

# Environmental issues of Lake Bosomtwe impact crater in Ghana (West Africa) and its impact on ecotourism potential

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**Abstract**— Lake Bosomtwe is the largest natural lake in West Africa and is an important resource supporting about 22 local communities in Ghana. The lake attracts a lot of tourist nationally and internationally and has significant ecotourism potential. However, the declining environmental quality a decade ago has potential negative effects on ecotourism. Thus, the study provided an overview of the adverse environmental situation of the lake and its natural ecological environment and its effect on ecotourism potential development. It also identified key facilitating pollutants and sources that need further rigorous research, control and proper management to safeguard the fragile lake's ecological environment. The research provides a baseline for improving the ecotourism benefits of this lake to support the socioeconomic development of the country. Undoubtedly, it is established that developing ecotourism in the Lake Bosomtwe basin depends a lot on the lake.

**Keywords** — Lake Bosomtwe, impact crater, ecotourism, ecological environment, indigenous people, Ghana

## 1 INTRODUCTION

Human land use processes have changed our planet [1], leading to unintended effects to the natural ecosystem [2]. Land-use pertained transformation is now regarded the principal driving force of biodiversity loss in the world, especially in tropical ecosystems [3]. The environment has been the base of material extraction for development and survival of people [4] which relies on the victimization and utilization of its resources. Ecotourism has evolved as an improving tourism venture which has provided opportunities to promote natural resources preservation and biodiversity conservation [5]. It is considered to be a potential strategy to support natural ecosystems conservation as well as improving sustainable local development. Recently, with the increasing development of

individual economies and living standards, people desire to enjoy life through touring after attaining the basic needs of life. Thus, the tourism of scenic environment has become a recent popular option of leisure and vacation. However, the quality and sustainability of the environment is the cornerstone on which tourism environment within the tourism industry stands. Ecotourism is highly inclusive and based on the ecological environment and its development is materially base on a sustainable ecological environment. [6] explained ecotourism as a sustainable, non-encroaching type of nature-based tourism that centers mainly on exposing nature originality, and which is morally handled to be low impact, non-devastating, and locally focused. Ecotourism is highly principled in minimizing environmental impact build, ensuring cultural consciousness and respect, providing access to financial gains for conservation and welfare and empowerment to the local people. Ecotourism has evolved as an improving tourism and has received much attention since its popularization throughout the early 1990s [5] essentially characterized by ecological environment protection and conversation. It gives a model that is benchmarked on sustainable development option which targets human development and social progress [7] giving a symmetrical development between economy, society, humans and nature. The remit of ecotourism is to protect tour-

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ism assets, esteem for the economy, society, culture of its terminus with a basic aim of being close to and protect nature and maintaining ecological balance [4].

Ghana is among the few countries in the world gifted with many rich tourism resources from biocultural diversity to a pool of antiquities and histories. In reality, it has been proved that smaller countries promote better their national tourism as a productive industry [8]. Tourism stands as one of the biggest foreign exchange generators in countries such as Guatemala, Costa Rica, and Belize [9]. Also in Ghana, years of severe development policies have threatened the integrity of the ecosystem. Hence, there have been difficulties recently in attempts to balance the request for economic growth with the preserving natural resources. Also, tourists are growingly searching to enjoy undisturbed natural places where they can experience pleasant scenery, unparalleled historical and cultural features. Ecotourism seeks to brainstorm tourists the impact of people on the environment, and to bring a better admiration of the natural habitats. It is seen as one of the fastest-growing part of the tourism industry, recording an annual 10-15% growth worldwide and has become a major initiative and many countries are benefiting from it. In Costa Rica, ecotourism has boosted the tourism industry in general growing from US \$10 million to \$661 million within 30years, with over a million tourists going to Costa Rica annually [7]. Ecotourism has been named as a key developing tourism product by the government of Vietnam [10]. This has attracted a lot of foreign organizations and investors to participate in their natural areas and enhancing tourist visitation thus promoting ecotourism growth in Vietnam. Ecotourism sustainability and development depends on how best its components are conserved and protected because is nature based. The challenge to ecotourism is to provide its promise: 'responsible visit to natural places that maintains the environment and better the well-being of indigenous people' [7].

