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The role of water bodies in environmental enhancement and local development: A case study of Bagmati Fishery Pond

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Abstract
The increases in urbanization have kept tremendous pressure on environment resulting in need of proper plan to protect the environment. Similarly, with urbanization there is need for potential economic generating sectors and sustainable development of such area. During such instances, Lake ecosystems can be used as one of the incentives to foster environment balance as well as promote economic and physical development surrounding the area. This paper is conducted not only to understand but also to validate that an artificial lake can enhance environment and local development around the vicinity of lake. For this, an artificial lake located in Bagmati municipality of Sarlahi district, Bagmati Fishery Pond, also commonly known as Bharat Lake, is considered as the study area. This research used various techniques such as survey, interview, through observation, municipality data etc. in order to analyze environment, economical development, physical development as well as understand people's perspective of lake enhancing environment and developing urban areas. Therefore, both qualitative as well as quantitative method of data and information collection were used. The development of locality before and after construction of lake was also studied to observe the change brought by lake. The study showed that although the lake is still in construction phase, it has been able to provide employment opportunity, enhance economy of overall municipality, increase development around the area as well as make the surrounding climate and environment much more livable. Hence, this Lake have been able to enhance the environment as well as promote development round the area where there was barren land with no infrastructure at past.

Keywords
Urbanization, Environment, Development, Artificial, Infrastructure

1. Introduction

The balance of the environment and the well-being of communities are at risk due to the tremendous ecological challenges brought on by rising urbanization and human activity. Water bodies including lakes, rivers, and ponds are crucial in this context for regulating local habitats and promoting sustainable development. Lake, which is a large depression of freshwaters on Earth that is bordered by land and may be standing still or moving slowly, is one of the most essential parts of an ecosystem which contributes in enhancing the environment by changing the atmospheric condition near the vicinity. Small bodies of water causes local modification to the environment which are generally insignificant while large bodies of water such as lakes, cause major significant effect on climate and environment ranging from the microscale to the synoptic scale [1].

Generally, for people residing on developing countries, their major source of social well beings, economic dependencies and livelihood depends upon the goods and services available from different ecosystem including Lake Ecosystem [2]. Further, this ecosystem contribute to the development of local as well as national development through economic generation, enhancing in-migration, increasing social cohesion, adding toward tourism etc. Following the identification of importance of Lake Ecosystem to local and national development, there have been increased interests in development of new artificial ecosystem like lake and wetlands for supporting livelihood surrounding the water ecosystem [3] .

Lake constructed by human to fulfill their needs and demands are artificial lakes, also known as man-made lakes or reservoirs. These lakes are constructed for a variety of reasons such as for hydropower generation purpose, water storage, agriculture, irrigation, naturalistic purposes, recreational activities, hobbies like fishing, boating, and other outdoor pursuits including natural history, bird watching, painting and walking etc [4].

The maximum temperature has been increasing at rate of 0.05 degree Celsius per year for summer in our country making life difficult. Similarly, the maximum temperature during winter have been decreasing while mean annual maximum temperature have already reached above 30 degree Celsius in terai region. The coolness provided around the water bodies with tranquility makes people feel a profound emotional connection to water [5]. As a result, the majority of bodies of water within developments can be utilized as marketing tools to establish the new emerging center. Furthermore, artificial lake helps in changing physical state of the locality through improvement and transformation of the built environment via construction of new structures such as roads, bridges, buildings, parks etc. Similarly, these lakes attract new population which results in accumulation of different culture enhancing diversity.

Bagmati Fishery Pond also commonly known as Bharat Lake is the second-largest artificial lake in the nation and is located in the Bagmati municipality of the Sarlahi district in Nepal's

Mahendra Pradesh. After the construction of this lake, there have been waves of new development work around the lake surrounding. New markets have arises revolving around the benefits obtained through Lake Ecosystem. Further, the environments have been positively influenced by lake but the lake has been polluted as a result of throwing garbage in lake, improper management, boating etc. This is so as lakes are common resources (positive externalities): people tend to use these resources collectively but are not willing to pay for these resources either collectively or individually making it undervalued and overused. Hence, a comprehensive study to understand the influence of the lake on environment enhancement and local development along with people's perspective of lake was necessary for sustainable management and development of the lake: the research was conducted.

