. The absence of regional and national standards/guidelines to govern the monitoring of water quality, quantity, and cost-sharing mechanisms has led to continued environmental

degradation within the basin. LCBC's efforts at regional water resource management have failed.

Significant operational issues at the LCBC have arisen from the overall fragmentation of scientific effort, responsibility, and authority, leading to fiduciary concerns, the substantive lack of accountability, and a weakening of capacities at all levels. As a consequence, the organization's ability to function on a day-to-day basis is retarded.

Timeline for Reform

It is obvious that the current system is failing: lake and basin governance is lost, management is faulty, Lake Chad is endangered, and time and opportunities are running short. So the next question is of imminent importance: What is the timeline for reform? The problem already is having a negative impact on every single life system being sustained by the lake. The estimated 22 million people who depend on the lake and its resources for their livelihoods are at serious risk. The consequence of expanding extreme poverty in an already troubled region, already manifesting in the driest regions (that is, Eastern Chad, Northern CAR, and Western Sudan), will intensify the ongoing conflict and increase social disruption. Estimates of a worst-case scenario in which Lake Chad dries up with no alternative livelihoods or social safety net in place are dire.

Consideration of the Barriers to Knowledge Diffusion and Technological Innovation[8]

Before initiating reforms at LCBC, managers must assess the broader economic environment including potential for regional development, infrastructure, technology, innovation, and basic human capital stocks. Overcoming national and regional structural barriers may not be possible under the auspices of the LCBC restoration project as macroeconomic structural economic adjustments are called for to generate a "fundamental

shift in the business as usual model of governments" to achieve regional economic development (Murenzi and Hughes 2005, 43). In addition, constant political instability perpetually undermines regional economic progress and stunts the development of national learning "innovation" systems. However, at the institutional level, actions can be taken in order to evoke a "Lake Chad Basin Commission Learning System," for example, investments in knowledge creation, knowledge transfer, and a governance structure suited to ecosystem management and innovation approach (Murenzi and Hughes 2005, 43, 52).

The following sections highlight the preconditions needed for an effective learning system to evolve (regional integration, infrastructure, and education) and offer two international good practices for learning and innovation system development in the context of ecosystem management: (1) U.S. Land Grant Agricultural Development Model, and (2) USA-Canada-Great Lakes Ecosystem Management approach.

Regional Development (Macroeconomic Policy)

Romain Murenzi and Mike Hughes believe that the recent African effort at regional economic development reflects recognition of the importance of "science and technology" in development (2005, 51). They suggest that new efforts to import technologies must be combined with homegrown institutional innovation in order for the development to be successful. In addition, they posit that new strategies for international cooperation in Africa consider major trends such as globalization and regional integration initiatives (Murenzi and Hughes 2005, 48-59). For example, they stated:

> World Markets are a source of technology and capital; it would be silly for developing countries not to exploit these opportunities. But globalization is not a short cut to development. Successful development strategies have

> always required a judicious blend of imported practices with domestic institutional innovation. (Murenzi and Hughes 2005, 51)

Infrastructure (Technological Learning)

According to Murenzi and Hughes, the *ability* of infrastructure development to diffuse technical skills into the economy has been overlooked. In relation to this position, they argue that Rwanda's growth policies since 1997 stipulate that new regional infrastructure projects should be tailored to the transfer of skills and facilitation of the learning process in order to be effective (Murenzi and Hughes 2005, 57). In relation, T. Ridley and Yee-Cheong Lee (2005, 62) support that "the absence of infrastructure services[9] is a serious problem hindering efforts to develop Africa."

Juma (2005) posits that the technological learning process can provide organizations an opportunity to acquire and diffuse new knowledge and skills. During a presentation to the leaders at the African Development Bank, April 2006, he stated "development and infrastructure literature often overlooks infrastructure's dynamic nature. Every stage of an infrastructure project, from planning and design through to construction and operation, involves the application of a wide range of technologies and associated institutional and management arrangements" (Juma 2006b). Thus, infrastructure constitutes a major part of the development of a dynamic learning system.

Education (Human Development Policy)

Oyelaran-Oyeyinka and Barclay (2003) argue that the base of human capital and the institutions inherited by African states have set the tone for the development in national systems of innovation. They consider the African development context as a "non-dynamic system of innovation" and suggest that limited human capital development explains the

relatively difficult processes of implementing science and technology institutions on the continent. They suggest that in order to be effective, national and international innovation systems must include important factors, such as: basic education, economic growth, and industrialization.