The Bosomtwe community where the lake is situated is a home for people who are mostly into farming and fishing [11], but recently the idea of tourism has become an alternative source of income. Lake Bosomtwe is the largest natural lake in West Africa and the only naturally occurring inland freshwater lake in Ghana. It is tropical lake filling a meteorite impact crater in south of Ghana [12]. The Lake Bosomtwe impact structure was created in 2.1 Gyr Precambrian metasedimentary and metavolcanic rocks in the forest zone of southern Ghana [11]. The structure aged 1.07 million years, is a well-preserved complex impact crater and a vital geological heritage site, 10 kilometers in diameter within a marked rim. The lake is affiliated with one of only four recognized tektite strewn fields [13]. [14] point details on the geology of Bosomtwe and the arguments about the recognition of its impact origin. It is among the nineteen known impact structures in Africa, and seen as the youngest well-preserved complex impact crater on Earth. The lake is the largest natural lake in West Africa, the only naturally occurring inland freshwater lake in Ghana and has presented itself as one of the richest areas of biodiversity in the country.

However the lake basin and its natural environs are negatively impacted by the activities of the people [15]. This is

characterized by unorganized as well as unplanned tourism development which includes abuse of natural resources, overcrowding, waste disposal mismanagement and other adverse practices. Lake Bosomtwe, being the main focus for ecotourism development in the Bosomtwe basin, needs to be protected and preserved. The rise in menial activities and development around the lake of late promotes an adverse increase in pollution within the lake's basin, which could prevent the development of ecotourism in the Lake Bosomtwe basin in the future. The lake is in a closed hydrological basin (Figure 1), so all pollutants stay, and concentrations will keep on increasing ([16], [17]). This is of great concern.

This paper thus assesses and provides an overview of the adverse environmental situation of the lake and its natural ecological environment and its effect on ecotourism potential development. It argues that the declining environmental quality over the years in and around the lake will have potential negative effects on it.

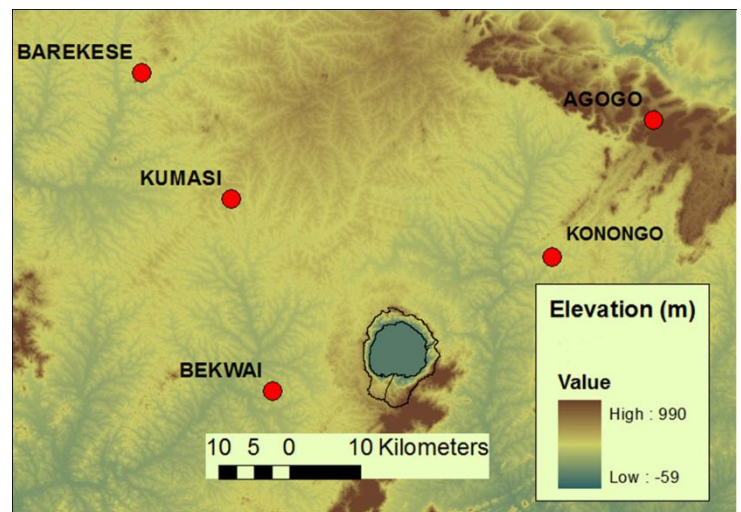


Figure 1. Map of the Lake Bosomtwe structure showing the lake as a hydrological basin (Edited from [19])

## 2 STUDY AREA

Lake Bosomtwe located in the southern part of Ghana (Figure 2) within an ancient meteorite impact crater, is the only known naturally occurring lake in Ghana and is a popular recreational area. The surrounding crater rim reaches a minimum height of 110m above current water level which amounts 99 m amsl, separating the hydrology from the surrounding Pra River Basin, as well as creating conditions of reduced wind stress [18]. The crater structure is nearly occupied by Lake Bosomtwe about 8 km in diameter and about a depth of 80 m at its center.

Turner et al., 1996a pointed out that although the lake is closed, it has experience some overflow in the past. It receives all hydrological inputs from precipitation with an estimated 80% from direct precipitation to the lake surface area, 48.6 km<sup>2</sup> ([16], [17]). Consequently, the lake's water level fluctuates in

close correspondence with changes in the ratio of precipitation to evaporation [16]. Its watershed is covered by diverse land use mainly farmland which is about 50% of the landcover (Figure 3b). The parts covered by farmland are found closely around the lake and on hilly areas. It is also partly covered by an original forest region both open and close and natural and rural landscape.

