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Willingness to Pay for Restoring a Degraded Freshwater Lake Ecosystem: The Case of Lake Bosomtwe, Ghana

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ABSTRACT

Lake Bosomtwe, a UNESCO biosphere reserve is a vital source of livelihood for the surrounding communities. They rely on fish catches for cash and protein. The lake's ecosystem services (ESs) value have declined due to human activities. Managing the Lake's ESs is hindered by the community's insufficient engagement and participation in conservation efforts. The surrounding communities Willingness to Pay for the cost of restoration efforts are currently unknown. Therefore, this study assessed the community peoples' Willingness to Pay for restoration of degraded natural freshwater Lake Bosomtwe ecosystem. Using convenience sampling, 150 respondents from 15 communities surrounding the Lake was selected and interviewed through a semi structured questionnaire. Contingent Valuation Method was used to determine respondents' Willingness to Pay and multiple regression was used to identify factors that affected respondents' Willingness to Pay towards a restoration project. The results showed that majority of the respondents are aware of the ESs provided by the ecosystem of Lake Bosomtwe. Also, the results showed that, majority of the respondents' activities within the Lakes' environs are unfavorable towards the sustainability of the ESs. Lack of employment is among the factors hindering respondents' Willingness to Pay. The average Willingness to Pay amount is twenty Ghana cedi and fifty-five pesewas (GH₵20.55) per person monthly. About 78.67% respondents' Willingness to Pay results shows willingness to engage in a restoration program to protect Lake Bosomtwe. Key stakeholders involved in the protection of the Lake should provide alternative livelihood and social amenities to control the Lake's ecosystem degradation as recommended.

INTRODUCTION

A freshwater body is a natural resource for the sustainability of human life. Freshwater resources provide prime areas for human settlement, commercial activities for income generation and habitation for other living things (Amu-Mensah, 2020). They offer ecosystem services such as aesthetic, cultural, provisioning, regulating and supporting services (Makwinja *et al.*, 2021). These freshwater lakes provide biodiversity and economic value, which include goods and services that are important for the survival of humankind (Makwinja *et al.*, 2021). There have been a significant number of contributions to literature concerning the critical contribution of ecosystem services freshwater lakes provide to the local population. Example, Ga Mampa Lake in South Africa contributes US$211/year/household (Makwinja *et al.*).

Ghodaghodi Lake, Western Nepal, contributes US$63/household/year (Makwinja *et al.*, 2021), Njhum Dwip, Bangladesh, contribute between US$625 and US$937/household/year (Makwinja *et al.*), Lake Chiuta and Lake Malombe in Malawi contribute US$248/household/year and US$1943.08/household/year (Makwinja *et al.*). Although these contributions are globally massive, freshwater bodies are significantly threatened globally, which had led to a decline in their areas by 64% from the year 1977 to 2011 (Dodds, Perkin & Gerken, 2013). Some threatening yet unavoidable factors such as the rapid growth of human population, climate change, and increasing demand for food and other resources including economic development have increased beyond measure, exceeding the capacity at which these freshwaters can provide ecosystem services to the local communities and the world at large (Makwinja *et al.*).

Aquatic flora and fauna are endangered by human-induced activities and climate risks such as habitat alteration, poaching, pollution, over-harvesting, loss of soil fertility, landscape degradation, landscape dynamics and others (Bani & Damnyag, 2017).

Ghana's socioeconomic success depends on healthy ecosystems and the benefits they provide. In fact, aquatic biodiversity present in all the aquatic ecosystems has a very significant role to support and make life on the planet possible (Adom, 2018). The use of water for agriculture, tourism businesses, water cooling for small breweries are of great importance in terms of the amounts of water used, as well as the fish catch from the Lake for sale (Amu-Mensah *et al.*, 2017). These aforementioned indicates that, the biodiversity and economic value of freshwater lakes ecosystems are more important than many terrestrial ecosystems (Makwinja *et al.*, 2021). As a result, the country's revised Medium-Term National Development Policy Framework, the Ghana Shared Growth and Development Agenda II (GSGDA II), and the National Development Planning Commission's

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upcoming 40-year long-term national development plan reflect government policies to ensure sound management of the environment and natural resources while pursuing economic growth (IUCN, 2016). Environmental and natural resource management in Ghana will help to achieve the Sustainable Development Goals (SDG), mainly no poverty (SDG 1), zero hunger (SDG 2), good health and well-being (SDG 3), clean water and sanitation (SDG 6), responsible consumption and production (SDG 12), climate action (SDG 13), life below water (SDG 14), and life on land (SDG 15).

Lake Bosomtwe is located in the west central part of Ghana's Ashanti region. Lake Bosomtwe is known to be among the major meteoric lakes in the world. It has four streams flowing into it, but has no outlet (Boamah & Koeberl, 2007). Several studies conclude that, people living along Lake Bosomtwe Basin in Ghana rely largely on fishing in the lake and farming on the marginal lands (Boahen *et al.*, 2014). As a result, there is a relationship between land use practices in the catchments, people's livelihoods and the fishing environment of the lake, as a result of the belief that the catchment forests and streams help make the lake basin a rich habitat (Boahen *et al.*, 2014).

However, fish ecology has been altered as a result of unprecedented catchment degradation, resulting in limited livelihood prospects (Mohammed, 2018). Currently, the aquatic biodiversity in the Lake Bosomtwe is in a deplorable state due to human activities such as illegal housing construction (Mohammed); crop cultivation and deforestation (Boahen *et al.*, 2014); over fishing, pastoral farming and waste disposal (António *et al.*, 2016). The residents of the area have had to alter their livelihood strategies.

The lake is a vital source of revenue and protein for the towns that surround it, as they rely on fish catches for both cash and protein. For natives of the Ashanti region, Lake Bosomtwe is also a spiritual spot. The case of Malawi where, rapid population growth, infrastructure developments (increased inflow from human settlements and industries), agricultural activities (unsustainable farming systems and heavy use of fertilizers in the upland catchments of the lakes), and climate change have been linked to freshwater ecosystems degradation (Makwinja *et al.*, 2021), can be said of Ghana where, intensification of agricultural activities in the Lake basin and a sudden rise in the chain of hotels and other tourism facilities have resulted in an increase in the pollution of the lake (Prakash *et al.*, 2005).

The economic rationale for steps needed to improve the protection and sustainable use of the Lake Bosomtwe environment, as well as its contributions to meeting human needs, is presented in this study. It helps identify the value of ecosystem services for downstream people and companies and also helps to identify if local people are willing to contribute financially for restoration of degraded Lake Bosomtwe ecosystem.

Problem Statement

Most freshwater resources, like Lake Bosomtwe, serve as the source of livelihood for the survival of its surrounding community and the entire Lake's ecosystem. The Lake's ecosystem is currently degrading as a result of human activities in the Lake's catchment area. The lake is a highly productive biological system, providing water for consumption, fishing, irrigation, recreation and other domestic, agricultural and recreational uses (Rocha, 2013). Although Lake Bosomtwe is a unique and sensitive ecosystem that calls for proper care and management, it is gradually becoming one of the most abused of Ghana's natural resources (Rocha, 2013), impeding efforts to achieve UN SDGs such as life underwater (SDG 14), life on land (SDG 15), climate action (SDG 13), no poverty (SDG 1), and Aichi Biodiversity Targets. The effort to manage the lake ecosystem services is hindered by the community's lack of knowledge and experience with the restoration concept. If the problem is not addressed, the lake's ecosystem degradation will inevitably worsen and have a negative impact on the local communities that rely on it for survival.

Ecosystem restoration entails activities aimed at restoring degraded ecosystem services in order to stop biodiversity loss, ensure ecosystem resilience, maintain vital ecosystem services, promote human health and well-being, and alleviate poverty (Makwinja *et al.*, 2021).

Due to the indispensable roles and relevance of aquatic biodiversity, there is an urgent need to conserve and sustain them (Adom, 2018). Since the surrounding communities rely heavily on the ecological services provided by the Lake Bosomtwe for existence, it is anticipated that poverty will rise and livelihoods will be lost if the lake and its buffer are not protected. An environmental non-governmental organization (NGO), A Rocha Ghana, has warned of Ghana losing Lake Bosomtwe in 2035 if strategic measures are not put in place to conserve it. How then do we protect the Lake Bosomtwe range and sustain livelihoods? It is worth noting that, there are about 30 villages near Lake Bosomtwe, with a combined population of about 70,000 (Boahen *et al.*, 2014).

In order to safeguard livelihoods, the study will serve as a guide for a "just transition". The "Just Transition" concept is a framework developed by the trade union movement to encompass a range of social interventions needed to secure workers' rights and livelihoods when economies are shifting to sustainable production, primarily combating climate change and protecting biodiversity (ITUC, 2015). The integration serve as a vision-driven, unifying, and place-based concepts, processes, and practices that help people transition from an extractive to a regenerative economy (ITUC, 2015).

This research contributes to the advancement of knowledge in the field of the study. It also provides insight and assessment into how local residents regard the Lake Bosomtwe environment, as measured by their readiness to pay for its restoration or not. The conclusions of this study present a picture of Lake Bosomtwe's

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ecosystem as it currently exists, and can thus provide government agencies, business entities, the community, and other interested parties with a path forward in the lakes' protection and conservation. The issues that have been identified can be addressed, and the solutions can be tailored to the situations that have been reported on the ground. The study would also contribute to a better understanding of the root and symbolism for restoration of degraded natural freshwater lake ecosystem, both in theory and policy. This study serves as a starting point for policymakers to conduct cost-benefit analyses and develop a practical policy response framework for reversing the lakes biodiversity deteriorative situation and also achieving the UN Sustainable Development Goals as well as the Aichi Biodiversity Targets.

Aim of the Study

The purpose of this study is to assess local community's Willingness To Pay (WTP) for restoration of degraded Lake Bosomtwe ecosystem.

Research Objectives

1. To validate existing knowledge of activities disturbing the ecosystem of Lake Bosomtwe by determining activities respondents engage in that disturb the ecosystem of the area.
2. To determine major reasons for the community members to engage in activities that disturb the ecosystem of Lake Bosomtwe.
3. To determine community peoples' views on the importance of restoring water quality, soil retention, habitat provisioning, and recreational use ecosystem services of Lake Bosomtwe.
4. To determine the Willingness To Pay amount local communities are willing to contribute for the restoration of the ecosystem of Lake Bosomtwe.

LITERATURE REVIEW

Despite the significant body of research on natural freshwater Lake Bosomtwe ecosystem, there are still several gaps in our understanding. Specifically, few studies have explored the long-term impact of pollution on the lake's ecosystem and biodiversity; the effectiveness of current governance strategies in protecting the lake; socioeconomic factors influencing unsustainable practices around the lake; Sustainable development strategies that balance conservation with community needs; and understanding community based restoration efforts. This chapter explores the relevant literature related to freshwater resources and Lake Bosomtwe ecosystem as well as payment for environmental services and local community WTP for restoration of degraded ecosystem, with a particular focus on addressing the mentioned gaps.

Overpopulation as a Threat to Freshwater Conservation

Seventy-five per cent of the Earth's ice-free land surface has already been significantly altered, most of the oceans are polluted, and more than 85% of the area of wetlands has been lost (Almond *et al.*, 2020). Human population issues are extremely important when it comes to our way of life and our future on this planet (Ray & Ishita, 2011). The connections existing among the availability of life supporting resources, individual standards of living, the quality of the environment, environmental resource management, and population density are neither acknowledged nor understood (Pimentel *et al.*, 1995).

The result of high population growth rates are increasing population density, increasing number of people below poverty line and pressure on natural resources which contributes to environmental degradation through over exploitation of natural resources (Ray & Ishita, 2011). If human beings want to exist on earth, there is now crucial time to give top priority to protect natural resources and environment (Ray & Ishita, 2011). World population doubled between 1960 and 2000, from 3 billion to 6 billion people, and the global economy increased more than six fold during which food production increased by roughly two-and-a-half times (a 160% increase in food production between 1961 and 2003) and water use doubled (Reid *et al.*, 2005).

