



An Ecosystem Approach for The Sustainable Use and Management of the Lake Victoria Ecosystem

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Abstract. The key to achieving sustainable development is striking a balance between exploiting natural resources for socio-economic development and preserving ecosystem services, which are essential to everyone's well-being and livelihood. This can be achieved by using the ecosystem approach which promotes fair conservation and sustainable use of both land, water, and living resources. Over the years, human activities have played an important role in the degradation of natural ecosystems, either due to pollution or unsustainable development. Lake Victoria is the best example of the impact of anthropogenic activity on ecosystems, as it has undergone dramatic biophysical and geochemical changes in a relatively short time. This article focuses on using the ecosystem approach to determine optimal management approaches for the Lake Victoria ecosystem's long-term sustainability. The study finds that an integrated stakeholder-based management system and holistic regional development in lake areas can help preserve natural ecosystems without compromising the sustainable use of ecosystem services. The study concludes that integrating the human dimension is essential for the successful implementation of ecosystem approaches and that socioeconomic considerations should be included in cost-benefit analyses for biodiversity conservation and sustainable usage.

Keyword:

Ecosystem Approach, Lake Victoria, sustainable management, wetland ecosystem

1. Introduction

The benefits that ecosystems deliver to individuals are referred to as ecosystem services. Ecosystem services, sometimes known as ecological services, have become an important feature of major international organizations' economic and political documents. The United Nations describes the key pathways of human progress in the twenty-first

century and specifies a green economy as the foundation for the transition to sustainable development, one of which is the preservation of ecosystem services [1]. Ecosystems are dynamic objects made up of a variety of interconnected abiotic and biotic components that govern their level of production and productivity [2]. The ecological mechanisms that determine the ecosystem's structure and functions, the inherent variability of biophysical processes, and the linkages between ecological, economic, and social processes are all equally complicated [3]. Good governance necessitates an understanding of this complexity. The key to attaining sustainable development is establishing a balance between the use of natural resources for socio-economic growth and the preservation of ecosystem services, which are critical to everyone's well-being and livelihood [4]. Understanding how environmental services contribute to livelihoods, as well as who wins and who loses as a result of development measures, is crucial. Many United Nations Sustainable Development Goals (SDGs) recognize the value of the environment [5]. The proposed SDGs on water and sanitation (SDG 6) and ecosystems (SDG 15) aim to restore ecosystems and provide water-related services. The objectives mention integrating ecosystem values into planning, development, and poverty reduction strategies. Lake Victoria's ecosystem has undergone more rapid changes in recent decades. The challenge is to meet the growing demand for freshwater, fish, food, sand, fibre, and fuel while reducing environmental impact. For example, the exploitation of natural resources has increased social and economic costs and will grow at an accelerated rate in the future if we continue to manage our resources as usual. Mapping and assessing ecosystems and their services are important activities in the EAC for achieving biodiversity goals and informing the development and implementation of appropriate policies for climate, agriculture, forests, water resources, marine, regional, and local land-use planning.

While determining the monetary worth of ecosystem services is challenging, economists are progressively determining the value of various services [6]. According to the Millennium Ecosystem Assessment from 2005, natural ecosystems are directly dependent on 70% of the 1.1 billion people living on less than \$1 per day. Government agencies do not serve the majority of these people, particularly rural residents. This circumstance makes them more reliant on nature for their basic requirements [7]. As a result, the anthropogenic impact on Lake Victoria is enormous, and the majority of its resources have already degraded or are on the verge of degrading [8]. Rapid population growth and rising living standards are accompanied by the active participation of new ecosystems for industrial, agricultural, and housing purposes. As a result, demand for ecosystem resources such as freshwater, fish, transportation, food, wood, sand, and other resources is increasing, while ecosystems' ability to neutralize and absorb wastewater, greenhouse gases, and air pollution is decreasing. Massive economic costs come from the destruction of ecosystems and the benefits they supply. Ecosystem services economics in Kenya is very undeveloped, both in economic studies and in legal and policy papers. This paper, therefore, tries to strike a balance between the conservation of the Lake Victoria ecosystem and its services and the exploitation of natural resources to fulfill socio-economic development goals for future subsistence and well-being in order to achieve sustainable development. As a result, the focus of this paper is on using an ecosystem approach to the sustainable management of the Lake Victoria environment.