2. Objective

The objective of this research is to analyze the role of water bodies in environmental enhancement and local development taking case of Bagmati fishery pond.

3. Literature review

Lake Defination

Lake is a natural depression that is surrounded by land from most sides and contains freshwater. Generally, in mountain region, at some place natural basin are formed with impervious beds. Water from springs and streams generally flows toward the basin ad lake are formed. Lakes in Nepal are commonly called Pokhari, Tal, Rah, Dah, Kund etc. Additionally, a lake may be isolated, with no apparent direct water input and, occasionally, no apparent direct discharge. These remote lakes are frequently salty as a result of groundwater intrusions or evaporation. Anywhere in a river basin, may have a lake depending on its source. A headwater lake is fed by numerous tiny tributary streams, direct surface precipitation, and groundwater influx rather than a single river. These lakes usually always have just one river outlet. Lakes in river basins further downstream have one major output and one major input, with the water balance from input to output fluctuating depending on other water sources.

Importance of Lake

Lakes provide necessary resources including food, water, and recreational advantages, promoting the health of both people and wildlife. Lakes regulate river flow and maintain ecosystem stability by retaining water, reducing the effects of floods and droughts. As rainwater flow is slowed by their presence, fast landslides are also prevented. Regularly spaced lakes can help to reduce temperatures and raise humidity, which helps to reduce the likelihood of wildfires. Additionally, availability of food and water in their native land (Forest), wild animals does not need to move toward community, reducing the attack of wild animals. Lakes also divert lightning strikes away from dry communities, reducing the possibility of wildfires and potential harm to populated areas. By storing water, they can control river flow, recharge groundwater, increase natural beauty, moderate local climates, maintain biodiversity, and enhance local beauty. By providing home to aquatic and semi-aquatic plants and animals, which in turn provide food for many terrestrial creatures, they also add to the environmental richness [6].

Economic Value of Lakes

Lakes are important resources for both communities and enterprises because they have a wide variety of economic value. These water bodies produce a cascade of economic advantages, from tourism and recreation that boost local economies through pursuits like boating, fishing, and camping, to the enhanced property prices of lakeside real estate. Additionally, lakes offer vital water resources for drinking, manufacturing, and agriculture, supporting a variety of sectors and maintaining livelihoods. Their ecosystem services, including as water filtration and flood control, and biodiversity contribute not just to environmental health but also to infrastructural cost savings.

Relation between Lake and Environment

Lake has an ability to modify the environment around the lake surrounding. The effect of large water bodies on environment depends on various factors of lake such as depth, areal extent, configuration of lake, location of lake, direction and velocity of wind flowing around lake. Through modifications to the atmospheric boundary layer, lakes have an impact on the climate because of:-

- The thermal lag of Lake Surface temperatures compared to the adjacent land areas.
- The availability of open water over lakes for evaporation, and
- Alterations of winds by lakes as a result of contrasts in surface roughness between the lake and the land surfaces. [6]

Lake on Air Temperature

On summer, the air temperature around lake area is slightly cooler then nearby area. A research done by [7] in Janakpur, a city with over 200 ponds, found that houses near these water bodies experienced a significant 2°C temperature reduction during summer compared to those situated farther away. But during winter, the vicinity around lake is slightly warmer then surrounding area.

Lake on wind

Due to less friction on water surfaces, wind speeds across lakes are higher than those over land. Wind speeds on land surrounding lakes are highest close to the shore and decrease further inland when friction slows the wind [1].

Lake as common resources

Any resource that offers people tangible benefits but that nobody in particular owns or has exclusive claim to is considered a common resource. It is free products, such as those that are commonly held by no one. Lakes are also common resources as they are used by all but are not given enough attention to promote and preserve it. These resources can be consumed by anyone without any discrimination makes these resources vulnerable toward over consumption resulting toward depletion.

Society Creating Risk

Sometime risk is induced by societies and community itself. As shown in the picture, there is a natural flow of water which is generally small but during certain period the flow increases. When a settlement starts growing in river bank, these settlements does not consider the return period of the biggest flood and grows with passing days. On certain time period, the river increases and return back to its original stage, flooding the whole settlement. Here, people are increasing risk toward themselves.

