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Sustainable Management Strategies Urban Water Bodies and Wetlands in the Indian Context

Umar Yaseen[1], and Er Shakshi Chalotra[2]

[1]M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2]Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

ABSTRACT- The urban and peri-urban water bodies and wetlands residing inside parks and the abundance of wildlife they support are being threatened by intensive visits and unexpected tourist and leisure activities in and around Indian cities. Urban revitalization efforts often result in the gradual devastation of local ecosystems. The major focus of this thesis is on determining whether or not current management approaches will secure the long-term viability of these delicate ecosystems. Nature Park, Taratala, Kolkata; Rabindra Sarobar, Kolkata; Eco Park, New Town, Rajarhat; Jubilee Park, Gayshpur, Kalyani; and Millenium Science Park, Ashoknagar, Habra were chosen as the five case study locations in and around Kolkata, India. Scope The fundamental goal of this study is to conserve urban and peri-urban water bodies and wetlands, thus we will be looking at the social, ecological, and economic sustainability of these ecosystems. This study's focus is on water bodies and wetlands within urban and peri-urban park settings, and it uses socio-ecological criteria and indicators to analyze the current state of five such case study sites. The study's goals are to identify critical issues, the responsible and determining factors of strengths and weaknesses at the case study sites, and relevant policies at site and system levels.

KEYWORDS- Urban Water Bodies, Wetlands, Sustainability

I. INTRODUCTION

Despite being the "Century of Cities," urban and peri-urban water bodies and wetlands are frequently overlooked. Natural or man-made water features and wetlands have been the lifeblood of Indian towns since ancient times. Oceans, seas, lakes, ponds, wetlands, rivers, streams, and canals are water bodies [1-4]. Some geographical characteristics are artificial. Wetlands are "at the boundary between fully terrestrial ecosystems and truly aquatic systems, making them distinct from each but strongly reliant on both. Wetlands are "regions of marsh, fen, peatland or water, whether natural or manmade, permanent or temporary, with static or flowing, fresh, brackish or salt water, including marine water areas less than six meters deep at low tide". Only 26 Indian wetlands are on the Ramsar List. Urban surroundings may sustain lively water bodies and wetlands, which are vanishing owing to urbanization. Climate change will cause impending water stress in the nation, according to the National Water Mission. Urban areas are climate change hotspots, according to the IPCC's fourth assessment report. By 2025, more than 50% of the country's population will reside in urban areas. Past and contemporary patterns of natural resource management in cities have failed to meet environmental issues, and cities squander natural resources, notably water. Rapid urbanization, population expansion, growing affluence, and industrial development are depleting water supplies [7-10]. This demands for effective management of urban and peri-urban water resources in India, since their survival is threatened by fast urbanization, a growing population, and climate change. The National Water Mission aims to "conserve water, minimize waste, and ensure its more equitable distribution across and within States via integrated water resources development and management." This is significant for managing urban and peri-urban water bodies and wetlands in India. The UN Committee on Economic, Social, and Cultural Rights recognized access to water a human right on November 26, 2002. According to Water Resources Group 2030, if current management methods continue, the gap between freshwater demand and availability would reach 40% worldwide. Due to water constraint, several Indian towns may dry up. [11] highlight multiple use water services such as irrigation, residential requirements, fisheries and recreation; groundwater recharge; flood control and silt collection, carbon sequestration, etc. by wetlands such as tanks, ponds, lakes and reservoirs. Some researchers believe [4,5] that urban water bodies and wetlands are life-supporting ecosystems in environmental and socio-economic contexts in Indian cities. Maintenance of hydrological balance as a source of water, storage and regulation of water table, role as "flood cushions" in cities, water purification, nutrient retention, maintaining climatic stability at micro and macro levels, role as carbon "sinks" and carbon sequestration are among their many functions.