The problem the world now faces is how to supply its increasing human population with the resources it needs, because as population expands further, water shortages will become acute. The current state of freshwater resources is continuously being threatened by overpopulation, climate change vulnerability, increasing demand, exploitation and degradation through anthropogenic activities (Amu-Mensah *et al.*, 2020). In retrospect, Kofi Annan in the year 2000 stated that for twenty years, the consumption of global freshwater rose six-folds in 1990 and 1995. He indicated that this was twice more than the rate of population growth, with an already water-stressed population of about one-third of the worlds.

The greatest threat to maintaining fresh water supplies is the overdraft of surface and groundwater resources used to supply the needs of the rapidly growing human population and of the agriculture which provides its food (Pimentel *et al.*, 1995). For instance, the population explosion in the South Asia region over the past century has created serious pressures on water resources, bringing about noticeable changes to the functioning of ecosystem and uses of the region's water resources (Babel & Wahid, 2008).

Demand for both freshwater and marine fish will expand because of increasing human population and changing food preferences (Reid *et al.*, 2005). Also, population density is a major factor that should be well controlled to overcome the rapid deterioration and degradation of the water ecosystem (Liyanage & Yamada, 2017) given that half of the world's population lives within three kilometres of a surface freshwater body, and over 40 per cent reside in coastal areas (United Nations Human Settlements Programme, 2020). Due to rapid urbanization, human activities have had a significant impact on the ecological environment (Liyanage & Yamada, 2017).

The strain on the water system will grow by 2050 when the

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world population will reach between 9.4 and 10.2 billion, a 22% to 34% increase (Boretti & Rosa, 2019). Owing to changes in climate and water consumption behaviour, and particularly effects of the spatial distribution of population growth relative to water resources, the population under water scarcity increased from 0.24 billion (14% of the global population) in the 1900s to 3.8 billion (58%) in the 2000s (Bindi *et al.*, 2018).

Recent studies have demonstrated that projected climate change will likely enhance nitrogen(N) and phosphorus(P) loss from farms and farmland, with the potential to worsen freshwater eutrophication (Wade *et al.*, 2022). For more than 30 years, since the Brundtland Commission's Our Common Future report in 1987, scientists, environmentalists and many others have called for dramatic changes to how we produce, consume and protect our world (Almond *et al.*, 2020) since as the population increases, and the per capita water availability declines, conflicts over water allocation are likely to increase (Babel & Wahid, 2008).

Effects of Human Activities on Freshwater Bodies

Water is life without pollution, but death when it is polluted (Igwe *et al.*, 2017). According to Dodds *et al.* (2013), humans are decreasing the provision of freshwater ecosystem services by about 16%. An extremely important factor is that substances added to the atmosphere, land, and water generally have relatively long timescales for removal or clean-up (Peters *et al.*, 2006). Various anthropogenic activities are threatening the biodiversity of rivers and the water systems associated with them (Kikkas & Kulik, 2018).

Dubois *et al.* (2017) reported that human activities directly affected lakes and their ecosystems. These activities included modifying the aquatic habitat, such as changing lake levels, and introducing new species. Detection of anthropogenic impacts leading to a change in ecosystem structure or function depends on the lake characteristics, human activities conducted in the catchment and environmental proxies considered (Dubois *et al.,* 2017).

Human activities commonly affect the distribution, quantity, and chemical quality of water resources (Dubois *et al.*, 2017). These activities include farming, deforestation, mining, sand winning, quarrying, liquid and solid waste disposal (Kankam-Yeboah *et al.*, 2004; Dubois *et al.,* 2017; Isaac *et al.*, 2021; Khatri & Tyagi, 2015). Human activities also impact negatively on the quality of water bodies, thereby limiting the scope of its usage (Dubois *et al.,* 2017). Land degradation caused by extensive farming, deforestation and mining activities cause sedimentation of rivers and silting of natural and artificial reservoirs (Dubois *et al.,* 2017).

Human activities change land use and land cover, which changes the water balance and usually changes the relative importance of processes that control water quality (Khatri & Tyagi, 2015). The groundwater or surface water quality is a function of natural influences and human activities either severally or collectively (Khatri & Tyagi, 2015). The primary water-quality issues affected by human activities include organic material, trace elements (heavy metals), acidic atmospheric deposition and runoff, salinization, nutrients (primarily nitrogen and phosphorus), pathogenic agents including bacterial pathogens, enteric viruses, and protozoans, suspended sediment, oil and grease, synthetic organic compounds, thermal pollution, exotic and invasive species, pesticides and herbicides, and radioactivity (Peters *et al.*, 2006). Human activities have severely affected the condition of freshwater ecosystems, to a point where many freshwater species are facing rapid declines or extinction (Peters *et al.,* 2006).

Human investments within river corridors, on floodplains, and adjacent to lake shores have resulted in conflicts between those investments and dynamic movement of streams or lake shorelines (Campbell & Valere, 2018). Small-scale dredging activities in freshwater bodies have the potential to impact habitats and food resources that fishes depend on, and ultimately impact fisheries productivity (Campbell & Valere, 2018). Agriculture, which accounts for 70 percent of water abstractions worldwide, plays a major role in water pollution (Mateo-Sagasta *et al.*, 2017). Farms discharge large quantities of agrochemicals, organic matter, drug residues, sediments and saline drainage into water bodies (Mateo-Sagasta *et al.*, 2017). Agricultural activities that can cause pollution include poor animal husbandry practices, overgrazed grasslands, over and excessive use including untimely application of pesticides, ploughing over irrigated fields and application of fertilizers (Khatri & Tyagi, 2015).

For instance, a large amount of Nitrogen pollutants is transported through the Ganjiang River to Lake Poyang in China (Li *et al.*, 2015). Isaac *et al.* (2021) reported other instances where, anthropogenic activities including gold mining, water withdrawal for human uses, use of small-mesh fishing nets, overfishing, industrial waste discharge, pesticides use for agricultural purposes along watersheds, obnoxious fishing practices and increase in human population, were listed by fishermen as other stressors contributing in depletion of Ivorian freshwater fish abundance. In Benin and the Volta region, overfishing was reported to cause changes in fish community structures and distributions, fish abundance reduction was reported as a consequence of climate change and several anthropogenic activities (Isaac *et al.,* 2021).

State of Freshwater Resources in Ghana

Water is life, and it is linked with lots of services either directly or indirectly, such as: human health and welfare and social and economic development (Owusu *et al.*, 2016). Ghana is drained by three main river systems: Volta, South-Western and Coastal River Systems (Yeleliere *et al.*, 2018). The Volta system consists of the Black and White Volta rivers and the Oti River (Yeleliere *et al.*, 2018). In addition, the sole natural freshwater lake in Ghana is Lake Bosomtwe (Yeleliere *et al.*, 2018).

Ghana has major surface water resources in Lake Volta and its tributary rivers, but away from these, groundwater

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is a key resource, particularly in dry seasons and in the drier north (Obuobie *et al.*, 2018). Overall some 40% of households depend on groundwater, and this rises to 60% in rural areas (Obuobie *et al.,* 2017). In the drier north, urban areas also depend primarily on groundwater (Obuobie *et al.,* 2017).

With the exception of localized pollution engineered by illegal mining and other nuisance perpetuated by indigenes, the quality of water (surface and groundwater) in Ghana is generally better (Yeleliere *et al.*, 2018). Sometimes one is tempted to believe that the mineral endowment of most African countries is more of a curse than a blessing as the above mining problems are a case in point in most African countries where these minerals are extracted (Duncan, 2020). While the resource productivity in European Union countries is increasing, many mineral-rich countries in Africa are still struggling to cope with the environmental impacts of rising extraction rates: huge amounts of waste, wastewater, and dissipative losses (Duncan, 2020).

River bodies that were the main source of water for drinking, for household chores and other activities have all been destroyed by activities of illegal small scale mining of gold (Owusu *et al.*, 2016). Water contamination from mining activities results from the discharge of effluents, which contain toxic chemicals such as cyanide and other organic chemicals used in the processing of mineral ores (Duncan, 2020). These chemicals together may result in effluent with high acid levels which can either seep into underground water or flow into the environment (surface water bodies) posing danger to the nearby community's especially those which depend on such water bodies for drinking and other domestic purposes (Duncan, 2020).

Rapid pollution from mining and agricultural activities have compromised water quality making it very expensive to treat for domestic use (Yeleliere *et al.*, 2018). Cyanide is among the most harmful substances on Earth and it is harmful to humans and most aquatic life even at low concentrations (Kwaansa-Ansah *et al.*, 2017). Also, discharges of untreated sewage from municipal waste have resulted in serious pollution of water in most urban settings (Yeleliere *et al.*).

Lagoons and Rivers situated near industrial areas are gradually perishing due to the discharge of untreated municipal waste from domestic and industrial effluent that causes odour and nutrient enrichment leading to algal bloom (Yeleliere *et al.*, 2018). For instance, large quantities of untreated industrial waste emptied into open drains has led to severe pollution in the Korle lagoon and disrupted its natural ecology (Owusu *et al.*, 2016).

Duncan, (2020) reported that illegal mining has created many challenges in Fena River of Ghana. He continued that, the first challenge is the diversion of the river path and mining on the river bed resulting in a high level of siltation that threatens the drying up of the river. The second problem is the introduction of high levels of suspended solids that are potential carriers of heavy metals into the river. The third problem is that the gravels, mud, and rocks displaced during river dredging for the mineral have disrupted the natural flow of the river. The fourth problem is that the fishermen in the area complain of not enjoying a good harvest as in the past (Duncan, 2020).

The quantity and quality of fresh water are still a major problem in most countryside of Ghana as people have to use rainwater, surface water, and shallow groundwater as their drinking water sources (Yeleliere *et al.*, 2018). A research conducted by the Council for Scientific and Industrial Research-Water Research Institute (CSIR-WRI) showed that aside climate change considerations, Ghana is predicted to become a water stress country by 2025 (Owusu *et al.*, 2016). Due to the persistent widespread in illegal mining activities, pollution of water bodies occurs mostly in the south-western parts of Ghana (Yeleliere *et al.,* 2018).

Socioeconomic Value of Lake Bosomtwe

Ecosystems serve as a stock of diverse resources providing food, water, raw materials, medicine, and other essential services that support livelihoods directly and indirectly (Yamba *et al.*, 2017). Local communities in Africa depend heavily on biodiversity for their livelihoods, such as subsistence agriculture, fishing, hunting and the extraction and processing of non-timber forest products like snails, honey and medicinal plants (António *et al.*, 2016). In Ghana, communities on the fringes of forests utilize timber and non-timber forest products for a wide array of livelihood support (Yamba *et al.*, 2016).

Lake Bosomtwe has been a source of socio-economic livelihood for thousands of people living in the three districts of Bosomtwe, Atwima Kwanwoma, Bosome Freho District and the Bekwai Municipality (Adu-Boahen, 2017). Environmental assets of the Lake Bosomtwe Basin include the lake itself, vegetation, marine life, and other physical features such as mountains, caves, cemeteries, and shrines (Mohammed, 2018).

The lake is a highly productive biological system, providing water for consumption, fishing, irrigation, recreation and other domestic, agricultural and recreational uses (Rocha, 2013). Farming and fishing are the main livelihoods for the twenty-four indigenous communities around the edge, so the lake and its catchment area are an economically significant part of their existence (Rocha, 2013). The 24 communities around the lake, rely heavily on fishing for income and food, as well as water for household use and farm irrigation (Darko *et al.*, 2017).

The 24 villages, a total population of 11,800 people (the average size of a village is 500 people) along the 32km shoreline of Lake Bosomtwe (Yesutanbul *et al.*, 2021). The people living along the lake have limited income to satisfy their needs. Their development depends on the relationship among humans (social organization, knowledge, skills, and insights), nature (water, land, and ecosystem), and the spiritual realm (rituals, religion, beliefs, norms, and values) (Boahen *et al.*, 2014). The fairly uniform distribution of temperature and rainfall enhances the cultivation of food and cash crops (Amu-

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Mensah *et al.*, 2018).

Most of the men are farmers and fishermen, and the women sell fish (Boahen *et al.*, 2014). Agriculture is the primary occupation in the Bosomtwe District which employs 62.6% of the district's labour force with crop farming and fishing, respectively, constituting 57.4% and 5.3% (Yamba *et al.*, 2017). The next highest alternative livelihood activity is charcoal production accounting for 11% of alternative activities (Yamba *et al.,* 2017). Abundance of trees suitable for charcoal production was found to be the prime driving force for the practice (Yamba *et al.,* 2017).