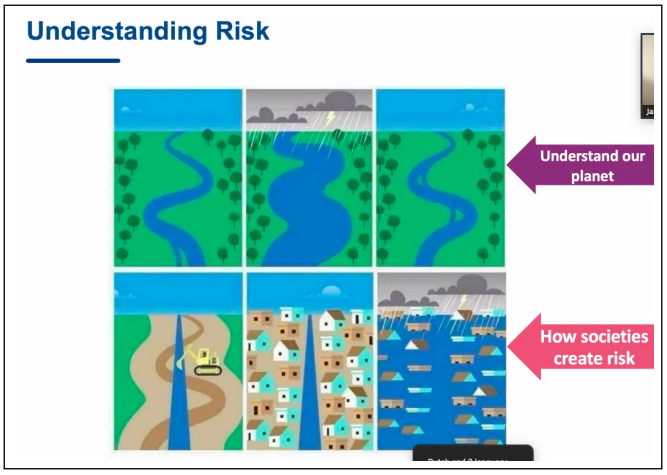

Figure 1: Risk created by society [8]

Buffer zone

Lands that are immediately next to waterbodies like lakes, reservoirs, rivers, streams, and wetlands are referred to as riparian buffer zones. Both the prevention of nonpoint source pollution and the associated water quality in neighboring waterbodies are significantly impacted by these land areas. They are therefore frequently utilized in water resource protection projects. Since the early days, different cities have had laws restricting the use of private land that is a certain distance from a river, lake, wetland, or tidal shoreline. These "setbacks" or "buffer strips" are used for a variety of reasons, including the preservation of riparian habitat and waterfront amenities as well as the protection of surface waterways from pollution and erosion. The use of setbacks has been more prominent in present days as water bodies have been constantly encroached and polluted. For instances, National Green Tribunal's (NGT), an environment protecting body of India, has increased buffer zone from 30m to 75m in Bengaluru city.

Setting up suitable landscaping near lakes and ponds can have long-term advantages in addition to improving course's aesthetic appeal. Buffer zones, for instance, help to lessen the amount of nutrients and sediment that are transported through the system and out to the watershed. There will be indirect benefits to the health of pond when buffer plants are actively filtering nutrients and the plants are adding little nutrient input to the water. The filtering of nutrients from runoff as well as direct filtration of the water from any plants that are "feet wet" will prevent the growth of unwanted plants and algae in the water.

Without a barrier separating the grass area from the lake or pond, erosion along the shoreline may happen, leading to high sedimentation rates into the water body, poor water quality, and the destruction of the original environment. A suitable buffer zone will stabilize the beach and greatly lower the likelihood of erosion-related problems. Additionally, a well-maintained buffer can serve as a useful habitat for "good" species and a deterrent to opportunistic wildlife. While allowing for an increase in the species richness around the lake, buffers can offer safe habitat for many desirable species, such as birds, frogs, and rabbits. In contrast, where there is a well-established buffer, nuisance animals is often kept away from aquatic settings. Due to their inability to observe possible predators when access to the water is restricted, geese frequently select alternate areas for breeding. In the absence of sufficient breeding places, geese frequently select other feeding grounds.

International Context

Lake on preventing flooding

Tonle Sap Lake prevents and control flooding due to Mekong River by taking water during monsoon season when rainfall is very high and act as a retention pond. This lake can be taken as an example of how a lake can prevent flooding acting as a retention pond [9]. In this same way, artificial lake can be created to be used as a retention pond near river area with high probability of flooding to prevent flooding and reduce the risk of life and property.

Bhopal Development

The capital of Madhya Pradesh, Bhopal, is a special example of how human creativity and natural beauty can coexist. The city's abundance of natural beauty, highlighted by its undulating geography and several attractive artificial and natural lakes, is what makes it so alluring attracting huge number of population. The populations of the area have been utilizing the resources from artificial lake and making their living. At present, the increase in number of population is affecting artificial lake environment creating need of proper management [10].