Despite their many benefits, these ecosystems are threatened in and around Indian cities. 274 of Delhi's 611 water sources have dried up, and 190 cannot be resurrected, according to a Delhi Parks and Gardens Society report. South West Delhi's Rewla Khanpur hamlet originally had seven water bodies. As the city grew, peri-urban villages' water sources were filled. Chennai had 650 small and large water bodies, but just 30

remain. The city's 19 largest lakes have fallen from 1,130 ha to 645 ha, according to the Water Resources Department. Hyderabad's aquatic bodies shrunk by 3,245 acres in 15 years. Bengaluru has 280 interconnected tanks in the 1960s and 80 in 1993. Recent audits of 10 lakes in Bengaluru discovered encroachment, rubbish dumping, untreated sewage outflow, and delay.in restoration work and other lapses. The East Kolkata Wetlands on the eastern fringe of the city of Kolkata are also vanishing at the rate of 1% per year and are being severely threatened by human encroachment and contamination. In 2001, 137 lakes were listed in Ahmedabad city, and over 65 were reported being already built over. Another example exhibiting this increasing loss of urban water bodies is Hyderabad. Within the last 12 years, Hyderabad has lost 3245 ha area of its water in the form of lakes and ponds. Although wetlands in India are indirectly protected by an array of laws and India also being a signatory to the Ramsar Convention on Wetlands and the Convention of Biological Diversity and has drafted the Wetland (Conservation and Management) Rules in 2010, yet there is no significant development towards sustaining these ecosystems. The main reason is that, only selected number of wetlands has received significant attention (by way of financial and technical assistance from the central government) under the wetland conservation programmes (like NWCP and NLCP) while the remaining ones continue to be in neglected state. Moreover, there is lack of awareness of the values of these ecosystems among the policy makers and the implementing agencies and also the lack of a proper regulatory framework for conservation of water bodies and wetlands in India.

Wetlands [11-16] are already a major component of the tourism experience and will likely drive demand for new tourist destinations. At least 35% of Ramsar sites record tourist activity globally. Urban and peri-urban water bodies and wetlands are attractive for tourism, leisure, and human health. Wetland Parks have been recognized as important for nature-based tourism. "Urban nature", "ecological nature," and "park nature" are included. It's a public garden or park typically rebuilt from original swamps, reservoirs, ponds, and other natural or manmade waterways in the city or suburbs that gives chances for sight-seeing, recreation, popular scientific education, and other activities in accordance with the natural biological process. Hong Kong Wetland Park and Mai Po Marshes Nature Reserve are wetland tourist leaders. Nature-based tourism is currently considered a method for managing natural resources in rural and urban areas. It's the fastest-growing area of the tourist business and may produce revenue, conserve resources, and integrate people and the environment. Visits to urban and peri-urban water bodies and wetlands have risen in recent years, raising worries regarding their tolerance. Some researchers [13,23,24] identifies unplanned tourism as a key danger to these water bodies and wetlands. Tourism may disturb animals, pollute the environment with trash, disrupt local customs, and destroy cultural heritage. Many cities with poor infrastructure lack sewage pipes. Untreated sewage and solid waste are dumped in waterways, converting them into landfills. Eutrophication, induced by the introduction of nutrients from raw sewage, leads to abundant development of aquatic weeds in water bodies, destroying their ecosystem. In cities and urban parks, there is a significant push towards eco-cities, which work in harmony with nature. UNEP, WTO, and IUCN have specified guidelines for planning and managing sustainable tourism, particularly in protected areas, and the Ramsar Convention provides guidelines for the wise use of urban and peri-urban wetlands, but the sustainability of these vulnerable ecosystems in urban and peri-urban areas still faces severe threats and challenges due to a lack of planning and management guidelines. In India, despite the policies, plans, programs, acts/bills, and regulations for the protection of water bodies, urban and peri-urban water bodies and wetlands are being abused and diminishing quickly. Due to the biodiversity, they sustain, urban and peri-urban water bodies and wetlands are ecotourism attractions. When positioned in a neighbourhood, they also serve as a small urban park. City officials typically develop a "garden" around lakes, with groomed lawns, paved walks, flowers, and trees that don't thrive in wetlands, harming the native environment. Building parks to "beautify" lakes typically turns them into swamps and mosquito breeding grounds. Since conserving these sensitive ecosystems is a top priority, it's important to know whether current management approaches will secure their future sustainability.