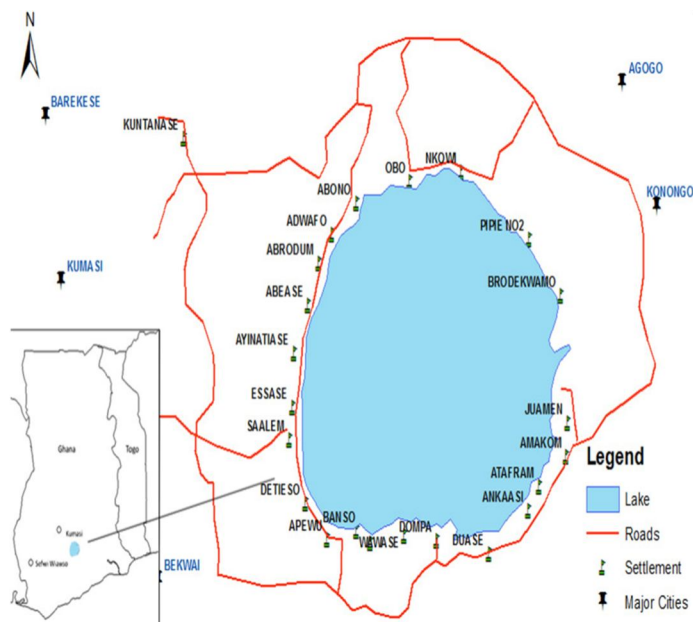


Figure 2. Map of the Lake Bosomtwe Basin, Ghana and surrounding communities

### 3 ENVIRONMENTAL POLLUTION ASSESSMENT

The primary environmental problem at Bosomtwe is the introduction of pollutants into the lake. Likely sources of these pollutants include agricultural and domestic processes, and atmospheric deposition. Human activities usually affect the dispersion, measure, and chemical quality of water bodies and these activities affect the dynamics of ground and surface water in all manner of terrain [20].

The Bosomtwe-Atwima-Kwanwoma District which inhabits the Bosomtwe Lake has increased in population over the years and this has increased the pressure on the lake relatively. Thus a connection between population rise and pollution is inevitable. As population and demand for more material wealth increases, menaces in regards to sustainability of ecotourism regions grow.

#### 3.1 Agriculture Practices

Agriculture is seen as a large exploiter of freshwater in the world and a major cause of eroding of surface and groundwater resources through erosion and chemical runoff having great effect on the global implications of water quality [21]. Aquaculture is currently deemed as a main problem in water environments, leading to eutrophication and ecosystem destruction.

The Lake Bosomtwe basin is filled with rural communities comprising mainly of who are into agriculture. The inhabitants plant various crops including mainly cassava, plantain, yam, and diverse vegetables, with cocoa as the main crop [11]. Areas close to the lake are use as farmlands (Figure 3b). Farming in the lake basin of recent has involved the intensive use of agrochemicals which includes organic and inorganic manure chemicals. Some of these chemicals are supplied by the government agencies and other NGOs to enhance the yield of cocoa. Likewise, the application of chemicals that enhance growth and pesticides (e.g., Dichlorodiphenyltrichloroethane [DDT]) on crops, particularly cocoa, has also been heightened. [22] estimated that the use of agrochemicals is expected to rise as more cocoa planting is becoming dominant in the area. The farmers apply the chemicals by the use of Knapsack sprayers and the washing of the sprayers is performed in the lake. The use of chemicals is harmful for the farmers who are exposed to them and also to nearby surface and ground water. Researchers (e.g. [23], [24]) have found organochlorines and toxics such as polychlorinated biphenyls [PCBs] and pesticides in lakes and rivers in Ghana similar to Lake Bosomtwe but with less comparative populations. Likewise, farmlands clearing and burning practices directly contribute to the atmospheric deposition of nutrients into surface water. Surface water runoff from rainfall drains the soil nutrients in the farmlands directly into the lake, causing eutrophication (abundant nutrients in the water).