4. Methodology

This research method uses pragmatic paradigm which believes that there are various methods to understand and interpret the world and performing research. During the study, the problem is constantly debated, renegotiated, interpreted and finally best output is taken as the one that solves the problem. In our study, to analyze the local development and environmental state surrounding around the new constructed lake area, both qualitative as well as quantitative data were analyzed. Qualitative data include the interview, key informant interview etc. and quantitative data were obtained through survey, observations etc. Additionally, QGIS, an open source Geographical Information System (GIS) program, helps in creating, managing integrating, mapping and analyzing data to a map. QGIS is used to create buffer around the study area and further understand the lake surrounding. Both these qualitative and quantitative data are also used to understand people view toward the growing economy and development around lake.

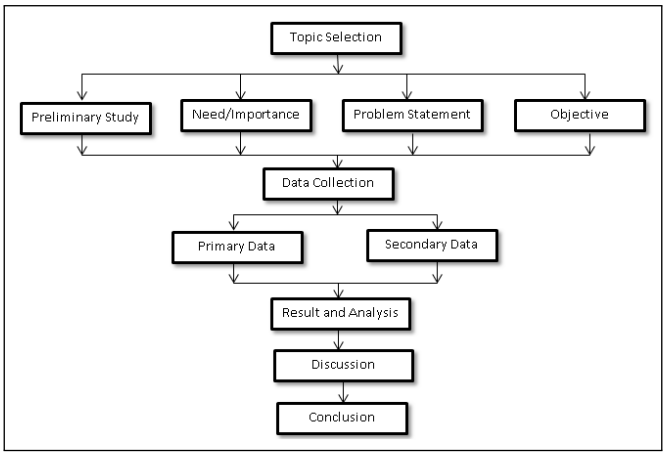

Figure 2: Conceptual framework of the research

Ontology

The ontological position of the research is that the development of artificial lake in a community will improve the environment around the area making the surrounding more livable and boost the development of locality.

Epistemology

The epistemology position of the research is that the study is a social science study about understanding influence of artificial lake on environment enhancement and local development which can be obtained through direct interaction with people as in interview, obtaining knowledge through survey, observation etc. and through secondary data sources.

5. Site Context

Bagmati Fishery Pond, second-largest artificial lake in the nation, is located in the Bagmati municipality of the Sarlahi district in Nepal's Mahendra Pradesh. This lake, which has a depth of 14 meters (45 feet) and a vast area of more than 150 bighas, is a tribute to the foresight and work of Mayor Bharat Kumar Thapa hence is also commonly known as Bharat Lake.

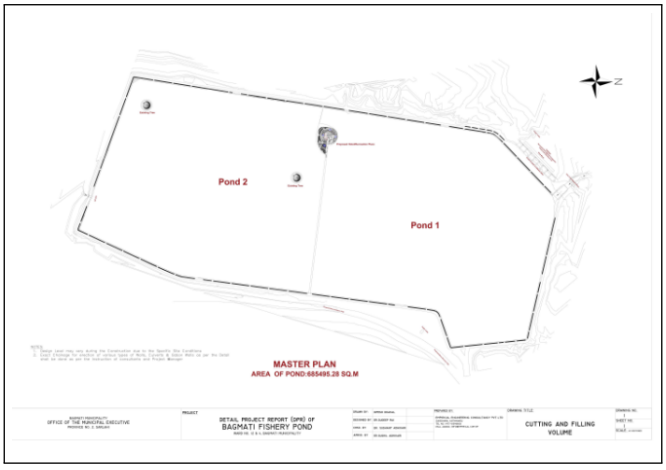

Figure 3: Plan of Bharat Lake

The lake's advantageous location from the East West Highway at Karmaiya in Sarlahi, just 1 km east of the Bagmati Bridge and 3 km south of the Bagmati Bridge, has aided in its growth as a well-known tourist destination. The construction of Bharat Lake has been a revolutionary undertaking for the area, providing both the local population and the government with a number of advantages through income generation, recreational center, improvement of environment etc. The formerly barren site has been transformed into a bustling recreational area, promoting tourism and local government and resident economic growth.

6. Finding, Data Analysis and Discussion

Sample Size

The population visiting lake is unknown as there are no data taken about number of people visiting the lake; however, people working around lake as well as official personal of lake suggested that the number of visitors ranges from few hundreds during normal days to few thousand during festive days. Hence, for the research the population is considered unlimited, confidence level taken as 95%, margin of error 10%, population proportion 505 to determine survey sample. The formula used is:

$$n = \frac{z^2 \times p \times (1-p)}{e^2}$$

where,
e = margin of error
n = sample population
z = z-score (for 95% confidence z=1.96)
p = population proportion

With calculation, the population to be surveyed was found to be 96 and so 120 visitors were surveyed.