II. RELATED WORK

A. Urban and Peri-urban Water Bodies and Wetlands

The numerous effects of urbanization on hydrology, geomorphology, and ecology make water bodies and wetlands in urban regions function differently from wetlands in non-urban lands. Furthermore [8] also argue that water bodies and wetlands in urban regions may possess human-related values that they lack in non-urban areas, as they provide some contact with nature, and some opportunities for recreations that are otherwise rare in the urban landscape. Within the urban fabric, other than providing major ecosystem services, they often develop into popular destinations of tourism, recreation and human well-being.

B. The Global Context

Globally, the relevance of water bodies and wetlands for urban livability is growing. Everglades National Park and UNESCO World Heritage Site is a large, flat tropical river and swamp in southern Florida near Miami. The US National Park Service reports 1 million annual visits. The "Liquid Heart of Florida" Everglades National Park contains 600,000 acres of wetlands with nine diverse habitats. Mangrove, cypress, estuaries, and coastal wetlands. It's home to 36 endangered or protected species, 350 birds, 300 fish, 40 mammals, and 50 reptiles (Wikipedia, 2017). New York City's marshy regions are either totally filled and hardened by urbanization or restricted to tiny landscape strips. Over 99% of the 224,000 acres of freshwater wetland in New York City have been lost. However, New York City's remaining wetlands are still important. The 10,000-acre NYC Park System contains woodlands, ponds, and meadows. New York City's most productive wetland areas include Jamaica Bay, Staten Island, and the Arthur Kill Watershed. Jamaica Bay has 300 bird species, while Staten Island's Arthur Kill Watershed and Arlington Marsh Complex have 50. Central Park's 843 acres host 230 bird species and 200 plant species in its

wetlands. Lake Claremont in Perth, Australia, improves the livability of the city by connecting inhabitants and visitors to nature and the outdoors. The lake is home to 96 bird species, over 60 aquatic macroinvertebrate taxa, various amphibian and reptile species, and three kinds of microbats. China's urban planners have recently recognized the relevance of wetlands in boosting the liveability of Chinese cities, particularly the wetlands and rivers in Central Beijing, the Taihu Lake between Nanjing and Zhenjiang, and the "mulberry-sided" polders and fish ponds of Hemu Wetland in Hangzhou. In 1995, the Ramsar Convention designated Mai Po and Inner Deep Bay Wetlands as "Wetlands of International Importance" This 1500-hectare region is used by 50 million migrating birds along the East Asian-Australasian Flyway. According to WWF-HK (2017), it's home to over 400 bird species (49 of which are globally endangered), over 250 plant species, over 20 mammalian species, over 20 reptile species, 8 amphibian species, etc.

C. The Indian Context

In India, the Sukhna Lake in Chandigarh [12] not only attracts the tourists but also daily morning and evening walkers as well. The lake, which is a sanctuary for exotic bird species, a tourist spot and a centre for recreational activities such as boating, sailing, kayaking was visited by 18474 foreign tourists and 6.01 lakh domestic tourists in 2015 (January to July). The Powai Lake, an oasis in the concrete desert of Mumbai with a jogging track and children's play area is used for fishing and is a popular tourist spot with migratory birds and crocodiles being the major attractions of the lake. The Hussain Sagar Lake, that joins the twin cities of Hyderabad and Secunderabad, was utilized for irrigation and drinking water needs up to 1930. A popular recreational spot with facilities for picnicking, boating, para-sailing, water-skiing etc., it attracts visitors of all age groups. Bangalore, known as the "City of Lakes" is dotted with numerous lakes or tanks in and around the city namely, Sankey Tank, Hebbal Tank, Ulsoor Tank etc. These tanks while being home to a diversity of birds, flora, fauna and fish also serve as recreational places for the urban population, who find solace by being close to nature and participate in activities such as swimming, boating, fishing and strolling along the lakeshores. However, natural water bodies also often tend to get absorbed in urban expansion and their catchment is disturbed as a result of development around. The condition of some urban and peri-urban lakes and water bodies in India, which also serve as nature-based destinations, is so dismal that the people have now filed a number of public interest litigation (PIL) to put pressure on government agencies to take action for their conservation. Many cases have been documented, Dal Lake in Kashmir, Delhi's Waterbodies, Kurpa Tal, Naini Tal, Bhimtal, Naukuchia Tal and Sattal in Uttaranchal, Charkop, Thanne lake, Powai and Eksar Lakes in Mumbai, Hussain Sagar, Saroo Nagar Lake, Kolleru wetlands in Andhra Pradesh, Vembanad wetlands in Kerala, Bangalore lakes, Bellandur lake in Karnataka etc.