There are three main types of agricultural practices: crop farming (food and cash crops farming), fishing and animal husbandry (BDA, 2020). Most households practice a mixture of the three (BDA, 2020). They grow variety of crops including cassava, plantain, yam, and diverse vegetables, with cocoa as the main crop (Mohammed, 2018). Agricultural production in the lake basin is done with simple farm tools such as the cutlass and hoes (Boamah & Koeberl, 2007). Also around the lake basin is a large population of livestock such as cows, goats, and sheep in the various communities (Mohammed).

A significantly high number of the keepers extensively graze their animals within the Bosomtwe Basin (Mohammed, 2018). Because of their large numbers, their impact on the lake is substantial (Boamah & Koeberl, 2007). Besides fishing, they depend on the aquatic resource for drinking water and irrigation water for agricultural activities (Prakash *et al.*, 2005).

The lake also provides the basis of other social and economic opportunities such as transportation and tourism (Prakash *et al.*, 2005). The presence of Lake Bosomtwe as a tourist site, water and forest resources, and fast growing peri-urban centres presents opportunities to engage in varied alternative livelihood activities to safeguard household income and food supply (Yamba *et al.*, 2017). The local people mostly farm and fish, but recently tourism has evolved as an alternative source of income, providing them with new employment opportunities, new infrastructure development, and government revenue (Boamah & Koeberl, 2007).

The lake is endowed with many tourist attractions which include: the biggest natural lake in West Africa and a vital geological heritage site, the best-preserved young complex meteorite impact crater in the world as deemed by United Nations Educational, Scientific and Cultural Organization (UNESCO), a unique and very attractive position in a virgin forest zone, rich geological and biodiversity information, the main lake for its recreational and aesthetic qualities (Mohammed, 2018). Other cultural heritage of the Lake Bosomtwe Basin are music and dance, architecture, traditional shrines, beliefs and practices, Ghanaian cuisine, and traditional village life (Mohammed, 2018). The expansion of hotels and guest houses has been increasing: Lake Inn, Paradise Hotel, Lake Point, Rainbow Gardens and a new equestrian hotel, with many more anticipated (Otu, 2010).

According to Mohammed (2018), there are about 1000 fishermen operating in Lake Bosomtwe. They use 18m wooden planks as fishing boat, and employ three types of fishing gears, namely: the wire mesh traps, efficient gillnet 25m x 2-3m and 4cm stretched mesh as well as 2-3.1m radius cast net (Mohammed, 2018). Lake Bosomtwe Basin is located within the gold layer of the Ashanti region where several private enterprises are undergoing various explorations and mining activities (Mohammed, 2018).

Governance of Lake Bosomtwe

Governance is a means to an end, and the type of governance should match the level of risk or the magnitude of the problem to fit policies to places (OECD, 2018). Water is indispensable for all forms of life (Iza & Stein, 2009). It is important to ensure that efforts to improve water resources management and services over the best long term (Jim *et al.*, 2020). Any water system is an inseparable part of the environmental system as a whole and that the societal and environmental systems are inextricably bound up with each other as well (Hoekstra, 2006). State and sub-state governments have the official authority to govern water in the majority of watersheds in the world, although they may choose to delegate, rescind, or even neglect that authority (Moore, 2013).

However, the global water governance literature indicates that the complexity of water governance relates to the fact that, at the organizational level, the authority for steering the water agenda is lacking (Moore, 2013). Without effective institutions, compliance and enforcement are likely to be lax (Iza & Stein, 2009). How a country manages its water resources determines the health of its people, the success of its economy, the sustainability of its natural environment, and its relations with its neighbours (Iza & Stein, 2009). Water governance capacity reflects a society's level of competence to implement effective water arrangements through policies, laws, institutions, regulations, and compliance mechanisms (Iza & Stein, 2009).

According to Batchelor (2007), water governance covers the manner in which allocative and regulatory policies are exercised in the management of water and other natural resources and embraces the formal and informal institutions by which competition for limited water resources is daunting. Maintaining the integrity of water ecosystems using approaches that also impact positively on levels of poverty and take explicit account of the risks and uncertainties of climate change is an even greater challenge (Batchelor, 2007). Since the UN water conference at Mar del Plata in 1977, there have been international debates about how water governance could and should respond to the challenges of sustainable development (Woodhouse & Muller, 2017).

The management of water resources in Ghana is regulated by the Water Resource Commission (WRC) of Ghana. The WRC of Ghana was established by an Act of Parliament (Act 522 of 1996) with the obligation

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to regulate and mange Ghana's water resources and co-ordinate government policies in relation to them (Owusu *et al.*, 2016). Act 522 of 1996 specifies that ownership and control of all waters are vested in the President on behalf of the people, and defines the WRC as the overall body responsible for the management of water resources in Ghana (Owusu *et al.*). Freshwater governance in Ghana has evolved through several approaches to the Integrated Water Resources Management (IWRM). The National Water Policy of Ghana is intended to provide a framework for the sustainable development of Ghana's water resources.

In Ghana, traditional authorities continue to have significant amount of power. Each village and town have a royal family and a group of elders (including a chief and sub-chiefs) who together form the traditional council which makes decisions on behalf of its population about issues such as local land use, timber concessions, development and distribution of land access (Bissell, 2020). The concept of integration provides a frame for understanding the relationships among these various elements of a water governance system, and, more importantly, a means for reconciling fragmentation and overcoming the resulting gridlock through frameworks such as Integrated Water Management (IWM), Integrated River Basin Management (IRBM), and Integrated Water Resources Management (IWRM) (Maas, 2011).

Local conservation and stewardship organizations have a long history of fish stocking and habitat maintenance and restoration projects in Whiteman's Creek, and thus have significant concerns related to securing water for ecosystem integrity (Maas, 2011). Currently Nana Kuntansehene, Nana Kokofuhene and Nana Asamanhene are in control of land around the lake area with the Asamanhene in charge of the Lake, holding it in trust for the Asantehene (Amu-Mensah *et al.*, 2018). Traditionally, law enforcement used to be upheld through experiences, beliefs and traditional practices of the people in the protection of the lake (Amu-Mensah *et al.*).

Sustainable Management of Lake Bosomtwe in the Ashanti Region of Ghana has an ultimate goal: The conservation of the environment of this geographic area, its sustainable development to preserve the Bosomtwe Lake of the impacts endangering the ecosystem, as well as to preserve the Lake's biodiversity (António *et al.*, 2016). The lake is enclosed within two administrative districts, Bosomtwe District and the Bosome-Freho District, all within Ashanti Region of Ghana. It must be noted that, but for the proper management of the Lake Bosomtwe catchment, vegetation would have decreased by higher extents (Mantey & Baffoe, 2013). The water sector's policy and legal framework do not adequately incorporate key government stakeholders and management entities into basin planning processes and address conservation needs, including forests and wetlands according to United States Agency for International Development (USAID) (2021).

Biodiversity of Lake Bosomtwe

The Biosphere reserve is located in the deciduous forest zone of Ghana consisting of a mixture of three basic types of ecosystems: forests, wetlands and mountains (António *et al.*, 2016). Lake Bosomtwe is rich in aquatic biodiversity of national and global significance (Appiah, Akoto & Partey, 2018). Given its ecological, economic and social importance, Lake Bosomtwe was designated as a biosphere reserve by UNESCO in 2016.

Biosphere Reserves were launched by UNESCO's 1974 Man and Biosphere Program which recognized the need to reconcile the conservation of areas that are host to valuable biodiversity with local land-use needs through the delineation of core areas, buffer areas and transition zones (Yesutanbul *et al.*, 2021). The overlapping southernmost section of the Lake with northern part of the reserve creates a combination of forests, wetland and mountain ecosystem (Appiah *et al.*, 2018).

According to Anim, Li, Agadzi and Nkrumah (2013), its watershed is covered by diverse land use mainly farmland which is about 50% of the land cover. The lake environment is surrounded by steep hills, rocky areas and inaccessible places due to the topography and nature of the slopes (António *et al.*, 2016). Most of these areas are left as fallow lands which has a total area of 2851.15 hectares, forming 9.9% of the total area of the Biosphere Reserve (António *et al.,* 2016). 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 (Anim *et al.*, 2013).

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 (Anim *et al.*, 2013). The lake is the habitat for large number of aquatic species and serves a great deal of recreation and tourism activities (Nketia *et al.*, 2016).

The local inhabitants carry out subsistence farming to feed their families. The total area covered by these activities is 5058.36 hectares, which forms 17.58% of the total area of the Biosphere Reserve (António *et al.*, 2016). Most of the farmers are also involved in other food and cash crops farming like large scale food cropping and other tree cropping like cocoa, oil palm and citrus plantations. The total area covered by these types of farming is 13853.82 hectares, which forms about 48.16% of the total are of the Biosphere Reserve (António *et al.,* 2016).

The Southern Part of the Bosomtwe Basin is covered by a Gazetted Government Forest Reserve with a total area of 1434.73 hectares, this also forms 4.9% of the total area (António *et al.*, 2016). According to António *et al.*, the natural vegetation of the area falls within the semi-deciduous forest zone, specifically the rain forest of Ghana. The basin has different tree species that have high economic value including Mahogany (*Khaya ivorensis*), Onyina (*Ceiba pentandra*), Wawa (*Triplochiton scleroxylon*),

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Asanfena (*Aningeria spp*.) and Denya (*Cylicodiscus gabunensis*) (Appiah *et al*., 2018).

Indigenous tree species include *Terminalia spp, Ceiba pentandra, Celtis mildbraedii, Triplochiton scleroxylon,* and *Ficus spp* (Appiah *et al*., 2018). The forests in Lake Bosomtwe harbours a variety of fauna that are recognized nationally and/or globally as endangered. These species include palm squirrel (*Epixerus ebii*), giant pangolin (*Manis* [*phataginus*] *gigantea*), tree pangolin (*M. tricuspis*), long-tailed pangolin (*M. tetradactyla*), the bareheaded rock fowl (*Piscathartes gymnocephalus*), and many more (Yesutanbul *et al*., 2021). Important trees in the catchment area include endangered commercial timber species such as the mahoganies- *Khaya senegalensis* and *K. grandifoliola* (Rocha, 2013).

However, due to extensive farming activities in the area, the original vegetation has been degraded to a mosaic of secondary forest, thicket, and regrowth with abandoned farms of food crops and vegetables (Yamba *et al*., 2017). The high level of unsustainable human interaction with this sensitive ecological area suggest that there is an urgent need to place emphasis on geo-ethical thinking as far as the protection of the natural environment is concerned and in particular around Lake Bosomtwe as a designated Biosphere Reserve (Yesutanbul *et al*., 2021).

The Lake forms the main water body of the area with a total area of about 4927.60 hectares corresponding to 17.13% of the total area of the Biosphere Reserve (António *et al*., 2016). There are 11 known species of fish in the lake, including one endemic cichlid (*Tilapia discolors*) (Mohammed, 2018). Clarias species and hetero bronchus species are sometimes caught in the lake (Boahen *et al*., 2014). Research indicates that Lake Bosomtwe is rich in aquatic biodiversity of national and global significance. The fish species include *Sarotheroden galilaeus multifasciatus, T. discolour* and *T. zilli* which is much of importance (Yesutanbul *et al*., 2021). The lake also has the endemic fish, *Tilapia bosonama* (Rocha, 2013).

This forest and wetland ecosystem is globally significant for its flora and fauna, the wooded slopes providing habitat for many mammals, including the globally endangered Jentink's Duiker *Cephalophus jentinki* (Rocha, 2013). Five mammal taxonomic groups, representing 17 families, 26 genera, and 29 species have been confirmed during a baseline survey in 2013 (Rocha, 2013). The only species of serious conservation importance of Near Threatened: the tree pangolin was recorded in the core area of the Bosomtwe Range Forest Reserve (IUCN, 2016). Both Tullberg's soft furred mouse (*Proamys tullbergi*) and the shrew (*Crocidura gradiceps*) are endemic to West Africa (António *et al*., 2016).

Confirmed carnivores in the area were mongooses, civets, genets and pangolins (António *et al*., 2016). Major ungulate species including bushbucks, Maxwell's duiker, royal antelopes and black duikers were also restricted to areas that have had minimal disturbance (António *et al.,* 2016). A few indirect recordings of primate activity of pottos, galagos, lesser spot-nosed and Lowe's monkeys were made in core areas represented by the Bosomtwe Range (António *et al.,* 2016).