Hence, around lake area, total of 149 sample of data were collected among which 120 of them were visitors visiting the lake, 20 were shopkeeper residing shop near lake vicinity, 7 cameraman roaming around lake, 1 owner of horse and 1 owner of camel. These surveys were conducted to understand the influence of lake on economy of people, change in climate around area as observed by people and to validate the new development waves brought after construction of lake.

Study on atmosphere

Questionnaire on temperature variation during summer among visitor suggested that around 88% believe that lake area is relatively cooler then surrounding area while 50%

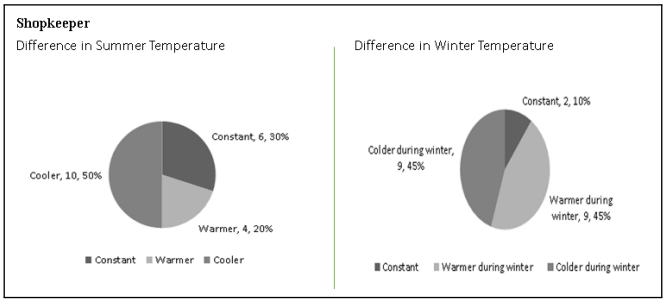

Figure 4: Pie chart showing shopkeeper perception on temperature change

shopkeeper believes that lake area is cooler. This showed that area around lake is generally cooler than other area. Furthermore, 45% shopkeeper thinks that winter temperature is slightly warmer around lake then far area from lake suggesting lake makes winter climate warmer. Similarly, around 88% visitors and 80% shopkeeper found that the intensity of wind to be greater in around lake area.

Study on economy

Questionnaire on money spent by visitors suggested on average people spent around Rs.1043 per one visit while shopkeeper earned around Rs.1300 per day during normal days while this can increase during festive days. The lake has been attracting large number of tourist from all around the country along with few from foreign country mostly from India. Similarly, the lake has been able to provide employment opportunities to more than 500 people directly and numerous people indirectly. The lake is still under construction indicating after complete construction more tourists will be attracted and more people of municipality will be benefitted.

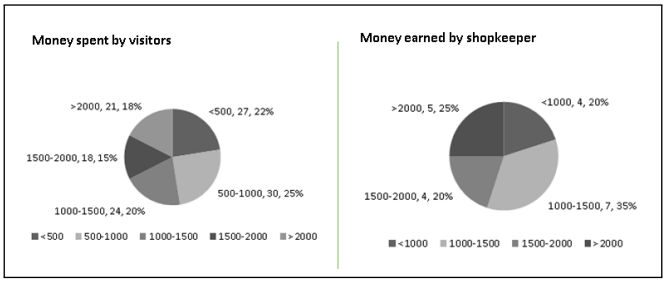

Figure 5: Pie chart showing money spent by visitors and earned by shopkeeper

The lake has been a source of economic generation for the municipality as well. The municipality collects Rs.1200 to Rs.2500 per months from shopkeeper depending on the size of shop around the vicinity of lake. Additionally, cameramen, camel owner, horse owner and other recreational activities owner also shall pay Rs.2500 per months to the municipality. Furthermore, municipality collects 20% tax from each individual riding on boat as well as sky cycle. The money collected from this taxation is further used for the welfare and betterment of lake.

Study on environment

Bharat Lake have also increased the ground water table downstream of lake to area such as Rajghat, Soltee to up to Bharatwa (which is around 10km south of lake) as suggested by Ranjit Misra and Sugan Badal, Sub-Engineers of the municipality.

Bharat lake is located along the edge of Bagmati river. This lake can act as a retention pond during small flooding protecting nearby surrounding. But during large flooding, this lake act as source of disaster. Bharat lake have attracted huge population around the lake surrounding which is a flood plane area. The populations around the lake are vulnerable toward flood.