Easterlin (1981 in Oyelaran-Oyeyinka and Barclay 2003) expanded on this argument. He stated, "there is a direct correlation between schooling of the relevant context and countries' ability to master new technologies." Oyelaran-Oyeyinka and Barclay (2003) elaborated, stating that "the combined rates of technological and human capital (transmitted through educational attainment) are connected, and the existing supply of human capital such as a mixture of skills at the onset of the industrialization process is an important prerequisite for economic growth." When considering the elements necessary for progress through the lens of the disappearing Lake Chad situation, one question raised is whether existing national structures of innovation and human capital base are sufficient to provide capacity to support a standalone model institution aimed at providing knowledge services to achieve integrated water resource management.

International Experiences — What Works?

In order to respond to the current challenges faced by Lake Chad and development in the surrounding region, managers and political leaders must elicit the preconditions for a regional dynamic innovation system to evolve. Two international practices are offered that provide comparative insights into this problem: the USA Land Grant Model (national example) and the Canada-USA-Great Lakes Ecosystem Management strategy (trans-boundary example). In relation to the first, the expansion of rural education and the linkages to agriculture were essential to the success of agriculture and sustainability practices in the

United States. Since its establishment in 1892, the land grant system of colleges and universities in the United States has grown to represent a unique system of widely accessible research that is relevant for solving real problems and for reaching out to all citizens in a way that has elevated U.S. society. Second, the recent adoption of the ecosystem approach by the Great Lakes Management Authorities is proving to be a successful experience that is building upon the innovation systems theory.

US Land Grant Institutions — Success of American Agriculture

The development of American agriculture is a demonstrated success. U.S. agriculture today embodies the concepts of sustainability, food security, efficiency, and profits. This was not always the case, as the country redefined agriculture from a rudimentary and subsistence activity in 1892 to a knowledge-based activity today by designing policies and institutions to bring the latest scientific and technical knowledge to its primarily rural farming community. In essence, the growth and efficiency of American agriculture is attributed to the development of land grant institutions that taught agriculture, military tactics, and the mechanic arts as well as classical studies so that members of the working class could obtain a liberal, practical education (West Virginia University 1999). As a successful growth-stimulating system, the forward-oriented policies encompassed three major missions:

1. Objective or unbiased research (done by the experiment stations)
2. Nonformal education and information dissemination (carried out by the extension services)
3. Classroom or college instruction (taught at each land grant campus)

Through the institution of the land grant system, the government offered in every state, the opportunity for a liberal and broader education to larger numbers, not merely to those destined to sedentary professions, but also to those needing higher instruction for the world's business, for the "industrial pursuits" and the "professions of life" (West Virginia University 1999). In addition and central to the program's success for supporting the intensification of farming, good practices, and having a direct positive impact on the local economy (growth of local markets) was the institution of the agricultural experiment station program created by the Hatch Act of 1887 (West Virginia University 1999). The Hatch Act authorized direct payment of federal grant funds to each state to establish agricultural experiment stations in connection with the land grant institution there. In addition, the Smith-Lever Act of 1914 established the cooperative extension service nationally, as each state administered an extension service through the state's land grant university. Exemplary arrangements with U.S. colleges, such as Iowa, Cornell, and Texas, have had direct impacts on farming intensification and economic spins, for example, extension to "disseminate useful and practical information" to the public (West Virginia University 1999). In contrast to agriculture in Africa, currently being characterized as a "rudimentary and subsistence" activity, requiring no more than "a primary level education," the United States succeeded in modifying its research, government, and educational institutions to better suit the demand of "knowledge based agriculture."[10]

This model provides an excellent example of how strategically directed investment for strengthening and/or building new institutions can promote technology transfer and local innovation for agricultural and sustainability issues. Through formalizing practical linkages to institutions of higher learning, such as local and regional universities and other

existing educational institutions, the outreach model will contribute to broader economic development and regional integration. LCBC can emulate this model through the following:

1. Providing objective or unbiased ecosystem-related research (done by the experiment stations); this requires linking LCBC with local, regional, and international universities or schools.

2. Encouraging nonformal education and information dissemination (through extension services); this requires LCBC managers to make formal links with institutions of higher learning or research institutes in the five countries.

3. Providing classroom or college instruction (through strengthening and expanding on the currently underfunded LCBC agriculture school).

