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An indicator framework for assessing the technology aspect of Integrated Lake Basin Management for Lake Malawi Basin

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ABSTRACT

Lake Malawi is one of the African Great Lakes and is well known for its fish biodiversity which is the greatest in the world for freshwaters. The lake basin is a valuable resource to the riparian countries. Activities associated with the derivation of the values offered by the lake basin, however, result in the generation of wastes and pollutants that also impact on the lake basin. Such anthropogenic activities within the lake basin place considerable strain on the lake system and may lead to the degradation of the lake basin. Proper application of technology can effectively supplement command-and-control measures and economic instruments for better lake basin management. Currently, no comprehensive framework exists to assess the management of the lake basin. Such a framework is necessary to guide managers and policy-makers in the formulation of management plans and strategies for the sustainable management and utilization of the lake basin. We propose an indicator framework for assessing the technology aspect of Integrated Lake Basin Management (ILBM) in the context of the Lake Malawi Basin. We further demonstrate applicability of the proposed framework through a study conducted in the Malawian side of the basin. We applied a five point Likert-type scale in our indicator assessment. Overall, our results show that the technology aspect of the management of the lake basin is weak to moderate. This threatens the sustainability of the lake especially in the areas of solid waste management, sanitation services, pollution control and protection of wetlands and lagoons which performed from very low to moderate. The major challenges are weak institutional capacity, weak regulation enforcement, and insufficient resources.

1. Introduction

Lake Malawi is one of the African Great Lakes and is well known for its fish biodiversity which is the greatest in the world for freshwaters (Ribbink et al., 1983; Bootsma and Hecky, 1999). The lake and its basin are shared by Malawi, Mozambique and Tanzania with the largest portions of the lake and basin in Malawi. The lake basin is a valuable resource to the riparian countries. In Malawi, for example, it is important in many aspects including hydroelectric power generation (on its only outlet), fisheries, domestic and industrial water supply, rain-fed and irrigated agriculture, navigation, mineral resources, and tourism. Activities associated with the derivation of these values however, result in the generation of wastes and pollutants that also impact on the lake basin. Such anthropogenic activities within the lake basin place considerable strain on the lake system and may lead to the degradation of the lake basin. Examples of such strain include sedimentation and siltation of inflowing rivers and the lake resulting from soil erosion, and pollution of water bodies from industrial and municipal wastewater (ILEC, 2005; Castañeda et al., 2011; Ngochera, 2014). The major challenges that Lake Malawi Basin is facing are: deforestation; uncontrolled bush fires; soil erosion; inorganic pollution from agricultural activities; pollution from domestic and industrial wastewater; overexploitation of some fish species; heavy extraction of water for irrigation from some rivers in the dry season; increasing mineral resource extraction; and industrialization (Bootsma and Jorgensen, 2005; Chafota et al., 2005; Jamu et al., 2011; Msilimba and Wanda, 2012; Ngochera, 2014). Many of these challenges relate with technology issues. No comprehensive framework exists to assess the management of the lake basin despite the increasing need for such a framework to guide the formulation of management plans and strategies.

Water bodies receive pollutants from various point and nonpoint sources. Point sources have well defined and easily

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identifiable points of origin (e.g. municipal/industrial wastewater and industrial emissions) while nonpoint sources are diffuse (e.g. fertilizers and pesticides). Technology plays an important role in water resources management and if appropriately applied, can help reduce the stress exerted upon lakes (ILEC, 2005, 2007; Nakamura and Rast, 2011). There are several forms of lake basin management related technologies such as those developed for and applied in management options aiming at reducing stress on water bodies and/or those aiming at minimizing the impact of natural hazards, the former including sewage treatment plants, sanitation facilities, and wetland restoration, and the latter including weirs and dykes construction (ILEC, 2005; Nakamura and Rast, 2011). In Japan, the implementation of the Lake Biwa Comprehensive Development Plan (1972–1997) included the construction of lakeshore embankment and a sewage treatment plant which resulted in better flood control and improved lake water quality (LBCPLCC-LBCPPC, 2003). Technological measures in themselves can provide significant environmental benefits but at the same time impose significant environmental costs. To be effective, technological measures need to be affordable and properly combined with other measures such as policies and institutional arrangements (ILEC, 2005). Proper application of technology can effectively supplement command-and-control measures and economic instruments for better lake basin management.