Also around the lake basin is a large population of livestock such as cows, goats, and sheep in the various communities. A significantly high number of the keepers extensively grazed their animals within Bosomtwe basin. These animals graze and drink from the lake defecating along its banks. It is therefore most probable that these large portion of the dung (made up of phosphorus and nitrogen) gathers close to the

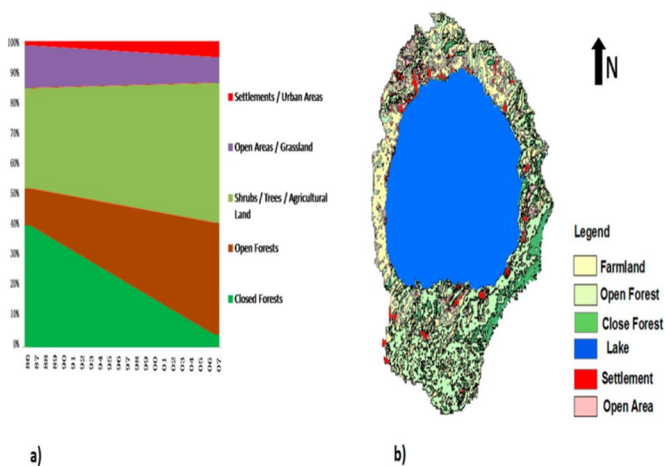


Figure 3. a) Land covers change at the Lake Bosomtwe basin over 21years (1986-2007). b) Land covers around the lake. (Edited from [19]).

shore and are finally drains into the lake when it rains. The impact of these livestock activities on the lake is substantive because of their number. Moreover, other farmers have engaged in the use of some of the dung as organic manure. Mostly, locals of the various communities surrounding the lake rely on agriculture than on fishing [15]. Over the years, land cover around the lake which used to be mainly forest (closed) has been converted to agricultural land and open forest (Figure 3a). Hence, this has resulted in the extensive use of irreversible natural resources such as land tilling, overgrazing, and deforestation. Recent increased deforestation issues have also contributed to deteriorating the ecology around the lake and also exposing the lake which increase evaporation of the lake water. Agriculture has been the cause of significant modification of landscapes throughout the world. Practices like tilling of land alter the infiltration and runoff features of the land surface, which affects the way water and sediment move to surface-water bodies, and evapotranspiration. One consequence of this is increased soil erosion due to the bad farming techniques, which amounts to more nutrient runoff and leaching. Agriculture practices are the leading cause of sediment pollution because bare lands are susceptible to large amounts of erosion (Safe Drinking Water Foundation [SDWF], 2011).

The communities around the lake also involve in fishing. The increasing application of chemicals in agriculture over the years resulting in the subsequent pollution of the lake as explained will surely affect the aquatic life in the lake such as fishes. However, as of now, no research has been carried out to evaluate the effect of this to the fish population in Lake Bosomtwe [11]. Also, the population rise around the lake basin is contributing to more fishing activities, possibly leading to overfishing. Already there are indications that primarily only smallish fish can be collected. Agriculture activities in and around the lake cannot be indefinitely sustained due to the increasing population.

### 3.2 Domestic activities

The dangers of human activities on the quantity and quality of water resources are experienced over a broad range of space and with time [20].

Population within the lake basin and its immediate environs keeps on increasing over the years (Figure 3a). There has been increasing human activities along the lake shore and close areas over the years which in many diverse ways affect the environmental situation of the lake.

Activities such as clothes and cars washing with detergents in the lake and also at the shore of the lake prevailed over the years. Eventually, the used water is discharged into the lake. Some inhabitants and fishermen also bath and wash their fishing nets using soaps in the lake. Research has shown that detergents can have poisonous consequences in all types of aquatic life when they are introduced in sufficient quantities. Most fish will die when detergent concentrations increase. Phosphates in detergents can result in freshwater algal blooms that introduce toxins and remove oxygen in waterways. The algae consume the oxygen available for aquatic life when they decompose. The communities also occasionally organize community environmental activities to clean the lake

shore where lake banks are weeded regularly and the weeds are collected and burnt. The burning of these weeds which mostly contain PVC (polyvinyl-chloride) discharges extremely poisonous dioxins into the atmosphere. The residue from the burning mostly remains on the shore and is finally washed into the lake when it rains or by the wind. The Bosomtwe locals are traditional people and there are practices of cultural siltation during festive season. During these annual festivals, idols in various forms are introduced into the lake and these practices have resulted in metallic pollution of the lake.