2. Materials and Methods

The primary purpose of this paper was to explain how to manage the environment surrounding Lake Victoria in a sustainable manner utilizing an ecosystem approach. To accomplish this purpose, a comprehensive evaluation of peer-reviewed papers, books, theses, consultant and government reports, and databases containing information on Lake Victoria's ecosystem services was done. Several relevant databases were utilized to acquire relevant data for this study, including Science Direct, Google Scholar, Scopus, and Web of Science. An examination of the literature revealed research gaps, which influenced the search strategy. All publications published in peer-reviewed journals that investigated the ecosystem approach to wetlands were chosen. Nonetheless, the research chosen was confined to publications published in English in the previous decade (1 January 2011 to 30 January 2021). The majority of the material required on ecosystem approaches was freely available, well-sourced, and well-documented. Furthermore, the keywords ecosystem services and wetland management were utilized in conjunction with the ecosystem approach to retrieve all connected studies. The titles and abstracts of these papers were reviewed for duplicate data. The titles, abstracts, and full texts of the publications were evaluated and vetted for inclusion. As a result, several unrelated books, book chapters, and reports were excluded from the search, leaving just significant references in this study.

3. Results and Discussions

3.1 Lake Victoria Biophysical Context

Lake Victoria occupies a shallow depression between Kenya, Tanzania, and Uganda in East Africa, and its tributaries are the source of the Nile River. Lake Victoria is an invaluable resource for East Africans who depend on it for food, transportation, employment, domestic and industrial water supplies, climate regulation, and other ecosystem services [9], [10], and [11], [12]. Lake Victoria's ecosystem has changed on a scale rarely seen elsewhere [13]. Lake Victoria's biophysical and geochemical status has changed dramatically in an unprecedentedly short time due to human activities [14]. These activities can be broadly classified as expanding commercial exploitation, biomanipulation (characterized by introducing species), and catchment processes. Fishing in Lake Victoria is mostly artisanal, with most of the catch coming from silver carp, Nile perch, and Nile tilapia [15]. Lake Victoria is the world's largest inland fishing destination, with 1 million tonnes of fish caught each year. The Lake Victoria Basin's human population is steadily increasing. The population is growing at a rate of 3.8 percent per year on average. The population in the Lake Victoria catchment area has grown from 8.7 million people in 1960 to about 42 million in 2020 [14]. As a result, the transparency of the water in Lake Victoria has dropped sharply over time. Increased exploitation of the lake's catchment area has led to the clearing of the surrounding natural vegetation, deforestation, and drainage of marshes, leading to soil erosion and siltation. [16] associate siltation with a decrease in water clarity in Lake Victoria. In addition, agricultural chemicals and household waste enter the lake, providing nutrients for massive algal blooms, and reducing water clarity [17].

3.2 Classification of Lake Victoria Ecosystem Services and Change Drivers

Uniform classification of ecosystem services for wetlands has not yet been developed. In most classifications, ecosystem services are grouped according to the functions provided, that is, the classification is based on a functional characteristic. The most famous international classifications are the UN Millennium Ecosystem Assessment, the TEEB

International Project Report and the European Environment Agency (EEA). The United Nations report, [18] divides ecosystem services into four categories: 1) provision of services such as timber, food, various natural materials, natural medicines, water, genetic resources, and so on; 2) cultural services such as aesthetic values, recreation and religious; 3) regulatory services affecting water resources, water treatment, waste disposal, erosion, and natural disasters; and 4) ancillary services such as nutrient cycling. For the TEEB project, functions were proposed to form the habitat and maintain species and their reproduction. [19] recommended categorizing ecosystem services based on human values. There are three types of resources: fundamental resources (food, drinking water, energy, and so on); a suitable environment; and socio-cultural needs. As a result, Lake Victoria provides several environmental services that are quite easy to quantify, even in terms of monetary contribution to the economy (e.g., commercial fishing, recreational fishing, and hydropower production). Lake Victoria ecosystem services were then classified, based on a combination of UN Millennium Ecosystem and TEEB, into three categories: provisioning services, regulating services, and cultural Services. Figure 1 depicts the link between environmental services in Lake Victoria and human well-being.

