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HOW THEY CAN INCREASE FOOD SECURITY AND NUTRITION

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Africa's inland aquatic ecosystems: how they can increase food security and nutrition

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Sustainable ecosystem services of Lake Bosumtwi, Ghana – implications for livelihoods and food security

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Summary

Lake Bosumtwi is one of the six meteoritic lakes in the world and enlisted among the World Network of Biosphere Reserves. Current limnologic evidence indicates changing physical and chemical lake conditions that affect ecosystem functions. The cycles of overturn, where anoxic and nutrient rich bottom waters seasonally mix with surface waters, have not occurred since 2008, resulting in lower fish catch and changes to the lake ecology. With heightened effects of a warming climate, coupled with diminishing fish catch, livelihoods of the fishing communities are becoming increasingly vulnerable. This is also stimulating harmful adaptive actions, including the use of agrochemicals for fishing,indiscriminate clearing of vegetation for farming and tourism. These activities are expected to have serious negative feedback on the lake's functionality through increased siltation and pollution. Although there are a number of watershed management programmes in place, the fisheries and associated livelihoods will continue to be threatened by individual and synergistic effects of a changing climate and increasing anthropogenic stressors on the lake's ecosystem services. Based on the synthesis of current evidence, this paper summarizes the current state of knowledge on lake productivity. It asserts that sustainable management requires a far more comprehensive framework for assessing the impacts of multiple stressors on the lake's unique ecology towards supporting livelihoods of the 24 surrounding fishing communities. This can be supported by integrated research models such as that of the ongoing RELAB[7] project which is assessing lake function, fisheries productivity, land use change and livelihood responses to meteorological trends and lake functionality. Scientific data generated will provide better information to inform sustainable management of the lake and maintain its economic, historical and cultural values.

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7 *RELAB (REsilience of LAke Bosumtwi to climate change)*

Introduction

The Lake Bosumtwi (also spelled *Bosomtwe* in other publications), the only natural lake in Ghana, is one of six major meteoritic lakes in the world. The lake lies within a meteorite impact crater, a circular depression of 11 km diameter formed 1.07 million years ago (Figure 1a), with an area of about 52 km^2 and maximum depth of 81 m. As a hydrologically closed basin, inputs are restricted to rainfall, and consequently lake level fluctuates in response to variations in the balance between the rates of precipitation (80% direct precipitation on the lake surface area) and evaporation (Turner *et al*. 1996). Well-stratified layers of water masses differing in temperature establish the physical structure and basic ecological operating mechanisms of the lake that are important for fish productivity (Turner *et al*. 1996; Otu 2010).

Historically, seasonal increases in fish productivity have been linked to predictable changes in the lake's physical and chemical conditions. Important ecological cycles of overturn, where anoxic and nutrient rich bottom waters seasonally mix with surface waters, were well-known and understood by fishermen and local communities. Seasonal fish kills marked these events due to the anoxic conditions, and the lake became fertilized with accumulated nutrients from the deeper waters which sustained the fisheries throughout the growing season. However, according to the fishermen, this overturn has not occurred during the last decade (2008 – 2018), resulting in no fish kills, nutrient deficiency and disruption to the onset of the fish growing season. These dramatic changes to the lake are strongly believed to be caused by climate warming (e.g. Russell *et al*., 2003), which is affecting the temperature-driven physical structure of the lake that controls other important ecological functions.

A dense human population resides within the catchment, with a total of 24[1] communities comprising about 150 000 people in 2010. Subsistence farming and fishing are the predominant livelihoods. Traditionally, 18 foot wooden planks are used to navigate the waters (Figure 1b) and fish are collected from rudimentary fishing gears such as wire mesh traps, gill nets and cast nets. Typically, fishing is by males, whilst females process and market the produce. Fish catch is currently very low, less than 5 kg per fisherman per net or trap (Dassah & Agbo, undated) (Figure 1c). The lake supports four principal fish species, *Tilapia busumana*, *T. discolour*, *Sarotherodon galilaeus multifasciatus*, and *Hemichromis fasciatus*. There is observable seasonal variation in species dominance. The fishes are generally small in size, between 8.5-12.7 cm in length and 11.9 – 30.8 g in weight (Dassah & Agbo, undated). Since the study of Whyte (1975), who reported nine genera of fish belonging to five families, no other comprehensive studies monitoring fish population have been carried out.

Due to recurring low fish catch, communities are exploring other options to increase fish catch, for example, through the use of non-selective gears and agrochemicals. Observing these unsustainable practices, the Government of Ghana through the Ministry of Fisheries and Aquaculture and the Fisheries Commission, in 2016 planned to restock the lake with fingerlings. However, the gains of such an initiative will not be achieved with continued pressure on fish stocks and use of prohibited fishing practices. In addition, increasing encroachment and farming activities within the core of the lake's basin, expanding tourism facilities and poor sanitation practices are driving sedimentation and pollution of the lake. These have adverse effects on the lake's recovery with negative implications on fish food security and animal protein availability.