Degradation of Lake Bosomtwe Ecosystem

Socioeconomic development needed by human society must not imply the degradation of the natural environment and loss of biodiversity that negatively affect the very viability of the development model (António *et al*., 2016). Ecosystems and communities across the globe are facing the negative impacts of the intensifying socio-ecological crisis: deepening inequality, loss of biodiversity, climate breakdown, and ecosystems that are unable to function properly (Bissell, 2020). In the IUCN Red List, 34% of freshwater species are threatened more than any other group.

The current state of Lake Bosomtwe is a major concern to many environmentally informed citizens of the global community (Quartey, 2011). The lake is becoming a popular tourist attraction in Ghana and has the potential to be developed as an ecotourism site in the future. However, there have been some unregulated human activities and unplanned infrastructure development, and there are increased levels of pollutants in the lake water (Boamah & Koeberl, 2007). Human activities along the Lake during the past 40 years, however, have increased rates of soil erosion (Otu, 2010). Over the years, land cover around the lake which used to be mainly forest (closed) has been converted to agricultural land and open forest (Anim *et al*., 2013).

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 (Anim *et al*., 2013). Protection of Lake Bosomtwe environmental assets enhances the attractiveness of the Lake Bosomtwe Basin as a tourist destination, on the other hand, their destruction erodes the natural and aesthetic appeal of the basin and thereby debases it as an attraction (Mohammed, 2018). The rapid pace of development in the area has resulted in a conflict in the need for immediate consumption and the need to ensure the long-term supply of these resources (Adu-Boahen, 2017). This has resulted in host of problems such as increased erosion in the areas, siltation, and loss of resources and the destruction of the fragile marine habitat (Adu-Boahen, 2017). From the period 1st March to 30th August, 2021, there were 32 reports of harmful farming activities (clearing vegetation less than 30 meters from the water body) and 16 reports of charcoal burning around the riparian vegetation (Yesutanbul *et al*., 2021).

The overwhelming numbers of tourists during festive occasions create problems of efficient monitoring of tourist activities by government officials (Mohammed, 2018). This has led to the creation of illegal roads by tourist vehicles in some environmentally sensitive areas such as shrines and cemeteries (Mohammed, 2018). The hitherto pristine environment of the Lake Bosomtwe Basin has been despoiled by the incessant littering, especially during the public holidays peak periods. Plastics bags, cans,

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and bottles as well as biodegradables such as leftover food, pieces of paper, and pet excreta are common sight along the roads, on the beaches, and on the outer rim of the lake (Mohammed, 2018).

The springing up of hotels, lodges, and camps in the lake basin each with its separate septic tanks and sewage collection receptacle respectively is likely to increase the potential for ground water pollution (Mohammed, 2018). Septic tanks for human waste have not been built in conformity to environmental design standards, and in the adjoining local communities such tanks are unavailable except "pit latrines," which have not been integrated with septic tanks in the tourist hotels (Mohammed, 2018).

In the Lake Bosomtwe Basin, septic tanks of hotels and camps are located in areas where groundwater is closer to the surface, especially at the lower terrace closer to the sandy beaches on the rim of the crater (Mohammed, 2018). Over the years, land cover around the lake, which used to be mainly closed forest, has been converted into agricultural lands and open forest (Mohammed, 2018). Recent human activities and shoreline changes of the lake are believed to have subjected the catchment areas to undue deforestation from uncoordinated farming practices (Boahen *et al.*, 2014).

There is, therefore, an increase in the utilization of unsustainable natural resources in terms of land cultivation, overgrazing, and forest exploitation. One consequence of this is increased soil erosion, which results in more nutrient runoff and leaching (Boamah & Koeberl, 2007). The locals, due to reduced fish catches, have resorted to increased agriculture on the steep slopes of the impact crater. As more and more of the hills are converted into farmland, exposing the surface to the impacts of torrential rainfalls, soil erosion is expected to have a greater impact on siltation of the lake (Amu-Mensah *et al.*, 2019). The clearing of tropical forest for agriculture contributes significantly to greenhouse gas emission which hastens climate change (Appiah *et al.*, 2016). Extensive and repeated farming activities have altered and degraded the original vegetation (Mantey & Baffoe, 2013).

Also, around the lake basin is a large population of livestock such as cows, goats, and sheep in the various communities. These animals graze and drink from the lake defecating along its banks (Mohammed, 2018). It is therefore most probable that large portions of the dung (made up of phosphorus and nitrogen) gathers close to the shore and are finally drained into the lake when it rains (Mohammed, 2018). In the case of animal rearing, fecal materials from sheep, dogs, pigs, ducks and fowls are washed into the lake during rain events, consequently increasing the organic matter load in the lake (Amu-Mensah *et al.*, 2018).

Illegal miners and prospectors have heavy equipment with which they scour out large areas of vegetative cover and dig out pits, tunnels and trenches (Mohammed, 2018). This generates huge quantities of waste that is often made up of heavy metals (such as metals 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 (Mohammed, 2018). Informal gold mining, logging, and the expanding cocoa sector are increasing flood risks, erosion, and sedimentation in the South-western and Coastal Basins. Gold mining contaminates municipal water sources with heavy metals, especially in the Pra Basin. Municipal, domestic, and industrial waste also contaminate 60 percent of surface water and degrade ecosystems and biodiversity, especially downstream of Kumasi and Accra (USAID, 2021).

The rampant and uncontrolled destruction of trees and forests on and along the hills has left in its trail bare land and gullies and, at best, grasslands (Yesutanbul *et al.*, 2021). These illegal operations are carried out at nights and in the middle of the forests and forest reserves, ostensibly to hide from the forest guards (Kyere-Boateng & Marek, 2021).

The unparalleled degradation of the catchments has disrupted the fish ecology, hence dwindling livelihood opportunities (Boahen *et al.*, 2014). When it rains, surface runoff water washes away the soil nutrients and all the streams in the farmlands flow directly into the lake, causing enrichment of the lake water (eutrophication) (Prakash *et al.*, 2005). Eutrophication ultimately leads to the reduction of oxygen in water, release of cynotoxins, massive fish kills and damage to recreational activities (Prakash *et al.,* 2005).

The increasing population around the lake is leading to more fish being taken from the lake, resulting in overfishing (António *et al.*, 2016). The sizes of fish being caught presently are becoming increasingly smaller resulting in the use of net mesh sizes as low as mesh size of mosquito nets which is 2mm, with the obvious impacts of non-selective fishery (António *et al.,* 2016). The increasing use of pesticides in farming, as well as the input of anthropogenic pollutants during the past decade's most likely has already resulted in the fish being contaminated with various chemicals (Boamah & Koeberl, 2007).

Clothes are washed with detergents in the lake water and also at the bank of the lake shore where the used water is eventually thrown into the lake (Boamah & Koeberl, 2007). Some of the people in the community bath with soaps in the lake water and fishermen wash their nets with soap in the lake (Boamah & Koeberl, 2007).

Theoretical Framework

Total Economic Value is the concept in which this study is dependent on. Total economic value (TEV) is the total measurement of the economic value of services of a given ecosystem (Pearce *et al.*, 2006). Regarding the TEV concept, there are several techniques proposed to evaluate and estimate Willingness To Pay for improved environmental services (Ward, 2007). They are the direct and indirect methods. The direct methods are Travel Cost Method (TCM), Hedonic Pricing Method (HPM),

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and Advertising Behaviour. The indirect methods include Contingent Valuation Method (CVM), Conjoint Analysis, Choice Ranking, Contingent rating, and Choice Experiments.

Travel cost method gained popularity as the best valuation method in the Australian context (Jackson *et al.*, 1990). It makes the assumption that people go on repeated trips to tourist and recreational sites until marginal utility derived from a trip and the marginal costs of that same trip is equal to zero, i.e. marginal utility = marginal cost. The marginal costs are time and transportation cost (Jackson *et al.*, 1990). This can be accounted as directly revealed preference for recreation and an indirectly revealed preference for nature (Makwinja *et al.*, 2021). The travel cost method only considers the demand for trips to a recreational site depends on income, travel costs, prices of substitutes, characteristics of the site etc. (Jackson *et al.*). However, it is a drawback to choose individual environment service from the broader and extensive set of ecosystem services (Marcot, 2012).

The Hedonic Pricing Method (HPM) since the 1970's has been applied extensively in the environmental economics (Ndebele, 2009). The method is centred on market goods usually traded at prices where amenities are internalized (Ndebele, 2009). This method is based on the assumption that differences in environmental quality can be valued through property prices. The HPM technique cannot evaluate the non-use values of the lake ESs since its validity is questionable, aside the fact that the shape of the hedonic price function is unknown (Chumpitaz *et al.*, 2010). However, the technique can be used to evaluate the differentials in property prices and wages between locations, in doing so, isolates or exempts the proportion attributed to the quality of the environmental services provided by the lake ecosystem.

Contingent valuation method (CVM), on the other hand, is the preferred choice for evaluating environmentally sensitive areas. The analysis is dependent on a survey where respondents are asked WTP amount to use or conserve natural goods. CVM stated preferences are based on the assumption of contingency upon the alternate goods given in a 'hypothetical market'. The most important factors of the survey are the natural goods to be valued, the payment method, and the hypothetical market. CVM employed in this valuation helps in the achievement of the objective of the study which is centred on improving the provision of Ecosystem services that benefit the community members including the farmers both directly and indirectly in the landscape (Bani & Damnyag, 2017).

Measuring Willingness to Pay (WTP)

In measuring WTP, the value of goods and services is measured based on the importance of the goods and services for consumers and their preferences and choices (Kokoye *et al.*, 2018). Consumer preferences are evaluated by the amount they are willing to pay for the goods or services. Thus, the WTP for goods or services is defined as the maximum price people are willing to pay for goods or services (Wertenbroch & Skiera, 2002; Yegbemey *et al.*, 2014).

It involves targeted patrons for products and services in establishing the preferences for the products or services presented and the amount of money the respondents are ready to pay for the product or service. WTP studies are widely used in analysing markets, goods, services, entrepreneurs and for environmental valuation. For determining the WTP for a product or service, two main methods have been employed. These methods are the revealed preference and stated preference which includes the contingent valuation method (CVM) and choice experiment. In stated preference methods, however, such as the contingent valuation, respondents are asked about their preferences for a nonmarket good and how much they are willing to pay for the good (Brako, 2015).

In this study, the CVM was used. CVM is a survey-based methodology that simulates a market in which respondents are exposed to information on goods or services and make decisions about their WTP (Chee, 2004; Zapata & Carpio, 2014). CVM is flexible and adaptive to valuation tasks that other techniques cannot handle (Padi, Awuah-Addor & Nunfam, 2015). It has been widely used by studies in environmental and health economics fields (Cho *et al.*, 2011; Cho, Newman & Bowker, 2005; Hudson & Hite, 2003).

Nicosia *et al.* (2014) evaluated a community's WTP for ecosystem service restoration in a highly urbanized and degraded watershed located in coastal New Jersey, the Barnegat Bay Watershed (BBW). Makwinja *et al.* (2021) also determined the WTP for the ecological restoration of an inland freshwater shallow Lake of Malombe in Malawi.

However, because CVM uses a hypothetical market, the main issue is whether people are actually willing to pay what they claim they will pay. The CVM has been criticized for its inability to deliver reliable and accurate estimates of the WTP (Diamond & Hausman, 1994) and for many biases include strategic bias, design bias, hypothetical bias, and operational bias (Padi *et al.*, 2015).

Despite being prone to starting point bias in the sense that the final WTP is related to the starting point WTP, the method is efficient in developing countries as compared to developed countries (Brako, 2015). Demographic and other characteristics are used as independent variables to create a formula to predict how WTP varies by individual characteristics (Nicosia *et al.*, 2014).

Factors Affecting WTP for Restoration of Degraded Ecosystem

Factors affecting restoration of degraded ecosystem include age, gender, educational attainment, income as well as household head (Brako, 2015). In Makwinja *et al.* (2021) study on WTP for the ecological restoration of an inland freshwater shallow of Lake Malombe in Malawi, the respondents believed that the initiative would improve the Lake Ecosystem services, fish biodiversity, income level, water quality and mitigate climate change impact.