The Great Lakes Model — Integrated Water and Resources Management

The Great Lakes Ecosystem Management approach recognizes the interrelated nature of air, land, water, and all living beings (GLIN 1994). The Great Lakes Ecosystem Management system is a successful endeavor that also builds upon the innovation systems theory. As the Lake Chad River Basin is to Central Africa,[11] the Great Lakes-St. Lawrence River system is the lifeblood of eight U.S. states and two Canadian provinces. The Great Lake system encompasses 20 percent of the world's supply of fresh surface water and is an inseparable part of the region's history, economy, and quality of life. The region supports one-fifth of the manufacturing activity in the United States and provides drinking water to more than 30 million U.S. citizens (Great Lakes Commission n.d.). The Great Lakes Management approach is characterized by the following key features:

- Includes the whole system and not just parts of it

- Focuses on interrelationships among the components of the environment and between living and nonliving things
- Includes consideration of the natural environment, society, and economy
- Is based on natural geographic units such as watersheds
- Incorporates the concepts of sustainability
- Respects species other than humans and generations other than the present

An ideal model of ecosystems management, this approach outlines a new organizational structure and technology including the human capacities needed to evoke a dynamic ecosystem "learning system." The new system ideally can support technological innovation and diffusion and focus on strengthening and building partnerships, research and development, knowledge dissemination, and knowledge networking. In this sense, in Africa, LCBC can outline a knowledge management strategy with a focus on building practical linkages to institutions of higher learning, including locally, regionally, and internationally. This can serve to support local ecosystem-based research and development and create a learning loop. LCBC institutional structures may vary, but the mechanisms that support dialogue and coordination to ensure a measure of knowledge integration, knowledge dissemination, and learning concerning core sectoral issues are absolutely essential. Through emulating the Great Lakes model, the LCBC can define a new reform policy centered on building an ecosystem learning system that emphasizes the role of science, technology, and research capacities at all levels.

Lessons Learned

The following sections consider the above U.S. examples in terms of lessons learned for future investment in LCBC reform.

Sustainable Development: Policies and Incentives for Knowledge, Investment, and Infrastructure

Although the situation of Lake Chad and its surrounding area and the United States are two very different contexts, as defined by space, time, and conditions (political, social, ecological, and economic), it is clear that the separation of research, training, and day-to-day farming is hindering agricultural development and sustainable agricultural practices in Africa. To solve these problems, political leadership in the basin (Sudan, Central African Republic, Chad, Cameroon, Nigeria, and Niger) is needed to align agriculture research and training with existing institutions such as the Lake Chad Basin Commission and/or to create new institutions in order to serve the affected communities.

Strategic Partnerships (International, Regional, National, and Local)

Rather than focus on geopolitical boundaries and departmental divisions, as with the Great Lakes Ecosystem Management approach, the situation in Africa calls for creative partnerships to cover natural boundaries, such as watersheds, as the unit of management. Managers must ensure that state-of-the-art technology, human capacities, and infrastructure are present to help meet the challenge of solving broad ecosystem problems across political boundaries. Infrastructure, including equipment and the right personnel, is an essential part of this strategy, as managers must pursue complex multidisciplinary research. Equipment such as state-of-the-art vessels that permit the operation of scientific personnel safely under varied environmental conditions were among the requirements for broad-scale research in the Great Lakes and its coastal environments. Other specialized equipment, such as sensors,

and people with the ability to use them, as well as computer technology, were required to ensure the highest quality and quantity of data was available for assessments. Developing this type of system is expectedly costly given the infrastructure and human resources needed to sustain it.

Infrastructure for Research and Development

Central to the Great Lakes ecosystem approach was direct investment for research and development to promote local innovation and enhanced cooperation between two riparian countries. The Great Lakes Water Quality Agreement of 1978, for example, called for an ecosystem-wide approach and broadened the view of the boundaries of an ecosystem and the management tactics it would embody (GLIN 1994). The system benefited from an intergovernmental partnership that supported various research and development programs, including the National Sea Grant College Program. The shared funds were essential to promote and support scientific research and outreach programs on topics ranging from aquatic nuisance species to sustainable coastal development, now highlighted as an important element that contributed to the program's success. Clearly, investment in local research is essential for contextual learning and innovation to occur around the problem and opportunities of the region.

Conclusions

In 2000, the LCBC Vision 2025[12] was promulgated in line with the Lake Chad Basin Commission's future development. The strategy calls for an organizational reorganization that is suited to a renewed vision of Lake Chad, "where land, water and all natural resources are conserved, and managed in an integrated manner and shared equitably, in order not only to eradicate poverty and improve living standard of the people in the Lake Chad Basin, but

also to ensure peace, security, cooperation and sound economic developments of the region" (Lake Chad Basin Commission n.d.). Achieving this vision will require the development of extensive scientific, technological, and research capacity at all levels. At a minimum, LCBC managers must create the preconditions for investments that strengthen domestic capacity for technology and innovation for Lake Chad River Basin's sustainable management. Such actions are imperative to manage a pending water crisis in the Lake Chad River Basin, which could personally impact 22 million people who depend on it as a life source.