D. Sustainability Issues, Challenges and Threats

The 3 million-acre Everglades are now half their size, according to the Everglades Foundation (2006). Nearly 1800 kilometers of canals and dams redirect water to coastal towns and cities. With a growing population comes pollution, notably from fertilizers. Nutrient pollution encourages foreign plants and animals to proliferate, which disrupts the environment. One research indicates that Jamaica Bay lost 1,174 acres between 1900 and 1974 owing to construction, airports, and landfills, or 16 acres each year. [21] say that in Australia, colonization and European agricultural methods that led land removal for agriculture, urbanization, and eutrophication degraded Lake Claremont. Due to the removal of the lake's canopy cover, more sunshine and nutrients reached the water body, which led to an increase in invasive plants and mosquitoes. To address this, alien fishes were imported, which was eco-disastrous. Traditional fish ponds in Hong Kong are maintained by abundant vegetation and contribute to the wetland ecology. These are gradually vanishing near the Ramsar site in Mai Po and are being replaced by industrial-scale ponds with minimal ecological value. Water birds, formerly widespread on ponds, are now entirely gone, indicating the ecology is under decline.

In India, these habitats are threatened by pollution, encroachment (planned and unplanned), eutrophication, illicit mining, unregulated tourism, cultural abuse (immersion of idols during religious celebrations), and lack of institutional structure. Naini Lake, Nainital; Dal Lake, Srinagar; Powai Lake, Mumbai; Hussain Sagar Lake, Hyderabad; Deepor Beel, Guwahati; Surajkund Lake, Delhi; Okhla Barrage, Delhi; Neela Hauz, Delhi; East Kolkata Wetlands, Kolkata. Naini Lake's water level has dropped by 16 feet owing to fast siltation. Tourism and population growth have boosted lake water use. Sewage inflow enhanced the lake's organic load [13,14]. Over a 10-year period, BOD has climbed 20-fold while CO2 has increased 670-fold. Dal Lake's water quality and aquatic life are threatened by 15 main drains' untreated effluents. From 1538 hectares in 1971 to 1305 ha in 2008, its area has reduced. The lake's solid waste has expanded due to the growth of hotels and restaurants (9000 metric tonnes annually). At Powai Lake, untreated sewage and rubbish from adjacent residential and slum colonies have impacted the water quality, which also suffers from Ipomea and Water Hyacinth overgrowth. Unplanned quarrying also damaged the lake's watershed. The lake bed has increased by 3000m3 due to silt deposits. Fish populations and types have plummeted. Encroachment has decreased Hussain Sagar Lake by 40% in the previous four decades. The lake receives 150 million litres per day of industrial effluents and home waste. High nutrient levels cause algal blooms. According to [22], local infrastructure development and real estate expansion threaten EKW despite being legally protected. Due to siltation and bed-level rise in fish ponds, there is no rational, need-based, equitable sewage distribution system or sewage water, reducing fish output. Tenurial rights (owner-worker disputes), chemical pollution from several tanneries, and diminishing biodiversity (bird species down 84%) are further challenges in this area. Due to the authorities' lack of an environmentally sensitive

strategy, urban development is continuing to the east and south of Kolkata, jeopardizing the city's delicate ecology.