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Factors such as age, gender, literacy, income, social trust, institutional trust, access to extension services, period of stay in the area, household distance from the lake, lake ecological dynamics impact, having the hope of reviving the lake health ecological status, perception of having lake ecological restoration program, participation in lake restoration program, access to food from the lake, involved in fishing and Lake Malombe primary livelihood sources significantly influenced WTP (Makwinja *et al.*).

On the other hand, Nicosia *et al.* (2014), study on determining the WTP for ecosystem service restoration in a degraded coastal watershed, demographic variables such as education, age, employment status, marital status, distance from the bay, and household size were found to be not significant and were not included in the final model.

In Adongo, Otieno and Abuor (2020), study on Economic Value of Ecosystem Restoration for Sustainable Development of River Migori, Kenya, the variables gender, marriage, household size, income were found to be significant with a positive coefficients.

Conceptual Framework of the Study

The conceptual framework developed for this study is presented in Figure 1. Arrows represent hypothesized relationships. It maps out concepts and expectations of the study taking into account issues raised in the reviewed literature, a description of the current state of four ecosystem services (water quality, soil retention, habitat provisioning, and recreational use). Knowledge and

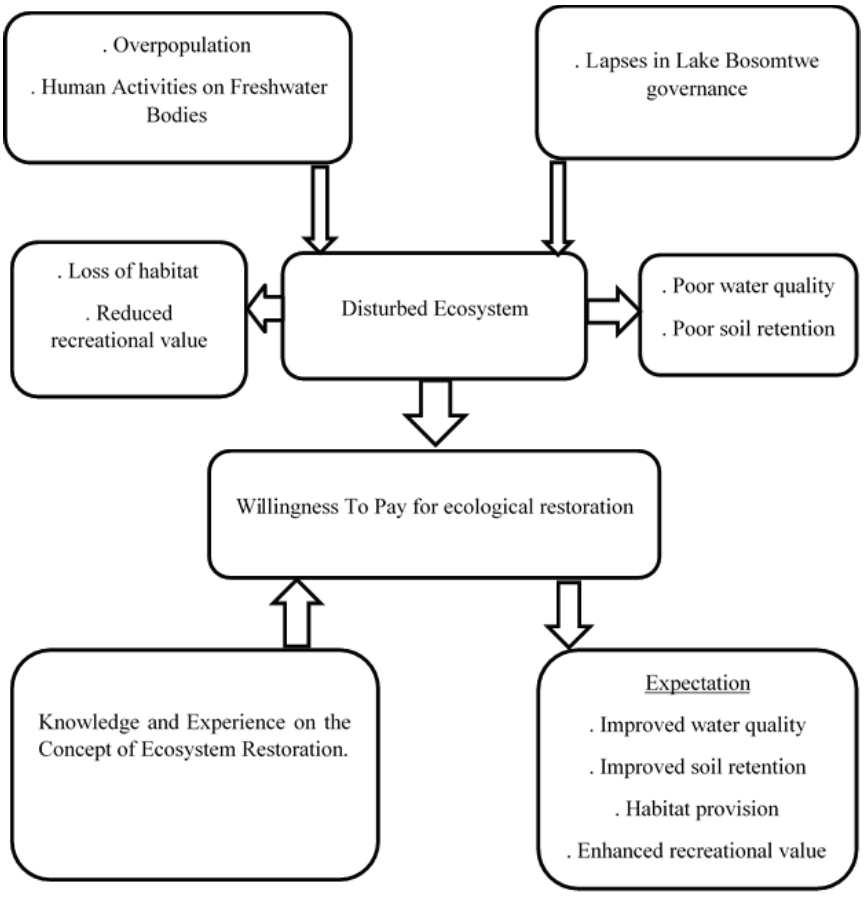

Figure 1: Conceptual framework of WTP for restoration of degraded Lake Bosomtwe ecosystem
Source: Author's Construct

Experience on the Concept of Ecosystem Restoration will lead to WTP for a restoration, resulting to what environmental managers expect the state of the ecosystem service to be after restoration.

MATERIALS AND METHODS

This chapter shows the research methodology that was used in the study including description of study area, sampling method and sample size, methods of data collection and methods of data analysis.

Research Design

The decision regarding research approach is a very important decision in the research design process because it determines how relevant information for a study will be obtained; however, the research design process involves many interrelated decisions (Aaker *et al.*, 2008). The study adopted quantitative research designs. The quantitative research method enabled the examination of various variables while including numbers as well as statistics to project and analyse the result. Respondents were given a briefing of the concept of environmental services being

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benefits humans derive from the environment as a result of effective and efficient management. Four ecosystem services were chosen to be included in the survey. These were soil retention, habitat provisioning, water quality and recreational use.

It was explained to the respondents that, soil retention is the amount of water the soil can retain and is a key component of the hydrological cycle in Lake Bosomtwe, while habitat provisioning is the protection of the habitats of the various species of the Lake Bosomtwe enclave. Water quality includes maintaining the health of the Lake to ensure that human and non-human organisms can use the water which means decreasing nitrogen and other contaminants that enter the Lake from land. Recreational activity is also a large part of the Lake Bosomtwe enclave and maintaining it relies on keeping water quality and the surrounding at desirable levels.

Study Area

Lake Bosomtwe is enclosed within two administrative districts, Bosomtwe District and Bosome-Freho District, all within Ashanti Region of Ghana. The 15 communities selected are Pipie, Abaase, Juaman, Nkawi, Ankasi, Duase, Adwafo, Brodekwano, Detieso, Atafram, Esaase, Apewu, Amakom, Obo and Abonu. All these communities are surrounding the lake.

Lake Bosomtwe is the only known naturally produced lake in Ghana and is a popular recreational destination. It is located in the southern portion of the country amid an ancient meteorite impact crater. The surrounding crater rim reaches a minimum height of 110m above current water level which amounts 99 m alms, separating the hydrology from the surrounding Pra River Basin, as well as creating conditions of reduced wind stress (Anim *et al.*, 2013). The crater structure is nearly occupied by Lake Bosomtwe about 8 km in diameter and about a depth of 80m at its centre (Anim *et al.,* 2013).

According to UNESCO, the biosphere reserve supports 35 tree species, some of which are exploited for lumber. The location also supports a diverse range of wildlife as well as a human population of approximately 50,000 people whose main economic pursuits include farming, fishing, and tourism, as the lake is a popular tourist attraction (Amu-Mensah, 2020). The region is also used for environmental education at schools and institutions, as well as research, particularly on climate change.

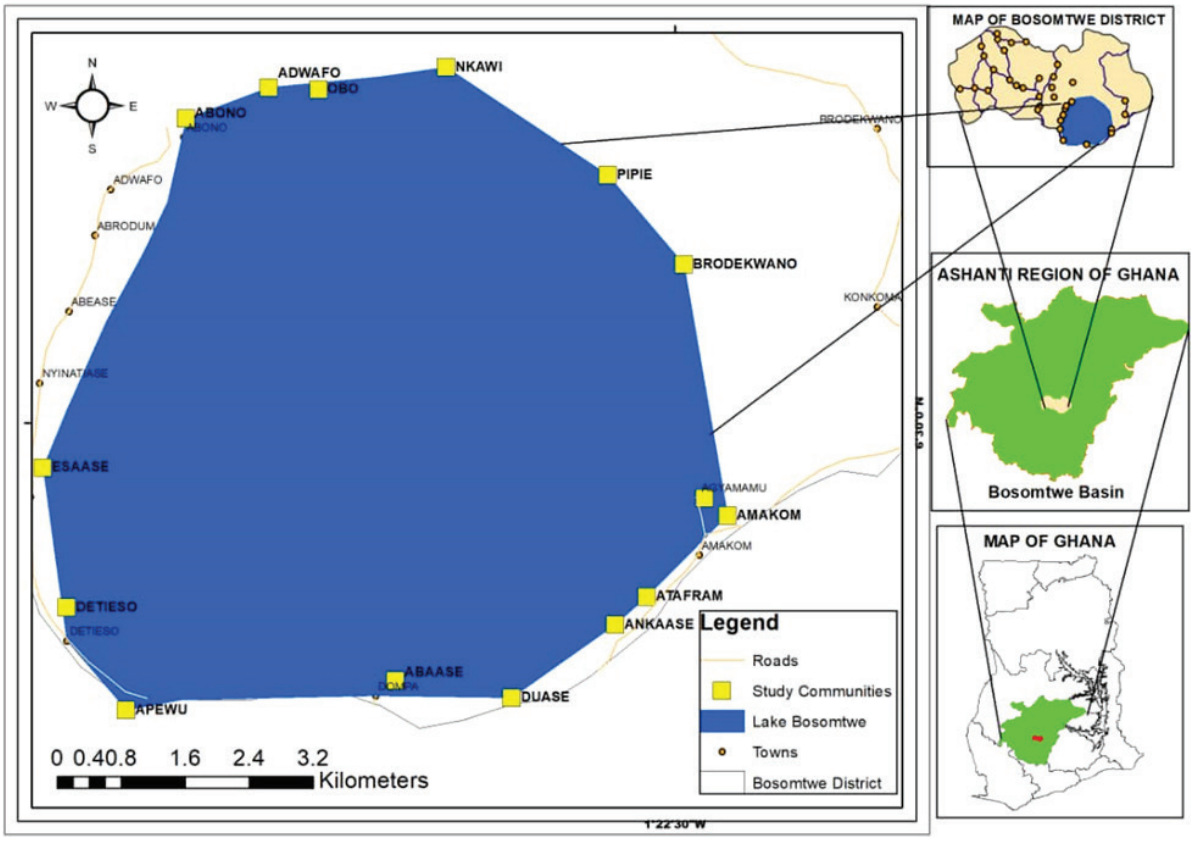

Figure 2: Map of Lake Bosomtwe and surrounding communities
Source: Author's Construct

According to oral legend, several years ago, a hunter (Akora Bompe) on a Sunday hunting journey came upon lake. It is said that a wounded antelope he had shot and was running after jumped into pond-like water and vanished. Akora the hunter named the Lake "Bosom" meaning something that is precious and "Otwe" meaning antelope (Amu-Mensah, 2020).

Population

The target population for the study was all community

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members living in Lake Bosomtwe adjoining communities.

Sample Size Determination

Cochran's formula is used to calculate the sample size because the population of community members was unknown.

Cochran's formula: n0 = Z2pq/e2 where:

n = the sample size

Z = desired confidence level (95%-1.96) p = maximum variability= 0.5

q= 1-p

E=desired level of precision= 0.05

= {(1.96)2 (0.5) (1-0.5)}/ (0.05)2

= 385

Given the results above, the sample size for this research then is 385.

Although, the expected sample size given by the formula is 385 respondents, only 150 questionnaires were administered due to time and financial constraints. Therefore, the data was assessed based on 150 respondents using a questionnaire with open-ended and closed-ended questions.

Sampling Technique

The Study Area

Lake Bosomtwe, was purposively selected since it has surrounding communities targeted for this research. Amongst the surrounding communities, 15 were selected using convenience sampling: Pipie, Abaase, Juaman, Nkawi, Ankasi, Duase, Adwafo, Brodekwano, Detieso, Atafram, Esaase, Apewu, Amakom, Obo and Abonu. These communities selection was influenced by accessibility since some had transportation issues and others difficult to visit due to rain. From the above communities, ten (10) respondents each were selected at convenience using convenience sampling. Using convenient sampling to select the 10 respondents was due to the situation where most of the community people were complaining that after responding to several survey questionnaires in the area, they were yet to have an impact, therefore, their refusal to accept to respond to such surveys. 10 respondents each from a community was to ensure that the survey had an equal representation of respondents' views from the selected communities.

Type of Data

In this study, both primary and secondary data sources were employed.

Primary data was obtained from respondents through a survey with the aid of a semi structured questionnaire. Data on the socio-demographic characteristics of respondents, estimation of public WTP amount for the lake's restoration program, factors influencing the local communities WTP towards the proposed restoration program, and strategies to help in improving the conservation and sustainable usage of the Lake Bosomtwe were accessed through the semi structured questionnaires consisting of open and closed-ended questions. Secondary data was collected from the reviewed literatures.