LCBC reform calls for a knowledge-based institutional response that will facilitate organizational learning, investments, and linkages. It requires the mobilization of scientific and technical expertise at all levels: locally, nationally, regionally, and globally. Doing so will require costly improvements in technological capacity, human capital, and corresponding changes in governance. The existing LCBC response capability does not match the magnitude of the problem, and, therefore, new institutional mechanisms are needed.

In a recent address to the African Development Bank, Juma (2006b) argued that for effective growth strategies in Africa to withstand, "research, teaching and community outreach must merge in new institutional designs for innovation and technological diffusion." As it is related to the LCBC case, this translates, for example, into funding initiatives that would strengthen the existing agricultural research stations' teaching role (strengthening agricultural extension systems, promoting local innovation and knowledge diffusion) and forge strong links with universities (national and international). Juma argued that this process may involve costly reforms or upgrades within existing universities and even the creation of new institutions. LCBC management can consider the costly structural changes needed in line with Juma's thinking as part of a longer-term solution.

Policy Options: Learning, Investments, and Linkages at LCBC

In general, LCBC's institutional assessment unearthed seven key issues to be addressed for effective reform. The activities, in line with the linkages, learning, and investment theory, should be planned for the short, medium, and long term. Number six listed below — creating a knowledge response — thus poses the greatest challenge in terms of mobilizing resources and political will as it entails changes in organization, behavior, attitudes, and policies and in the general "business as usual model of incumbent institutions in Africa." The key issues are:

1. Improved fiduciary capacity
2. Overall organizational improvement
3. Improved management capacity
4. Improved enabling legal and policy environment
5. New communications and knowledge networking strategy
6. A knowledge response, knowledge-based decision making enabling environment and culture, which entails incentives and infrastructure for ecosystem research and development; agricultural extension expansion to promote local innovation systems and human capital development; linkages to universities and institutions of higher learning (local, regional, and global); informed decision making through science and technology diffusion; and open access to technical expertise for better irrigation systems and solution to other local issues
7. Broad consensuses on the new vision for lake and basin governance

The new lake governance systems will need to rely on knowledge-based decision-making. As Juma posited recently in response to a comment on tackling climate change, "Governance systems will need to rely on knowledge-based decision-making. It will take smart governments, informed leaders and strong international technology partnerships to steer those countries in the right direction" (Juma 2006c). For this, the LCBC reform can concentrate by building upon the lessons learned from the two good experiences presented in this article in order to create a functioning ecosystem "innovation and learning system" in Central Africa.

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[1]Oyelaran-Oyeyinka and Barclay (2003) suggest problems are usually related to the lack of investment in education and human capital needed to support the dynamic innovation system necessary to solve complex problems.

[2] The USA House Subcommittee on Technology, Environment, and Aviation of the House Committee on Science, Space, and Technology (103rd Congress) requested Congressional Research Service hold a workshop on the tools and techniques of ecosystem management. The purposes of the workshop were to demonstrate tools and techniques used in scientific research on ecosystems and to address technological aspects of developing and administering a national policy for ecosystem management. The conclusion was that the tools for ecosystem are extensive and are still evolving. See www.cnie.org/NLE/CRSreports/Biodiversity/biodv-5.cfm.

[3] This is an ecological approach to natural resource management to ensure productive, healthy ecosystems by blending social, economic, physical, and biological needs and values.

[4] The EU currently has nine policies related to building innovation systems.

[5] See 2.

[6] World Bank (2005) defines infrastructure as "about delivering essential services that are the foundation for development."

[7] Until 1994, the "conventional basin" excluded the upstream basins of the Komadogou-Yobe and the Chari-Logone Rivers.

[8] The basic premise is that LCBC will reform to the Integrated Water Resources Management/Ecosystem approach.

[9] Infrastructure: The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons. From www.thefreedictionary.com/infrastructure.

[10] These ideas have been adapted from Professor Calestous Juma's response presented during the 2006 World Food Prize awarded to Brazilian and American Agriculturalists. Found in "Special to the Des Moines Register" 21 October 2006.

[11] The Lake Chad River Basin encompasses five countries with more than 22 million people dependent on its water as a life source.

[12] The LCBC Vision was promulgated during the 2nd World Water Forum (WWF) meeting in the Netherlands in March 2000. Amendments to the 2025 Vision statement were reflected during the 3rd World Water Forum at Tokyo 2003. An LCBC workshop comprising representatives from the member states was held in N'Djamena in order to develop a new vision.