3.3 Lake Victoria ecosystem degradation

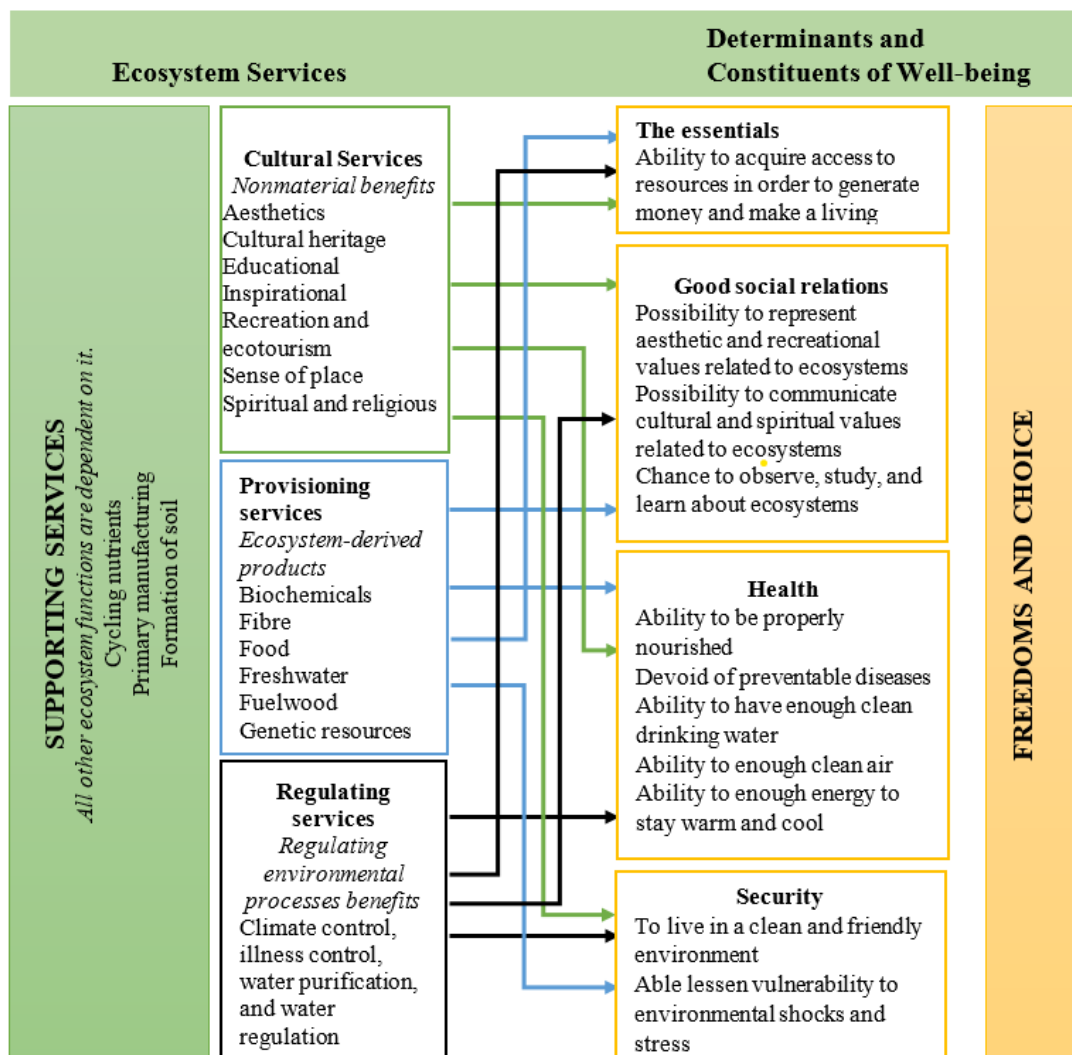


Figure 1. Lake Victoria Ecosystem services and the linkage to human wellbeing

Lake Victoria is an "international water" under significant pressure from many interrelated human activities; it has undergone tremendous environmental changes over the past 60 years [8]. Like any other wetland ecosystem, the Lake Victoria ecosystem is degraded by overuse. Intensive farming near the lake can have serious consequences for water levels, quality, and biodiversity in the ecosystem. Nutrient enrichment of surface waters is often associated with nonpoint source pollution of agricultural production areas where applied fertilizers are removed from the application site. Suppose this enrichment leads to eutrophication of the water body. In that case, the economic and environmental burden is imposed on society to correct the situation. Agroecosystem management programs aim to reverse land degradation to obtain local, regional, and global environmental benefits from the more productive as well as sustainable use of biodiversity and agricultural ecosystems. They respond to the need for concerted action by farmers, communities, lake shores, and watersheds to prevent degradation and ensure the conservation and sustainable use of land, water, and biological resources. Special attention should be paid to the biological diversity of natural ecosystems and the functions of agroecosystems on which human livelihoods and food security depend. The goal of managing natural resources in lake basins and watersheds through the widespread promotion and adoption of effective and sustainable land use planning practices is to ensure economically and environmentally sustainable agriculture and food security, an environment closely related to the diverse use of natural resources. lake ecosystem. To protect lake ecosystems and their watersheds, all wastewater from various sources must be properly treated and, if possible, reused for crop irrigation.