Questionnaire Design and Data Collection Procedure

A survey questionnaire was administered to respondents constituting the major primary data for the research. The questionnaire focused on: 1. Activities that community members engage in that disturb the Lake Bosomtwe's' ecosystem and major reasons for their engagement in that activity. 2. Community peoples' views on the importance of restoring water quality, soil retention, habitat provisioning, and recreational use ecosystem services of the area. 3. WTP for the restoration program, WTP amount and acceptable mode of payment. 4. The socio-demographic characteristics of the respondents. The questions were thoroughly explained to the respondents so that the answers given by the respondents will not be compromised.

Data Analysis

In analysing the responses that were obtained from the administered questionnaires, a computer software program was used. The data collected from the survey was analysed using STATA 13.0. The raw data from the questionnaire were coded and frequency tables were derived and used for the interpretation.

The study relied on primary data gathered through a contingent valuation survey including interviews. The primary data was focused on quantitative data. Using a semi structured questionnaire, primary data on objectives of the study were attained. The Contingent Valuation Method (CVM) was used to determine the WTP of respondents. The arithmetic Mean Willingness To Pay (MWTP) was computed using the following formula:

$$MWTP = \sum_{i}^{n} \frac{\text{figures indicated by respondents for WTP}}{n=150} \quad (1)$$

Where MWTP is the Mean Willingness to Pay

Multiple regression was run to identify factors that affect respondents' choice of an amount to pay for the restoration program. The Ordinary Least Square regression model was specified for the estimation based on equation (2). It is stated as follows:

$$Y = \propto +\beta x_1 + \beta x_2 + \ldots\ldots\ldots \beta xn + e \quad (2)$$

Where Y is the dependent variable, i.e. Amount (GH¢) the respondents were willing to pay every month for the restoration program, β is the coefficient, x_1, x_2….. x_n are the independent or explanatory variables and e is the error term (Equation 2). The variable description, measurement and a priori expectation of the independent variables used in the regression equation (2), Table 1.

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Table 1: Variable Description, Measurement and a Prior Expectation

Variable	Measurement	A prior expectation
Disturbed the ecosystem (x_1)	Yes = 1, No = 0	+
Know the products and services the area provides (x_2)	Yes = 1, No = 0	+
Gender (x_3)	Male = 1, Female = 0	+
Household size (x_4)	1 if < 5, 2 if > 5	+
Age (x_5)	1 if < or = 33, 2 if > 33	+
Level of education (x_6)	1 if J.H.S, 2 if S.H.S, 3 if tertiary, o if none	+/-
Annual income (x_7)	1 if < or = 500, 2 if > 500	+/-
Community (x_8)	1 if Abono, 2 if Obo, 3 if Amakom, 4 if Apewu, 5 if Atafram, 6 if Detieso, 7 if Brodekwano, 8 if Duase, 9 if Adwafo, 10 if Juaman, 11 if Abaase, 12 if Esaase, 13 if Pipie No 2, 14 if Nkawi, 15 if Ankasi	+
Occupation (x_9)	1 if farming, 2 if fishing, 3 if formal, 4 if other, 5 if unemployed	-

Source: Author's construct

Ethical Considerations

All the participants were fully informed about the purpose of the study in their native language. Before the interview, consent was sought from each participant, and no personal identification was registered. The consent was proposed verbally since the study's cross-section nature required descriptive data, and the response had no personal, social, political, or significant risks. The data's confidentiality was guaranteed.

RESULTS AND DISCUSSION

Result

This chapter presents the results and the key findings from the study. The results were subsequently discussed in chapter five.

Socio-Economic Characteristics of Respondents

The total number of respondents was 150. As shown in Table 2, 51.33% were males. About 45.33% were married and majority of them (34%) have senior high level of education. The average household size is 5, average age been 33years and the major occupation is fishing.

Table 2: Socio-Economic Profile of Respondents in the Study Area

Variables	Frequency	Percentage
Gender		
Male	77	51.33
Female	73	48.67
Marital Status		
Single	50	33.33
Married	68	45.33
Divorced	14	9.33
Separated	18	12
Level of education		
J.H.S	45	30
S.H.S	51	34
Tertiary	16	10.67
No formal education	38	25.33
Household size		
Mean	5	
Minimum	1	
Maximum	9	
Age		
Mean	33	
Minimum	18	
Maximum	78	

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Occupation		
Farming	35	23.33
Fishing	39	26
Formal	28	18.67
Unemployed	46	30.67
Farming and Fishing	2	1.33

Source: Field data (2022)

Activities That Community Members Engage in That Disturb the Ecosystem of Lake Bosomtwe and Their Major Reasons for Engagement

Fishing of smaller fishes (11.33%) is the major activity respondents engage in that disturb the lakes ecosystem. Their major reason for doing so is that, it is their source of livelihood and they do so due to little catch of bigger fishes in the lake. About 41% responded that they do not disturb the ecosystem of the area, represented by NA in the table. Washing along the lake shore (10.67%) and easing of oneself in the lake (7.33%) were the next major disturbing activities community members were into (Table 3).

Table 3: Activities Community Members Engage in That Disturb the Ecosystem of Lake Bosomtwe and the Major Reason for the Engagement

Activity	Frequency	%	Major Reason for engagement
Bathing in the lake	1	0.67	Nearest source of water
Easing of oneself in the lake	11	7.33	Lack of toilet facilities in the area
Littering in and around the lake	5	3.33	No waste bin or rubbish dump
NA	61	40.67	NA
Fishing of smaller fishes	17	11.33	Due to little catch of bigger fishes
Usage of chemicals for farming	13	8.67	To boost production
Washing along the lake shore	16	10.67	Nearest source of water
Livestock drinking directly from the lake	7	4.67	Nearest source of water
Building in the buffer zone	6	4	Land Inheritance
Illegal logging and lumbering	13	8.67	Charcoal production

Source: Field data (2022)

Community Peoples' View on the Importance of Restoring Water Quality, Soil Retention, Habitat Provisioning and Recreational Use Ecosystem Services of the Area

The respondents consider water quality as their most important restoration program (95.33) as it is their nearest source of water and their livelihood depend on it. Habitat provision (52.67%) and soil retention (52.00%) were also most important to majority of the respondents (Table 4).

Table 4: Community Peoples' View on the Importance of Restoring Four Selected Ecosystem Services

Variable	Most Important Frequency (%)	Very Important Frequency (%)	Important Frequency (%)	Least important Frequency (%)
Water Quality	143 (95.33)	6(4.00)	1(0.67)	
Soil retention	78 (52.00)	67(44.67)	5(3.33)	
Habitat Provision	79 (52.67)	20 (13.33)	47(31.33)	4(2.67)
Recreational Use	64 (42.67)	51(34.00)	5(3.33)	30(20.00)

Source: Field data (2022)

Analysis of Communities' WTP Amount for the Proposed Restoration Programme and Mode of Payment

To establish a potential payment for the restoration program, respondents were asked if they were willing to pay for the restoration program, 78.67% said Yes while 21.33% said No (Table 5). For those who said No, 56.25% had unemployment as their reason, 25% said it was government's duty and 18.75% said they live on low income (Table 6). The average amount respondents agreed on paying monthly is GH¢20.55 pesewas, i.e. twenty Ghana cedi and fifty-five pesewas (Table 7).

Table 5: WTP for the Restoration Programme

Respondents' willingness to contribute financially to the program	Frequency	Percentage
Yes	118	78.67
No	32	21.33

Source: Field data (2022)

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Table 6: Reasons for Unwillingness to Pay for the Restoration Programme

If No, Give Reason	Frequency	Percentage
Unemployed	18	56.25
Government duty	8	25
Low income	6	18.75

Source: Field data (2022)

Table 7: Descriptive Statistics of WTP Amount Respondents will be Willing to Contribute Monthly for the Restoration Programme

Variable	Mean	Standard deviation	Minimum	Maximum
If yes, State amount (GHC)	20.55	27.33	0	100

Source: Field data (2022)
NB: Assume No WTP = Ghc0.00

The total monthly WTP amount respondents are willing to contribute for the restoration program was also calculated on community basis. The analysis in (Table 8), shows that the community with the least total amount to be paid under the restoration program is Duase with an amount of GH¢77.00 and the community with the highest total amount to be paid is Abonu with an amount of GH¢480.00.

Table 8: Total WTP Amount Respondents in Various Communities were Willing to Contribute Monthly for the Restoration Programme

Communities	Number of Respondents	Total Amount (GH¢)
Abonu	10	480.00
Obo	10	150.00
Amakom	10	95.00
Apewu	10	145.00
Atafram	10	169.00
Detieso	10	340.00
Brodekwano	10	87.00
Duase	10	77.00
Adwafo	10	175.00
Juaman	10	160.00
Abaase	10	240.00
Esaase	10	312.00
Pipie	10	97.00
Nkawi	10	270.00
Ankasi	10	285.00

Source: Field data (2022)

Using the ordinary least square method (OLS), the question on, have you in any way disturbed the ecosystem, knowledge of the products and gender were identified to be positively significant (Table 9). NB: $\alpha = 0.05$. Multicollinearity test carried on the independent variables shows no collinearity exists among them as the variance inflation factor (VIF) for the independent variables is less than 10. Multicollinearity exists if VIF > 10.

Table 9: Multiple Regression Model Estimates of Factors Influencing the WTP Amount (Gh¢) Respondents were Willing to Contribute Monthly for the Restoration Programme

If yes, Amount (GHC) WTP	Coefficient	Standard Error	T	P> | t |	95% Conf.	Interval	Collinearity Statistics Vif
Disturbed the ecosystem	12.88	4.07	3.17	0.00	4.84	20.92	1.08
Awareness of products and services the area provides	15.18	8.15	1.86	0.07	-0.94	31.30	1.13
Gender	8.05	3.86	2.09	0.04	0.43	15.67	1.01

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Household size	-0.19	1.17	-0.16	0.87	-2.50	2.12	1.12
Age	0.27	0.16	1.66	0.09	-0.05	0.58	1.22
Level of education	1.95	1.69	1.15	0.25	-1.39	5.28	1.03
Annual income	0.00	0.00	5.36	0.00	0.00	0.00	1.08
Community	-0.19	0.45	-0.44	0.66	-1.08	0.69	1.03
Occupation	-0.06	1.29	-0.05	0.96	-2.60	2.49	1.15
_cons	-24.89	13.51	-1.84	0.07	-51.60	1.82	

NB: Number of observations = 150, F (9, 140) = 7.06, Probability > F = 0.00, R-squared = 0.31, Adjusted R-squared = 0.27, Root MSE = 23.39
Source: Field data (2022)

Mode of Payment
The study further analysed which mode would be convenient for the respondents to pay the monthly amount (Table 10). Approximately 44.67% of the respondents selected cooperative association since the communities already have a history of built and trusted cooperative societies, they choose that medium of payment where payment will be in a form of Susu collection. NB: None of the above means number of people unwilling to pay.

Table 10: Mode of Monthly Payment for the Restoration Programme

Mode of payment	Frequency	Percentage
Market tolls	33	22
Head tax	18	12
Cooperative association	67	44.67
None of the above	32	21.33

Source: Field data (2022)

Discussion
In the Lake Bosomtwe Ecosystem, the structure and function of the ecosystem serves as a source of livelihood to the community. The Lake is a national assert and therefore, it's protection and security is paramount to the state at all levels of concerns, as such, authorities have to strategize a way to ensure that the Lake and its surrounding areas are protected.