Also, much attention has not been given to introduction of unregulated waste disposal from sprouting accommodation facilities such as hotels around the lake. [15] recorded the abysmal littering at the shore of the lake with materials from food traders and sellers which eventually get to the lake water during heavy rainfall. In all, there is unmanaged fling of solid waste with the absence of proper waste control system measures.

### 3.3 Mining and Exploration

There is also a growing concern about the mining and exploration activities around the lake regions. There is little awareness of the environmental legacy of mining activities that have been undertaken with little concern for the environment and the lake in particular. The location of Lake Bosomtwe is within the gold layer of Ashanti region [25] where several private enterprises are undergoing various exploration and mining. Mining process normally requires huge removal of soil and rock to assess the valued ore. The result is greater measure of wastes that often comprises of heavy metals (such as arsenic, cobalt, copper, zinc and lead) and acid-generating minerals that are highly toxic to humans and wildlife and also dangerous to aquatic life in the lake water. Also, chemical agents (such as cyanide used by the miners to process ore) spill, leach from the mine site into the lake. The mining activity has left a dismal legacy of some contaminated site and ground and surface water. Also this activity destroys the topography around the lake region. This has deteriorated the aesthetic quality of the lake natural environment.

### 3.4 Atmospheric deposition

Surface water bodies in most environments are highly susceptible to acidic precipitation [20]. Pollutants in the atmosphere can deposit on all surfaces within a basin and then be washed off by rain which eventually becomes part of the water runoff that reaches rivers, lakes, and coastal waters [26]. Pollutants may also be deposited directly onto the surface of a water body. Activities like land preparation for farming which involve much burning substantially increase emissions into the atmosphere. Also, smoke from machines for mining and exploration are deposited in the atmosphere. The lake's primary water source is rainfall. Hence, pollutants emitted in the atmosphere are introduced into the lake water. Atmospheric deposition such as sulfate and nitrate can cause the lake water to be acidic.

#### 4 LAKE WATER BIOCHEMISTRY

The lake is stratified into an upper oxygenated and a lower anoxic region. There is a sharp alteration in the concentration trends of pH, NH<sub>4</sub><sup>+</sup>, PO<sub>4</sub><sup>3-</sup>, NO<sub>3</sub><sup>-</sup>, and Mn at a depth of 16 m [17]. Research about the chemistry of the lake water involved studies of lake-water samples taken in 1934 indicating a sodium bicarbonate water of high pH and low salinity [27] within the lake basin. In Lake Bosomtwe, the pH is high (average = 8.9; [28]) and results in Dissolved Inorganic Carbon (DIC) concentration predominantly in the form of bicarbonate. Water chemistry of tropical crater lakes is strongly affected by their restricted hydrological budget. It was confirmed that due to the biodegradation of organic content in lake sediments, the lake has over the decades experienced series of turnover [28] resulting to anoxic nature within the water depth resulting in huge death of the aquatic life. Total phosphorus concentration in the uppermost meter of Lake Bosomtwe is 2.4 μmol P L<sup>-1</sup>, whereas below the oxycline, concentrations are more than double this amount (5.9 μmol P L<sup>-1</sup>). These concentrations are well above the critical threshold of 0.1 μmol P L<sup>-1</sup>, known to be the condition of phosphorus famine for phytoplankton growth [29]. Also, total nitrogen concentrations range from 20 μmol N L<sup>-1</sup> at 1 m depth to 2000 μmol N L<sup>-1</sup> below the oxycline, and all concentrations are well above the level of insufficient nitrogen concentrations of 0.2 μmol N L<sup>-1</sup>[29]. [30] performed a chemical studies of two lake-mud samples and had the results computed on a basis of free water: 0.8 and 0.4 wt% total sulfur and 8.4 and 3.8 wt% organic carbon of Bosomtwe sediments. A rich presence of organic content was shown by these values. [31] 1992 also affirmed the changes in the composition of nitrogen and carbon isotopic of bulk organic content in sediments. Pollution by the organic content presents adverse consequences in lakes like Bosomtwe [32]. There is little physical disturbance of sediments because there are minimal riverine inputs to Lake Bosomtwe.