[1] Many documents refer to 24 communities in the catchment, however, reference is made to 22 communities by community members during interviews.


©*RELAB* project

Figure 1 – (a)


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Figure 1 – (b)


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Figure 1 – (c)

Figure 1 – (a) Aerial view of Lake Bosumtwi, (b) Fishing planks used by fishers for navigation, and (c) typical fish landing of a fisherman at Lake Bosumtwi.

Source: Building *REsilience of Lake Bosumtwi to climate change (RELAB) project*

Sustainable management of the lake

As a unique socio-ecological system, maintaining the lake's functionality is critical to the local food security and cultural identity of those living in the lake's catchment. Cultural values have been maintained through various practices of rites, rituals, customs and taboos, although these have declined over the years. Moreover, the lake is globally significant as it contains the vulnerable endemic species *T. discolor* and an archival system of well-preserved historical records of past climate change and ecological change in terrestrial regions of tropical West Africa (Beuning *et al*., 2003; Shanahan *et al*., 2009).

Over the years, local and international[1] institutions have initiated different programmes to change the local attitudes and unsustainable practices within the lake basin. These initiatives cover community environmental education, provision of alternative livelihoods, enhancement the lake's tourism potential, and building local capacity for sustainable management of the natural resource. One noted initiative is the designation of the lake as a Community Resource Management Area (CREMA) which empowers the communities to engage in co-management of the natural resources with the Wildlife Division of the Forestry Commission. The CREMA is legalised by the District Assembly by-law and encourages community decision making structures and processes. Women are also part of the management structure with administrative support from all regulatory and research institutions, and the Water Resources Commission as the coordinating institution.

Despite various successes of these programmes, sustainable management of the watershed and fish resources, however, requires a much more comprehensive understanding of the synergistic effects of climate change and anthropogenic stressors to make informed decisions and develop a long-term plan. For example, as new livelihoods emerge in response to poor fish harvest, altered land use patterns due to clearing of forests and increased pollution within the watershed will have unknown implications for lake health and its ability to recover. There is the need for comprehensive scientific tools of sustainability that rigorously assess ecological, social and economic factors, both individually and in various combinations, over space and time. Models that are able to link meteorological changes with the hydrodynamics of the lake, fish productivity, and land use activities in the watershed can provide managers with accurate information to help understand the resilience of the lake under different scenarios. Such processes can lead to innovative practices developed, even at the community level, that will enhance adaptation and support ongoing management of the lake's natural resources.

[1] In 2016, Lake Bosumtwi was enlisted among the World Network of Biosphere Reserves (WNBR) comprising 669 reserves in 120 countries. In Ghana, it became the third reserve after the Bia Biosphere Reserve in the Western Region and the Songhor Biosphere Reserve at Ada in the Greater Accra Region

Research and way forward

Many research projects and management programmes have assessed individual elements of the lake and its watershed. For example, the NSERC/ LBRP project[1] assessed the influence of climate on primary productivity but not on fish production; and baseline studies of fisheries, socio-economics, and land use land cover change, among others, carried out to nominate the lake as a UNESCO Biosphere Reserve, were all evaluated separately. To date, there has been no integrated research to understand the pathways and combined effects of multi-stressors on water quality, fish productivity and influence on livelihoods. The Building REsilience of LAke Bosumtwi to climate change (RELAB) project[2] will, however, contribute towards resolving knowledge gaps on the complex interactions at the ecosystem and watershed scale and linkages to socioecological dynamics. Since early 2018, high frequency data is being obtained by state-of-the-art instruments until the end of the project's five year period (2022). High resolution monitoring of lake physics, biogeochemistry, primary production, fisheries, land use changes, sedimentation and livelihood adaptive mechanisms, all linked to climate projections, will contribute to a comprehensive dataset that will be disseminated to stakeholders in user friendly formats through several mechanisms, such as hands-on workshops[3]. The training of scientists, students and managers will promote sustainable fisheries, livelihoods and watershed management towards building ecosystem resilience and reducing vulnerability of the communities in the Lake Bosumptwe.

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[1] Canadian Natural Sciences and Engineering Research Council (NSERC) and Lake Bosumtwi Research Project

[2] RELAB is funded by the Ministry of Foreign Affairs of Denmark and involves a collaboration of Danish, German and Ghanaian scientists and students.

[3] Up-to-date information will also be disseminated to the wider public through the project's website www.relabproject.uenr.edu.gh