Management of lakes and their basins is an important part of water resources management since lakes (and reservoirs) store about 90% of the world's surface freshwater resources (ILEC, 2005). Lake basin management is a complex endeavour as it requires the integration of management approaches across all related sectors with their diverse uses and users. Nowadays, lake managers are adopting Integrated Lake Basin Management (ILBM) in their management approaches as a guide for sustainable management of lake basins (Nakamura, 2009; Pokharel and Nakamura, 2010; Sharip and Jusoh, 2010). ILBM is a management framework that advocates for lake management approaches that are based on the proper understanding of the biophysical characteristics of lake ecosystems and interactions between lake ecosystems and humanity. The Integrated Water Resources Management (IWRM) approach forms the basis for ILBM. Basically, IWRM seeks to balance water for livelihoods and water for nature through the integration of both the natural and management systems (GWP, 2000). However, IWRM, with its focus on rivers, does not accord appropriate attention to lake specific concerns. Lakes have three unique characteristics which ILBM highlights. These are integrating nature (lakes receive all kinds of inputs from the basin and beyond), long retention time with a world average of 17 years (ILEC, 2005) which makes lakes relatively stable (it may take long for problems to be detected or solved), and complex response dynamics (lakes have non-linear responses to changes). IWRM falls short of giving sufficient consideration of these characteristics (Ballatore and Muhandiki, 2002). Individually, these characteristics are not unique to lakes as they are also exhibited by other water bodies e.g. groundwater exhibits long retention time as well. However, the combination of these three characteristics is unique to lakes (see ILEC, 2005, for details) and in this way, the ILBM approach complements the IWRM approach. ILBM is similar to the ecosystem approach in that both approaches focus on balancing the integration of conservation and sustainable use to maintain ecosystem services. The Convention on Biological Diversity (CBD) defines the ecosystem approach as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way". ILBM can thus be considered the ecosystem approach focusing specifically on lake basins. ILBM is based on six governance principles (termed pillars) which together form necessary components for an effective management response (ILEC, 2005). These pillars are policies, institutions, participation, technology, information, and finances (for further details on the ILBM pillars see ILEC, 2005; Muhandiki et al., 2014).

This paper focuses on the technology pillar and proposes an indicator framework for assessing the technology aspect of ILBM in the context of the Lake Malawi Basin. The current study is part of a broader study focusing on the assessment of the management of the Lake Malawi Basin. Moldan et al. (2012) observed that very limited experience exists with indicators that monitor environmental condition from the perspective of sustainable development, despite a growing demand from the policy side. This paper is a contribution towards addressing this concern regarding the Lake Malawi Basin. For details on how the framework was formulated, see Chidammodzi and Muhandiki (2015) for a complete ILBM indicator framework proposed for the Lake Malawi Basin from which the technology pillar is expounded upon in this paper. In this paper, we refine the technology indicators proposed by Chidammodzi and Muhandiki (2015) and demonstrate their applicability through a study conducted in the lake basin. It is important to recognize that the technology pillar is only one part of the overall ILBM framework, as such, the results of this study should be understood bearing the big picture in mind. Issues related to the other ILBM pillars have been discussed wherever necessary, especially regarding institutional and resource aspects.

2. Materials and methods

This section presents the methods employed for data collection and analysis, and the applied framework for assessing the technology pillar. The framework proposed by Chidammodzi and Muhandiki (2015) contains indicators for each of the six ILBM pillars. The framework proposes nine indicators for the technology pillar, covering the aspects of water and sanitation services, point- and non-point source pollution control, solid waste management, biodiversity protection and adoption of technology. The overall goal for the technology pillar is to utilize technological interventions for lake basin management where applicable. A key assumption in this study is that all the nine indicators carry equal weight in contribution to the assessment of technology pillar. The weight of each indicator is also equally distributed among its sub-indicators. This is because the data and information available in this study is not sufficient for us to apply meaningful weights. Although employing equal weights may introduce an imbalance regarding the importance of the individual sub-indicators and their contribution to the final score, our approach still provides a reliable picture of the situation in the lake basin. The choice of weights is not purely a scientific approach, especially regarding such a complex lake basin. Assigning meaningful weights would first require all key stakeholders to agree on the indicators that are to be applied, considering the big picture as well as their respective sectors. In deciding some weights, it would be necessary to involve various stakeholders to ensure their respective values and viewpoints are reflected, an activity beyond the scope of the current study. Since ILBM aims at achieving sustainable management of lakes through gradual, continuous and comprehensive improvements, our study serves as a starting point and our judgement of indicator performance, though providing useful insights, is not final.

2.1. Data collection and analysis

This study was conducted on the Malawian side of the lake basin. Both primary and secondary data/information were utilized. Data and information were obtained through document review, questionnaire survey, key informant interviews and site observations.