[15] performed a water quality analyses and quantified the yearly pollution to identify the levels of pollution (Nitrogen [N] and Phosphorus [P]) from certain pollution sources which includes agricultural (land run off and livestock), domestic and atmospheric deposition. It was estimated that N input in Lake Bosomtwe is the largest from atmospheric deposition and also agriculture contribute a lot of pollution. Figure 4 shows an estimation of the total contribution of pollutant (TN and TP) loads into the lake from the various pollution sources (based on [15] data).

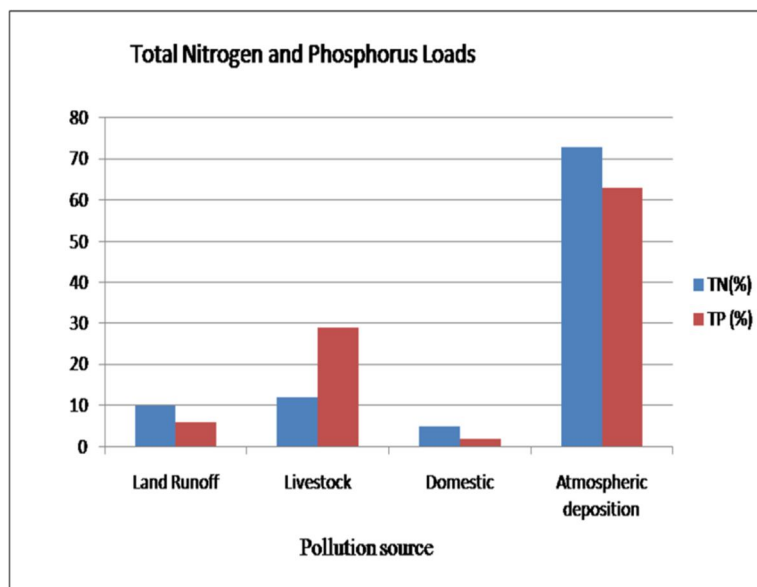


Figure 4. Quantification of the total contribution of pollutant (TN and TP) loads into the lake from the pollution sources.

#### 5 DISCUSSION

##### 5.1 Assessment of Ecotourism Potential in Lake Bosomtwe basin

Lake Bosomtwe gradually is turning into a known tourist point in Ghana and has an ecotourism development potential. Earlier plans to convert the area to be an ecotourism site has not been realized after the 1999 Abono Declaration that described the Lake Bosomtwe as an ecotourism zone [33]. To make these plans fruitful in a long term, a committee was set in the year 2000 which was endorsed by the Ashanti king and the government. They were to ensure that indigenous people are endowed to protect the lake basin. The lake is endowed with many tourist attractions which include: the biggest natural lake in western part of Africa and a vital geological heritage site; best-preserved young complex meteorite impact crater in the world by UNESCO; unique and a very attractive position in a virgin forest zone; rich geological and biodiversity information; the main lake for its recreational and aesthetic qualities; the crater rim formation and its relevance for impact cratering research; natural and rural diverse landscapes, behavior and cultural history of the its inhabitants. Ecotourism has become known with tourism subject to natural living and non-living surroundings and with any historic cultures markedly connected to those surroundings.

The tourism sector could be a source of sustenance for the people around Lake Bosomtwe that now relies to a great extent on agriculture. Most of the researches concerning tourism emphasize its economic benefits at both national and global levels ([34], [35], [36]). It can also serve as a generator of revenue to the government, for infrastructure building, and for single and organizational income yield. In relation to other tourists, eco-tourists rests in facilities mostly owned and con-

trolled by indigenous people than corporate agencies, and prefer local food and patronize local services ([37], [38]). Thus, exploitation of ecotourism could ensure to create employment opportunity for the indigenous people. [39] mentioned ecotourism and cultural could be link into a greater sustainable view that will acknowledge the natural surroundings, established environment, and attractions of areas as a cultural package.

Development of ecotourism can be done base on socially responsible, environmentally and economically efficient, and feasible process to further a structural dialogue about the needs of the locals in a perfect and comprehensible terms [40].