Activities That Respondents Engage in at the Area That Validates Existing Knowledge of Activities Disturbing the Lake Bosomtwe's Ecosystem
Local communities in Africa depend heavily on ecosystem services for their livelihoods, such as subsistence agriculture, fishing, hunting and the extraction and processing of non-timber forest products like snails, honey and medicinal plants (António *et al.*, 2016), freshwater bodies are significantly threatened globally, which had led to a decline in their areas by 64% from the year 1977 to 2011 (Dodds *et al.*, 2013). Human activities have severely affected the condition of freshwater ecosystems, to a point where many freshwater species are facing rapid declines or extinction (Peters *et al.*, 2006). Various anthropogenic activities are threatening the biodiversity of rivers and the water systems associated with them (Kikkas & Kulik, 2018). Demand for both freshwater and marine fish will expand because of increasing human population and changing food preferences (Reid *et al.*, 2005).
Amu-Mensah, (2020) posits that, the current state of freshwater resources is continuously being threatened by overpopulation, climate change vulnerability, increasing demand, exploitation and degradation through anthropogenic activities. This is confirmed by Makwinja *et al.* (2021) where he stated that, Some threatening yet unavoidable factors such as the rapid growth of human population, climate change, and increasing demand for food and other resources including economic development have increased beyond measure, exceeding the capacity at which these freshwaters can provide ecosystem services to the local communities and the world at large.
In Lake Bosomtwe surrounding communities, Farming and fishing are the main livelihoods for the twenty-four indigenous communities around the edge, so the lake and its catchment area are an economically significant part of their existence (A ROCHA, 2013). This might be a reason for the finding in this study where fishing of smaller fishes is the major activity (11.33%) respondents use to disturb the lake. This is confirmed by Darko *et al.* (2017) who reported that, the 24 communities around the lake, rely heavily on fishing for income and food, as well as water for household use and farm irrigation.
Another reason for fishing of smaller fishes might be the desire to serve the ever-increasing population. This is confirmed by António *et al.* (2016) who stated that, the increasing population around the lake is leading to more and more fish being taken from the lake, resulting in overfishing and that, the sizes of fish being caught presently are becoming increasingly smaller resulting in the use of net mesh sizes as low as mesh size of mosquito

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nets which is 2mm, with the obvious impacts of non-selective fishery.

Washing along the lake's shore was second major activity respondents are engaged in that disturb the lake's ecosystem. In a study by (Boamah & Koeberl, (2007) at Lake Bosomtwe, he confirmed that, Clothes are washed with detergents in the lake water and also at the bank of the lake shore where the used water is eventually thrown into the lake.

Nketia *et al.* (2016) reported that there is a presence of fecal coliform in the lake, a bacterium which can only be found in the feces of both animals and humans as they aid in the digestion of food. This can be confirmed by this finding where 7.33% of the respondents who said Yes, they disturb the Lake by easing of themselves in and around the Lake.

Bathing in the lake is also another activity respondent reported of engaging in to disturb the Lake. A study by Boamah & Koeberl, (2007) at the area confirms that some of the people in the community bath with soaps in the lake water and fishermen wash their nets with soap in the lake.

Littering in and around the lake is another activity disturbing the Lake ecology. This is confirmed by a study in the area where it was mentioned that, plastics bags, cans, and bottles as well as biodegradables such as leftover food, pieces of paper, and pet excreta are common sight along the roads, on the beaches, and on the outer rim of the lake (Mohammed, 2018).

According to Mateo-Sagasta *et al.* (2017), agriculture, which accounts for 70 percent of water abstractions worldwide, plays a major role in water pollution. This study affirms that of Mateo-Sagasta *et al.* by reporting of some respondents answering that they are engaging in the usage of chemicals for farming. It must be noted that, agriculture is the primary occupation in the Bosomtwe District which employs 62.6% of the district's labor force with crop farming and fishing, respectively, constituting 57.4% and 5.3% (Yamba *et al.*, 2017). Since. Studies show that the lake environment is surrounded by steep hills (António *et al.*, 2016), and that, the parts covered by farmland are found closely around the lake and on hilly areas (Anim *et al.*, 2013). These chemicals washed down the lake contributes to contamination and eutrophication. This is confirmed by Boamah and Koeberl, (2007) where his study at the area reported that, the increasing use of pesticides in farming, as well as the input of anthropogenic pollutants during the past decade most likely has already resulted in the fish being contaminated in the Lake with various chemicals.

Some respondents also said to be engaging in livestock rearing whereby they allow the animals to drink directly from the Lake. This is confirmed by Mohammed (2018) where he posits that, around the lake basin is a large population of livestock such as cows, goats, and sheep in the various communities. These animals graze and drink from the lake defecating along its banks. He continued that, it is most probable that large portions of the dung (made up of phosphorus and nitrogen) gathers close to the shore and are finally drained into the lake when it rains. This is also agreed by Amu-Mensah *et al.* (2018) where he reported in his study in the area that, in the case of animal rearing, fecal materials from sheep, dogs, pigs, ducks and fowls are washed into the lake during rain events, consequently increasing the organic matter load in the lake.

Building in the buffer zone, in agreement to this act which some respondents are into is a study that was conducted at the area that reported that, currently, the aquatic biodiversity in the Lake Bosomtwe is in a deplorable state due to human activities such as illegal housing construction (Mohammed, 2018).

Illegal logging and lumbering are the other responses given which is disturbing the Lake's ecosystem. This is confirmed in reports whereby the rampant and uncontrolled destruction of trees and forests on and along the hills has left in its trail bare land and gullies and, at best, grasslands (Yesutanbul *et al.*, 2021). These illegal operations are carried out at nights and in the middle of the forests and forest reserves, ostensibly to hide from the forest guards (Kyere-Boateng & Marek, 2021).

To confirm to occurrence of disturbing activities degrading ecosystems in and around other water bodies such as is reported in this research, Isaac *et al.* (2021) reported other instances where, many anthropogenic activities including gold mining, water withdrawal for human uses, use of small-mesh fishing nets, overfishing, industrial waste discharge, pesticides use for agricultural purposes along watersheds, obnoxious fishing practices and increase in human population, were listed by fishermen as other stressors contributing in depletion of Ivorian freshwater fish abundance. Also, Malawi where, rapid population growth, infrastructure developments (increased inflow from human settlements and industries), agricultural activities (unsustainable farming systems and heavy use of fertilizers in the upland catchments of the lakes), and climate change have been linked to freshwater ecosystems degradation (Makwinja *et al.*, 2021), can be said of Ghana where, intensification of agricultural activities in the Lake Bosomtwe Basin and a sudden rise in the chain of hotels and other tourism facilities have resulted in an increase in the pollution of the lake (Prakash *et al.*, 2005).

Major Reasons for Respondents' Engagement in Activities That Disturb the Ecosystem of Lake Bosomtwe

There are three main types of agricultural practices practiced by Lake Bosomtwe local communities: crop farming (food and cash crops farming), fishing and animal husbandry (BDA, 2020). Aquatic flora and fauna are endangered by human-induced activities and climate risks such as habitat alteration, poaching, pollution, over-harvesting, loss of soil fertility, landscape degradation, landscape dynamics and others (Bani & Damnyag, 2017). To identify major reasons for people engaging in activities disturbing the ecosystem of the area, the Lake been the

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Nearest source of water was the respondents influencing factor for engaging bathing in and around it, washing of clothes in and around the Lake as well as livestock owners allowing their livestock to drink in it. To confirm to this is the study by Mohammed (2018) which posits that around the lake basin is a large population of livestock such as cows, goats, and sheep in the various communities. Mohammed confirms further that, a significantly high number of the keepers extensively graze their animals within the Bosomtwe Basin. This is agreed by Boamah and Koeberl (2007), who reports that, because of their large numbers, their impact on the lake is substantial.

Another influencing factor by some respondents is the lack of toilet facilities in the area so the resort to easing of themselves in and around the Lake. This has really affected the environmental health of the area.

No waste bin or rubbish dump is an influencing factor leading respondents to resort to litter in and around the lake. Confirming to this is a study that reported that, the hitherto pristine environment of the Lake Bosomtwe Basin has been despoiled by the incessant littering, especially during the public holidays peak periods (Mohammed, 2018).

Due to little catch of bigger fishes they resort to fishing of smaller fishes. This can be due to the high number of fishing folks at the area which according to Mohammed (2018), there are about 1000 fishermen operating in Lake Bosomtwe. A study by Isaac *et al.* (2021) confirm to other similar ecosystems in Benin and the Volta region, where overfishing was reported to cause changes in fish community structures and distributions, fish abundance reduction was reported as a consequence of climate change and several anthropogenic activities (Isaac *et al.*)

To boost production they resort to usage of chemicals. To confirm to this finding, Mateo-Sagasta *et al.* (2017) reported again in his study that, farms discharge large quantities of agrochemicals, organic matter, drug residues, sediments and saline drainage into water bodies. Some respondents' claim of inheriting the lands in the buffer zone, they therefore undermine it by building in it. This might be the reason for several developments around and closer to the Lake. Otu (2010) reported that, the expansion of hotels and guest houses has been increasing: Lake Inn, Paradise Hotel, Lake Point, Rainbow Gardens and a new equestrian hotel, with many more anticipated. Mohammed (2018) also asserts that, the springing up of hotels, lodges, and camps in the lake basin each with its separate septic tanks and sewage collection receptacle respectively is likely to increase the potential for ground water pollution.

Charcoal production was responded to be an influencing factor for the resort to illegal logging and lumbering. This can be confirmed by Yamba *et al.* (2017) who reported that, the next highest alternative livelihood activity is charcoal production accounting for 11% of alternative activities and that, abundance of trees suitable for charcoal production was found to be the prime driving force for the practice. From the period 1st March to 30th August, 2021, there were 32 reports of harmful farming activities (clearing vegetation less than 30 meters from the water body) and 16 reports of charcoal burning around the riparian vegetation (Yesutanbul *et al.*, 2021).

Community Peoples' Views on the Importance of Restoring Water Quality, Soil Retention, Habitat Provisioning and Recreational Use Ecosystem Services of Lake Bosomtwe

River basins, lakes etc. are major sources of ecosystem services from which the society benefits from. They offer ecosystem services such as aesthetic, cultural, provisioning, regulating and supporting services (Makwinja *et al.*, 2021). These freshwater lakes provide biodiversity and economic value, which include goods and services that are important for the survival of humankind (Makwinja *et al.,* 2021). Lake Bosomtwe has been a source of socio-economic livelihood for thousands of people living in the three districts of Bosomtwe, Atwima Kwanwoma, Bosome Freho District and the Bekwai Municipality (Adu-Boahen., 2017)

The lake is a highly productive biological system, providing water for consumption, fishing, irrigation, recreation and other domestic, agricultural and recreational uses (Rocha, 2013). The use of water for agriculture, tourism, water cooling for small breweries are of great importance in terms of the amounts of water used, as well as the fish catch from the Lake for sale (Amu-Mensah *et al.*, 2017). The aforementioned indicates that, the biodiversity and economic value of freshwater lakes ecosystems are more important than many terrestrial ecosystems (Makwinja *et al.*, 2021). In measuring WTP, the value of goods and services is measured based on the importance of the goods and services for consumers and their preferences and choices (Kokoye *et al.*, 2018)

To determine community peoples' views on the importance of restoring water quality, soil retention, habitat provisioning, and recreational use ecosystem services of the area to the community members, respondents agree that the water quality of the lake is the most important ecosystem service to be restored in the area. This is highlighted in the work of Nketia *et al.* (2016) who stated that, good and quality water availability is an important feature to aid in the prevention of diseases and to improve the quality and productivity of life. Respondents' choice of quality of water as been their most important ecosystem service agrees with that of Asamoah *et al.* (2015) who stated in his study that, it is essential for the development and sustainability of every nation and very important for the growth of humans.

Respondents choice of quality of water might also be born out of their awareness to the changes in the water quality since the question on, have you in any way disturbed the ecosystem was positively significant, where also, different studies have ascribed to its degradation. For instances, Prakash *et al.* (2005) posits that, When it rains, surface runoff water washes away the soil nutrients and all the streams in the farmlands flow

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directly into the lake, causing enrichment of the lake water (eutrophication). From Dubois *et al.* (2017), he confirms that, human activities also impact negatively on the quality of water bodies, thereby limiting the scope of its usage, it commonly affect the distribution, quantity, and chemical quality of water resources. Also Nketia *et al.* (2016), confirms that the alkalinity and pH levels of the Lake Bosomtwe is slightly higher than normal and should be regularly checked.

Habitat provision was the next major ecosystem service respondents choose as an important restoration program. This might be because the Lake basin serves as the residence of the local community. Yesutanbul *et al.* (2021), reported that, The 24 villages, comprises a total population of 11,800 people (the average size of a village is 500 people) along the 32km shoreline of Lake Bosomtwe. Amu-Mensah (2020) agrees that, a freshwater body is a natural resource for the sustainability of human life and that freshwater resources provide prime areas for human settlement, commercial activities for income generation and habitation for other living things.