Study on physical development

After the construction of the lake, 3 roads have been upgraded by widening and black topping. The road along the river, called as Dam side road, was a gravel road which has been reconstructed and black topped. The road passing through the edge of settlement was a pedestrian road which is widened and black topped. The road east of the settlement have been widen and under construction for black topping. Also, the prices of lands have been increased around the area. KII informant suggested that the land price have been around double after construction of lake and is still rising. People are not interested in selling their as the land price is increasing at present, so land transaction have been very less.

After the construction of lake, new waves of development have been started. A new mini open zoo construction project have been started at the Nursery (90 bigha) where at present mango and tree to provide food for zoo animals like Churi, Amala, Lapsi, Tooth, 1Kimbu have bben planted. This lies just south of lake which will promote tourism and increase their stay at the municipality. A small wetland project due south of lake have been initiated and will use lake water. A open picnic spot and closed seminar hall is also under construction. On ward 11, a funpark called Buddha Park along with a hiking route is under construction. The vision of the municipality is that a tourist will visit Bharat Lake, observe zoo and wetland, go to funpark where there are hotels for night stay and during morning they can hike on the hiking route and complete their journey.

Pollution around the lake

Pollution is another major problem observed in the lake area despite few dustbin placed for throwing garbage. There is no separate waste dustbin for organic and inorganic waste material. Further there are only few dustbins around the area making it difficult for people to find the dustbin at their convenience. The major cause of pollution in the area was due to increased number of visitors in around the lake. Also, the food stall provide food in polythene bag or paper which after eating is generally thrown in around lake area or into lake water making both surrounding area as well as lake water pollution.

Buffer zone As per the building code of our country Nepal, the setback for construction of structure shall be 50m from boundary of lake and 10m from boundary of canal. A canal is used to provide water to lake continuously. Therefore, a 50m buffer around the lake and 10m buffer from canal edge was constructed using QGIS. Buffer is a component of geoprocessing tool for vector data analysis which help to create a layer of polygon around a feature at fixed given distance.

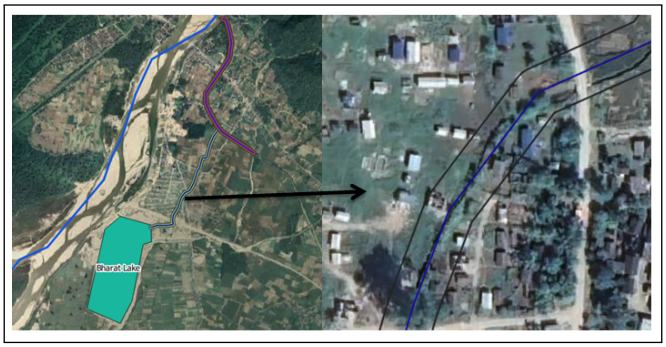

Figure 6: Buffer of 10m along the canal

This setback around lake is constructed to ensure protection of lake from unhealthy human activities as pollution. Similarly, setback along canal is made to ensure that the water of canal remains unpolluted which further make water of lake less polluted. But the rule is being violated along the canal as well as around the lake. Numbers of houses are constructed along the buffer or setback area. In around lake shops have been constructed to enhance economic activities but these shops shall be away from setback to promote lake health.

Figure 7: Buffer of 50m around the lakel

7. Conclusion and Recommendation

The research found out that the development of artificial lake i.e Bharat Lake have helped in development of the municipality as well as for enhancing the environment around the area. The survey showed that 88% visitors and 50% shopkeeper believe that lake construction has made the area cooler during summer than previous. Similarly, 45% shopkeeper suggested that winter is warmer near the area after construction of lake. Also, the wind intensity is high around the lake as suggested by surveyors. All these change in climate have helped in enhancement of environment. The populations of municipality have been economically benefited from lake as they have been able to work around the lake and earn their living. But as the numbers of visitors have been increasing, there have been increase in pollution around the area. So, proper plans and management shall be effectively implemented for preserving lake for future. Similarly, as the lake is located near river flood plain, proper flood management plan shall be prepared in case of flooding. In our country, new towns are being developed. These place need to attract new population for further development. For attracting new population, the town requires economic activities and development of locality. Economic activities and development around the locality can be generated with construction of artificial lake similar to Bharat Lake. Hence, if any place need to attract new settlement, then Bharat Lake can be used as reference to these upcoming new town to attract new population.

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