## 5.2 Environmental situation impacts on Ecotourism Potential

The agricultural (farming and fishing) activity within Lake Bosomtwe basin cannot be sustained indefinitely as mentioned earlier. Hence, attention is being turned to tourism as another means of income generation for the locals. The issue however is how to deal the existing and emerging environmental problems, significantly concerning the pollution of the lake. The quality of the lake water is expected to be adversely affected by the introduction of increasing nutrients pollution (P and N) into it as a result of atmospheric deposition and land runoff. Various farm equipments like hoes and cutlass are use for agricultural production in the lake basin. [41] mentioned that in addition to the everyday traditional agriculture methods and ways of life, there is an outcome rise in unsustainable natural resources uses being forest exploitation, land cultivation and overgrazing. The produce is generally not enough or minimal; there is a rise in demand for adequate land. Scheren also indicated that without advance technological measures, the cultivation and burning of the natural soil protecting coverings for agricultural purposes will remain. The effects are heightened soil erosion, leading to the runoff of more nutrients and leaching into the lake and deteriorating of the natural scenic ecological environment. Moreover, slash and burn practices contribute directly to the atmospheric deposition of nutrients.

As mentioned, ecotourism exploitation at the Lake Bosomtwe basin clearly depends largely on the lake and its declining environmental quality will impede ecotourism development. The aesthetic beauty of the lake will be affected due to the lake water pollution and dead aquatic life and eventually the recreational and tourism value of the lake will decline. Also, polluted waters could offer a home for various water and insect-borne diseases like diarrhea, bilharzia, cholera and so on. Hence various measures need to be taken to protect the lake and its aquatic life and natural environment.

## 5.3 Management strategy framework

Basic policy for conservation of Lake Bosomtwe includes: prolong its life span by preventing water pollution and sedimentation which is the major problems, preserve its environmental quality and promote it as an attractive tourist centre. Reaching this objective from current polluted status, an integrated and holistic approach should be employed along with portioning duties and benefits among those involved.

Measures including bio-physical, social and economic approaches can be taken as followings:

- i. Integrating conservation and development: This study is focused on assessing the adverse environmental situation of the lake and its natural ecological environment which is characterized by problem of lake water pollution, and other activities around the lake basin that threatened the lake ecology, species and habitats. The fundamentals for managing global lakes includes: watershed technique, intersectional cooperation, stakeholders' involvement and effective institutional arrangement for effectuation and supervision [42]. Maintenance of economic development initiatives is not substantive without the active participation of people.
- ii. Proper waste management system: provision of refuse dumps at vantage positions within the periphery of the lake and regular collection because if left to overflow will be carried into the lake during rainfall. Also, community facilities like showers and toilets that are connected to a good waste-water system needs to be supplied.
- iii. Education: [43] mentioned that proper and well structured education about the environment is known to be the most obvious gains to conservation provided by ecotourism. Informing local inhabitant about the adverse consequences of the use detergents and soaps in the lake, by also providing other alternatives. Also, the farmers should be educated on the use of animal droppings as organic manure. This will minimized the amount of nutrients that is eventually carried into the lake as runoff. Nutrient-capturing plants can be grown along the lake shore wherever possible to act as a natural obstacle preventing the influx of nutrient into the lake.
- iv. Integrating income generation into conservation activity: Local inhabitants should be encouraged to integrate income generation and nature conservation through education. [44] proposed that promoting income generating activities holds substantial relevance in regards to effectively enforcing environmental plans into reality as economic development controls environmental conservation.
- v. Adoption of Watershed/ ecosystem approach: Lakes that sensitive to environmental changes and also an integral part of a watershed positioned at low planes are open to pollution and sedimentation. This means conserving the lake requires coverage in ecosystem and watershed basis. [45] explain this underline on systemic approach.
- vi. Eco-zoning of Lake Shoreline: Non-point sources pollution such as agricultural land runoff are known to have greater effect than those of point

sources of pollution like washing areas, sewage disposal in Lake Bosomtwe. Regarded as a conservation method, wide buffer zone can be created around the lake to protect and preserve, within which intensive commercial farming, mineral exploration and mining activity can be prohibited and controlled. Afforestation technique can be employed within this zone to green the already depleted land. This should be fully implemented. Integrating planning with management practices, restructuring of the shoreline zone will provide a well balanced means of lake restoration and various uses of the lake [46].