Approximately 52% of the respondents chose Soil retention as important ecosystem service to be covered by the restoration program. This might be due to their farming activities. This study therefore agrees with Mohammed (2018) and Boahen *et al.* (2014), which states that, the major economic activities among the communities surrounding Lake Bosomtwe is fishing in the lake and farming on the steep crater slopes which provide them with their livelihood. Several studies also conclude that, people living along Lake Bosomtwe Basin in Ghana rely largely on fishing in the lake and farming on the marginal lands (Boahen *et al.*).

For recreational usage, the 42.67% of respondents who chose it as an ecosystem service to be covered might be due to their interest in the booming tourism activities in the area. This is confirmed by Nketia *et al.* (2016), who stated that, the lake is the habitat for large number of aquatic species and serves a great deal of recreation and tourism activities. To confirm to this, Mohammed (2018), reported in his study that, the lake is endowed with many tourist attractions which include: the biggest natural lake in West Africa and a vital geological heritage site, the best-preserved young complex meteorite impact crater in the world as deemed by UNESCO, a unique and very attractive position in a virgin forest zone, rich geological and biodiversity information, the main lake for its recreational and aesthetic qualities. Mohammed, posits that, protection of Lake Bosomtwe environmental assets enhances the attractiveness of the Lake Bosomtwe Basin as a tourist destination, on the other hand, their destruction erodes the natural and aesthetic appeal of the basin and thereby debases it as an attraction.

The negative side of the tourism activities might have contributed to the substantial percentage of respondents (20%) choosing that, recreational use is least important to consider in a restoration program since they might be aware of the degradation caused to the ecosystem of the lake by tourism activities. To confirm to this, Prakash *et al.* (2005), reports of sudden rise in the chain of hotels and other tourism facilities have resulting to an increase in the pollution of the lake. A study by Mohammed (2018), posits that, the hitherto pristine environment of the Lake Bosomtwe Basin has been despoiled by the incessant littering, especially during the public holidays peak periods. Plastics bags, cans, and bottles as well as biodegradables such as leftover food, pieces of paper, and pet excreta are common sight along the roads, on the beaches, and on the outer rim of the lake. He continued that the springing up of hotels, lodges, and camps in the lake basin each with its separate septic tanks and sewage collection receptacle respectively is likely to increase the potential for ground water pollution.

WTP Amount for the Degraded Lake Bosomtwe Ecosystem Restoration

Lake Bosomtwe 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 (Anim *et al.*, 2013). Any water system is an inseparable part of the environmental system as a whole and that the societal and environmental systems are inextricably bound up with each other as well (Hoekstra, 2006). The high level of unsustainable human interaction with this sensitive ecological area suggest that there is an urgent need to place emphasis on geo-ethical thinking as far as the protection of the natural environment is concerned and in particular around Lake Bosomtwe as a designated Biosphere Reserve (Yesutanbul *et al.*, 2021).

Lake Bosomtwe is home to a diverse biological ecosystem, contributes to the Gross Domestic Product (GDP) of Ghana, and supports the livelihoods of its local population. However, the lake's ecosystem service values have declined as a result of rapid population growth, increased poverty, landscape transformation, and overexploitation, impeding efforts to achieve UN SDGs such as life underwater (SDG 14), life on land (SDG 15), climate action (SDG 13), no poverty (SDG 1), and Aichi Biodiversity Targets.

The effort to manage the lake's ecosystem services is hindered by the community's lack of knowledge and experience with the restoration concept. If the problem is not addressed, the lake's ecosystem degradation will inevitably worsen and have a negative impact on the local communities that rely on it for survival. It is anticipated that poverty will rise and livelihoods will be lost if the lake and its buffer are not protected, since the surrounding communities rely heavily on the ecological services provided by the Lake Bosomtwe for existence

Due to the indispensable roles and relevance of aquatic biodiversity, there is an urgent need to conserve and sustain them (Adom, 2018). It is important to ensure that efforts be made to improve water resources management and services over the best long term (Jim *et al.*, 2020). Ecosystem restoration entails activities aimed at restoring

degraded ecosystem services in order to stop biodiversity loss, ensure ecosystem resilience, maintain vital ecosystem services, promote human health and well-being, and alleviate poverty (Makwinja *et al.*, 2021).

To determine the WTP Amount for the Lake Bosomtwe Ecosystem Restoration Programme, different individuals and communities expressed different views towards the proposed lake ecosystem restoration program. These varying views were linked to the importance of ESs derived from the improved lake ecosystem, and the results were reflected in varying WTP responses and amounts. About 78.67% of the sampled households were willing to contribute a mean sum of GH¢20.55 pesewas, i.e. twenty Ghana cedi and fifty-five pesewas household/month-a scenario also depicted in other freshwater ecosystems across the globe such as the WTP amount for the ecological restoration of an inland freshwater shallow lake: Case of Lake Malombe, Malawi was a mean lump sum of US$28.42/household/year (Makwinja *et al.*, 2021).

The results show that, there is high WTP for restoration of degraded Lake Bosomtwe ecosystem by the local communities in general in the study area (Table 7), and particularly in Abonu which is the community with the highest sum total to be paid with an amount of GH¢480.00. This implies that, community members in Abonu are more prepared to be involved in the restoration program unlike that of Duase which is the community with the least sum total of GH¢77.00. It could be that, the people of Abonu are more willing to pay due to the direct benefit that they stand to get, such as the improved quality of water and recreational usage that would enhance their tourism business.

The question on, have you in any way disturbed the ecosystem and gender, were identified to be positively significant at p = 0.00 and 0.04 respectively (Table 9).

Gender was positively significant probably because males made up a significant proportion of respondents than females and represented significant beneficiaries of the lake's ecosystem services compared to women. Observations showed that almost all of the gear owners and fish crew members in Lake Bosomtwe are males. Makwinja *et al.* (2021) and Adongo *et al.* (2020) also showed in their studies that the gender of the respondents influences the decision to participate in restoration programs positively. On the other hand, Nicosia *et al.* (2014), found gender to be not significant in his study.

Age displayed a positive relationship, suggesting that the youth were mostly willing to pay since the mean age was 33. Makwinja *et al.* (2021) also showed that, the age of the respondents influences the decision to participate in restoration programs positively. On the other hand, Nicosia *et al.* (2014): Study on determining the WTP for ecosystem service restoration in a degraded coastal watershed, demographic age was found to be negatively related and was not included in the final model.

The study found that awareness of the products and services the area provides was positively related. These individuals were more willing to pay than their counterparts. A similar observation was made by Makwinja *et al.* (2021) in Malawi. The respondents annual income had a statistical significant impact of zero unlike the observation of Makwinja *et al.* (2021) and Adongo *et al.* (2020), in their various studies, they attained positive significance.

Almost 78.67% of the respondents were willing to pay for a restoration because they believed the proposed program would improve the ESs. Their response resulted from the influence of the awareness of the degradation of the natural resources in the catchment. However, those who view the proposed program as important suggested that successful implementation of the program will improve quality of water, provide habitat, soil retention and recreational usage which will improve their livelihood.

On the other hand, 21.33% of respondents who said "No" had unemployment and living on low income as their reason. Makwinja *et al.* (2021) suggested that, low-income households are linked to over-dependency on ESs, government, and Non-governmental Organizations' food aid are perfect example of socioeconomic traps in which households cannot find enough resources to overcome the shock and consequently fail to participate in restoration programs. Creating temporary jobs that focuses on restoring the lake's ecological status could create incentives for this group of people and stimulate them to participate in the ecosystem restoration program. Approximately 25% of the respondents unwilling to pay pushed the responsibility to the government.

Acceptable Mode of Payment

About 44.67% of the respondents' selected cooperative association since the communities according to the respondents already have a history of built and trusted cooperative societies, they choose that medium of payment where payment will be in a form of Susu collection.

About 12% chose Head tax, was the least choice medium of payment. According to the respondents, they did not want to hear the word tax since that has been so much in recent times. Also, they think such medium of payment leave the funds in the hands of government where issues of mistrust and accountability may disturb cooperation.

CONCLUSIONS

This study provides both theoretical and practical insights into the diverse perceptions of individuals regarding the degraded lake's ecosystem services (ESs) and their responses to restoration initiatives. It highlights the integration of science and policy as a means to achieve a sustainable flow of ESs. There is clear evidence that the current state of the lake's ecosystem has implications for the attainment of Sustainable Development Goals (SDGs) and Aichi Biodiversity Targets. This study's insights serve as a valuable reference for the restoration of fragile inland freshwater lakes globally, contributing to national, regional, and global policy frameworks.

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The main objective of this study is to assess local community's WTP for restoration of degraded Lake Bosomtwe ecosystem of Ghana. To achieve this, the main objective was simplified to four specific objectives:
To identify activities that respondents engage in that disturb the ecosystem of the area that validates existing knowledge of activities disturbing the ecosystem of the lake, and their reason for doing so. Descriptive statistics, frequencies and tables were used to achieve it. It was identified that fishing of smaller fishes (11.33%) is the major activity respondents engage in to disturb the lake's ecosystem. Washing along the lake shore and easing of oneself in the lake are the next major disturbing activities caused to the lake by community members.
To determine major reasons of the people engaging in activities that disturb the ecosystem of the area, their reason for fishing of smaller fishes is due to little catch of bigger fishes. Their reason for washing along the Lake and easing of oneself around the Lake was that, the lake is their nearest source of water and toilet facilities situated far from their residence respectively.
To determine community peoples' views on the importance of restoring water quality, soil retention, habitat provisioning, and recreational use ecosystem services of the lake's area to the community members, the members were asked to rank from most important (1) to least important (4) which ecosystem service was important to them. Majority of the respondents selected water quality as the most important ecosystem service to be restored.
To determine local community's WTP amount and mode of monthly payment for the restoration program, majority of the respondents are willing to contribute an average amount of Ghc20.55 every month through cooperative association to ensure the commencement and successful implementation of the restoration program.
The study area was purposively selected for this study since it is the housing area of the Lake Bosomtwe. Amongst the communities in the district, 15 communities were selected using convenience sampling. These communities selection was influenced by accessibility since some had transportation issues and others difficult to visit due to rain
This study focuses on the ecological challenges that the lake and its surrounding communities is facing in the use of the ecological services. It also investigates respondents' WTP for the restoration of degraded Lake Bosomtwe ecosystem. Cochran's formula was used to calculate the sample size because the population of community members was unknown. Although, the expected sample size given by the Cochran's formula is 385 respondents, only 150 questionnaires were administered due to time and financial constraints. Convenient sampling was used to select 10 respondents from each community due to the situation where most of the community people were complaining that after responding to several survey questionnaires in the area, they were yet to have an impact, therefore, their refusal to accept to respond to such surveys. Ten (10) respondents each from a community was to ensure that the survey had an equal representation of respondents' views from each selected community.

RECOMMENDATIONS

1. It is recommended that efforts be made to ensure that waste bins are placed at vantage points around the lake to control lithering. This is significant because the people interviewed expressed lack of bins around the lake which is a contributing factor to the dirtying of the lake's shore. Having the bin is critical to the success of any restoration project around Lake Bosomtwe. Lack of the bin can make it difficult to control lithering especially on festive occasions.
2. Furthermore, more research is needed to fully comprehend the positive effects of adopting sustainable land use practices in and around Lake Bosomtwe environs. Such evidence and data would aid in the passage of enabling legislation that would promote sustainable land-use practices as a means of protecting the lakes' ecosystem.
3. Additionally, it is recommended that education on environmental protection at the community level be enhanced in the local dialect. Demonstration of practices should be done where possible, visuals should be included in all signposts to assist in the assimilation and understanding of what is being taught. Moreover, members in the communities should be actively included in environmental service demonstrations as this will boost their confidence and give them the autonomy to make right decisions to protect the lake's environment.
4. Moreover, non-governmental organisations and other government agencies should partner and fully participate in restoration activities to ensure a long-term sustainable project for the benefit of the present and future generations. This emphasizes the importance of engaging in a practical debate by all stakeholders to establish a consensus on Lake Bosomtwe Ecosystem restoration.
5. Lastly, while the proposed program garnered mixed views among local communities with 78.67% supporting the WTP concept and 21.33% opposing it, the research suggests that without a thoughtful debate, the restoration effort risks being perceived as a top-down approach, leading to strong resistance from local communities.
6. The findings underscore the necessity of inclusively addressing the broader interests and concerns of the local population in policy formulation, as this significantly shapes their support for the WTP concept in the proposed ecosystem restoration program.

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