The high population density puts intense pressure on the natural resources of the Lake Victoria Basin, leading to land degradation. The basin faces far more complex social, economic, political, and technical barriers than other transboundary lakes in the region. More than 60% of the Lake Victoria Basin suffers from degradation (for example, loss of land cover, increased soil erosion, decreased soil fertility, and agrochemical pollution), which directly affects the increase in sediment and nutrient load on Lake Victoria due to airborne sediment, river precipitation and runoff. In addition, water pollution from municipal waste (untreated sewage and storm sewage) and industrial waste also contributed to the eutrophication of the lake. The main characteristics of this eutrophication are aquatic hyacinths throughout the lake, algal blooms and algae blooms, and algal blooms in enclosed bays with a higher proportion of algae capable of producing toxins [20]. Three immediate causes of eutrophication can be identified: increased effluent discharge, runoff and stormwater, and increased particulate matter discharge. Increased wastewater discharge and storm runoff are the most important direct causes of eutrophication [8]. This has a direct impact on the lake's ecosystem services, water, and livelihoods, especially for coastal communities.

Consequently, this degradation needs to be corrected to maintain shared ecosystem services that support economic and social well-being. Reversing ecosystem degradation also requires unpaid costs. In the absence of rehabilitation, the capital of the ecosystem is amortized in the same way as any infrastructure. The Lake Victoria ecosystem capital degradation approach is based on asset values (the difference in the net present value of ecosystem services estimated using monetary valuation). This first approach, based on the monetary valuation of ecosystem services using Cost Benefit Analysis (profitability analysis) and the concept of total economic value, including non-marketable goods and services, raises several issues: reliability, aggregation of problems, misinterpretation of results and

analyses (cost of surrogate markets), lack of reference materials on shipping costs and the possibility of implementing such an approach. In the Impact of Pressure structure, the difference in physical assets leads to an impairment of ecosystem capital. To balance this depreciation, ongoing restoration costs are then estimated against the accounting pressures responsible for the degradation. Aggregating them by type provides an overview and assessment of ecosystem capital depreciation

3.4 Using an ecosystem-based Approach

An ecosystem approach is a method of managing water, land, and living resources in a way that promotes fair conservation and long-term usage [21]. The ecosystem approach is based on a collaboratively established vision of desired future conditions that includes ecological, socioeconomic, and institutional views, and it is applied within a geographic framework determined primarily by natural ecological boundaries. An ecosystem approach is based on the use of appropriate scientific methodologies that concentrate on layers of biological organization that encompass the key structure, processes, interactions, and functions that occur between organisms and their environment [22]. The ecosystem Approach emphasizes that people are an essential component of many ecosystems due to their cultural diversity [23]. The scope of the analysis and reaction must be determined by the issue at hand. To deal with the complex and dynamic nature of ecosystems, as well as a lack of comprehensive information or understanding of how they operate, the ecosystem method requires adaptive management. All of these tactics can be combined in the ecosystem approach to help people move out of tough situations and sustainable use and conserve Lake Victoria.

As a result, using the ecosystem approach will aid in achieving a balance between conservation, sustainable use, and the fair and equitable distribution of benefits generated from the use of genetic resources (see [24], [25] and [26]). There is no strategy to balance conservation and development, but we need to know who will benefit and who will lose as ecosystem services shift. According to the Millennium Ecosystem Assessment, "intersectoral and ecosystem approaches to wetland management, such as Lake Victoria, that consider trade-offs between different wetland ecosystem services are more likely to deliver sustainable development than many existing sectoral approaches and are critical to formulating actions in support of the Millennium Development Goals" [7]. By focusing more on ecosystem services, Lake Victoria resource planners can determine the values people attach to different parts of the ecosystem they live.