- vii. Environmental policies and management options: To reduce environmental problems in the Bosomtwe Basin, several environmental policies and management options related to air and water pollution will be required for checking pollutant pathways into and within the lake. Controlling pollutant loads from sewage and other point source, particularly in the towns close to the lake should be a top, immediate priority for the local authorities for restoring the lake. A comprehensive land use plan including structural and non-structural best management practices should be developed by local authorities and stakeholders to reduce the pollutant loads from non-point sources.

The problems with the lake ecosystem can be minimized and the benefits of ecotourism to the Bosomtwe communities can be optimized if the necessary planning, efficient mechanism for development and continuous initiatives for tourism are ensured. The local authority should enforce a more mature stance on preserved area development as tourists to the lake continue to rise.

#### **5.4 Local community participation in management of ecotourism environment**

Ecotourism is about connecting conservation, communities, and sustainable travel ([www.ecotourism.org](http://www.ecotourism.org)). It is characterized by preservation, economy and community involvement which are connected to the residents and communities of ecotourism site. In the general environment of the ecotourism sector, opportunities to local communities' participation in tourism have attracted attention and raised many prospects [46]. The development of ecotourism in the Bosomtwe basin will obviously have an impact on the locals either positive and negative hence their involvement in this development is necessary. Locals in the Bosomtwe community involvement are an important tool for protecting economic income and societal benefit thus core stakeholders of ecotourism. They are considered as the beneficiaries after optimizing the environment through ecotourism and will be victims when the ecological environment is degraded by the development of ecotourism. Hence, the communities' involvement in ecotourism is a positive direction in promoting the conservation of ecotourism environment. Their involvement can rally all social resources to distribute the ecotourism environment [4]. This involvement in itself has a nature of internal consensus where all res-

idents form a whole network of environmental conservation movement. Also, the communities can encourage all other residents to involve in the environment protection processes in a form of social morality thereby anyone who destroys the ecotourism environment will be despised by others. This will help to create a common behavior system and checks all activities that destroy the ecological environment. These measures of community participation can be achieved by;

- i. Improving the awareness of participation and environment conservation by the locals. This is ensured by educating the locals about the many benefits of ecological environment protection and ecotourism development. It will induce their exuberance of involving in protecting the ecotourism and ecological environment through good environmental behavioral attitudes and devotion towards controlling environment pollution and the lake.
- ii. Making the locals share the gains and welfare provided by ecotourism. Residents will always be ready to protect their own economic interest when they see themselves as shareholders. This will help to also change community local's attitudes of living on consuming resources which brings adverse effects to living on developing and managed resources to which ecotourism presents.
- iii. Introduction of procedure and management mechanism of ecotourism resources. This will be like an internal incentive inducing the locals to consciously involve in the preservation of the natural resources both as laborers and shareholders in the development and management of ecotourism. This will help to attain optimal administration of the resources and the sustainability of the community.

## **6 SUMMARY AND CONCLUSION**

The Bosomtwe impact crater and its environs have the relevant potential to be developed as an ecotourism site in Ghana. However, the declining environmental quality will have a negative effect on ecotourism development. The destruction of the lake's ecological environment needs to be addressed.

The lake structure is known to be hydrologically closed; hence all introduced pollutants are bound to stay in it, with concentrations certain to increase in the future. It is known that atmospheric deposition is the major source of pollution load especially nitrogen followed by agricultural (land runoff and livestock). Hence, there is the need to control factors that contribute to loads from these sources to reduce if not prevent the pollutant loads into the lake. Nevertheless, other sources should also be managed. Also, comprehensive conservation and management approach should be employed to restore the current nature of the lake's quality and protect its hydrological and ecological nature which will potentially open the doors for ecotourism development. The local community awareness of the state of the ecological environment within the Lake Bosomtwe basin and the call for all hands on desk involvement

should be highly looked at. With the development of ecotourism, natural policy of biodiversity can be complied, and fully substantiate the harmonious ecological coexistence between nature and society. It will help to do away with menial economic activities, and inquire the unity aligned with economical development, man and ecology, and finally balance the sustainable development of the environment and resources of tourism. The lake is the focal point for ecotourism in the basin, and the declining quality of the lake and its natural ecological environment may adversely affect ecotourism development.

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