The ecosystem approach is generally considered an essential set of guidelines to achieve sustainable use of water ecosystems [27]. The ecosystem approach emphasizes the importance of humans in various ecosystems via their cultural diversity. To deal with ecosystems' complex and dynamic nature, as well as a lack of comprehensive information or understanding of how they operate, the ecosystem method requires adaptive management. Ecosystem processes are usually nonlinear, with delayed results. Management must respond to such uncertainty by including elements of learning by doing and offering feedback on research findings. To successfully implement the Lake Victoria ecosystem approach, it can be difficult to:

1. manage the diverse ownership and institutional arrangements that exist in the ecosystem,
2. scale smaller ecosystems that are well managed by local populations versus larger ones that conservation organizations prefer through adaptive management,
3. deepen understanding of ecosystems' structure, function, and management,

empowering multilateralism.

4. Finally, to develop multiscale environmental assessments and indicators to be used in monitoring processes vital for adaptive management.

The following guidelines can be used to apply the ecosystem approach to the Lake Victoria ecosystem:

1. Carry out management actions on a scale corresponding to the problem being solved, with decentralization to the lowest level, depending on the situation.
2. Ensure cross-sectoral collaboration.
3. Focus on relationships and processes within the ecosystem.
4. Improving benefit sharing.
5. Use adaptive management techniques.

3.5 Measures for sustainable Lake Victoria water resources management

People, organizations, businesses, and society can all benefit from an ecosystem approach. The following measures are part of the ecosystem approach to Lake Victoria water resource management:

- I. Combining water and land management in catchments and river basins. Land and water resources are interconnected and therefore cannot be managed separately. Therefore, conserving or restoring land and water resources is critical. Actions include a) Protect important mountain slopes, wetlands and forests to maintain springs and combat soil erosion; b) Leave enough water in rivers to maintain or restore downstream ecosystems and their benefits; c) Restore ecosystems, springs and aquifers vital to water sources.
- II. Conserve aquatic biodiversity. The importance of aquatic ecosystems for the hydrological cycle, biodiversity, and livelihoods needs to be recognized. Their protection should be included in the basin and water management. Actions: a) Maintain or restore migration routes for freshwater species through design improvements or infrastructure upgrades; b) Wetland protection and judicious use should be considered in land and water planning.
- III. Refer to pollution. Pollution remains a serious threat to human health and ecosystems. Therefore, improving water supply and sanitation must be directly linked to reducing and preventing pollution. Actions: a) Implementation of basin plans for control and point pollution prevention; b) Develop financial, legal, and institutional incentives to prevent pollution from non-point sources; c) capacity building and technical support for demand-side water management.

4. Conclusions

One of the causes for the problems and inconsistencies connected with implementing ecosystem-based management strategies for Lake Victoria is a lack of adequate understanding of management objectives and tools to attain these objectives. This is compounded in cases where the people involved in the problem have completely different views even on the importance of the "ecosystem approach". For example, what does it mean to "protect the ecosystem"? This could mean a complete ban on human contact with a seamount, a complete ban on accidental fishing for sea turtles, and other measures prohibiting any human activity that could impact protection goals. On the other hand, it could mean reducing the number of fishing vessels fishing on the lake, altering gear to reduce the unintentional capture of sea turtles, and taking other restrictive steps to reduce

human impact on the protected target. Therefore, defining and communicating management objectives and a range of tools for achieving them to all stakeholders is an important element of the ecosystem approach. The study finds that integrating the human dimension is essential for the successful implementation of ecosystem approaches. Human activities and ecosystem conservation are not mutually exclusive. Instead, they complement each other, as described in the report of the UN Secretary-General: 310. The loss of marine biological diversity can significantly limit its socio-economic benefits for future generations, hence the importance of sustainable natural resources. Greater consideration should be given to the socioeconomic components of wetland biodiversity beyond national jurisdictions in the design, development, and implementation of conservation and management strategies. To achieve sustainable growth in this framework, environmental measures should be an integral component of economic planning. Furthermore, socioeconomic considerations should be included in cost-benefit analyses for biodiversity conservation and sustainable usage. Furthermore, the involvement of people who will govern measures in recognizing problems, devising solutions, and implementing them is required for the ecosystem approach of Lake Victoria to be successful. Specific management objectives must be established in order to create a shared understanding of the ecosystem approach's objectives among stakeholders, facilitate ecosystem approach implementation, evaluate the effectiveness of management measures, and, if necessary, change and improve management measures. However, because the stock state of the species and the peculiarity of the fishery varies, particular management objectives must be set on a case-by-case basis. In heated debates regarding the ecosystem approach, this fact is frequently neglected because it gives a simplistic argument for whether a particular fishery should be prohibited entirely or allowed with no restrictions. This basic approach will not aid in the achievement of ecosystem management objectives and will make the necessary engagement with stakeholders extremely difficult.

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