E. Management Approaches for Sustainability

Comprehensive Everglades Restoration Plan is a 50/50 state-federal cooperation to restore 16 counties and 18,000 square miles. Restoration of the Everglades reinstated a natural flow to the 2.4-million-acre marsh, resurrected habitat for more than 60 vulnerable and endangered species, and provided flood control to South Florida. Advanced water quality technology and farmer BMPs have saved 3,500 metric tons of phosphorus from entering the Everglades. Construction of 45,000 acres of man-made treatment wetlands, which employ native plants to purify water flowing into the Everglades, and better farming practices have lowered phosphorus concentrations by 76%.

WWF-HK manages the Ramsar Site of Mai Po together with the Agriculture, Fisheries and Conservation Department. It manages and enforces regulations, issues and checks permits, and helps with traditional shrimp farming and fishponds in the protected area for research and teaching.

Sukhna Lake, an integral component of Chandigarh City, is silting and losing water. The Chandigarh Administration plans to fill the man-made lake with purified tertiary water [36].

Delhi's Hauz Khas Lake has a lowered water table, a partially concreted dry bed, and no surface water to restore it. INTACH's restoration by filling the lake with water, introducing fish species, bioremediation, etc. has helped in the recreation of an environmental asset, and its transformation into a natural habitat with pleasing visual characteristics is beginning to attract citizens to the area as well as to nearby markets.

Hussain Sagar Lake absorbed sewage and industrial effluents from catchment regions. The water body became useless for enjoyment and pisciculture due to eutrophication, algal bloom, water weed development, and foul odor. HUDA is working to restore Hussainsagar Lake to its former ecological, economic, and cultural glory through appropriate technological interventions. These include improving the lake water quality by preventing pollutants from point and non-point sources from entering the lake, removing nutrient-rich sediments, intercepting and diverting dry weather flows, and improving nalas in the catchment area [35].

The 210-hectare Powai Lake in Mumbai, India, has a diverse environment that supports a diversity of flora, fauna, and aquatic creatures. Human activities are strangling the beach and degrading water quality.

Mansagar Lake, a 300-ha manmade lake in Rajasthan, has siltation, pollution, input of wastewater, eutrophication, and water loss due to downstream irrigation in summer. After multiple unsuccessful efforts to rehabilitate the lake by the Government of Rajasthan, a public-private partnership was developed in 2002.

Significantly, WWF- India's Aardhrabhoomi Project is conserving Kunigal and Kokkrebellur Wetlands near Bangalore to reverse biodiversity loss and enhance ecological conditions while increasing the well-being of local populations via natural resources-based livelihoods.

F. Sustainability of water bodies and wetlands

The literature may be grouped into the following five categories:

The “first category” of literature focuses on the various functions and services rendered by wetlands. Wetland functions include water quality improvement, floodwater storage, fish and wildlife habitat and biological productivity. According to [32], there are three basic categories of functions performed by wetlands yielding a range of value important to society. They are:

- Hydrologic - functions that affect the quantity of water entering, stored in and leaving the wetland.
- Water Quality - functions that affect the quality of water entering and leaving the wetland.
- Habitat - functions that provide food and shelter for plants and animals.

[29] enumerates their significance with respect to climate change as climate change is likely to affect the potentiality of wetlands to sequester carbon. Increased CO2 in the atmosphere will result in increased plant growth in most wetlands thereby resulting in increased carbon sequestration. Increased rainfall would result in sediment deposition in some wetlands. Increased temperature will lead to decrease in ground and surface water levels of wetlands which may result in decomposition and decrease in sequestration. [38] opines that in Asia, urban water-bodies and wetlands are being utilized for many environmental services including waste-water /storm water treatment in Phnom Penh, Cambodia, by many communities in Australia, at Luang Marsh in Laos PDR, at Ho Chi Min City in Vietnam, China, as well as the East Kolkata Wetlands in India.

While there is dearth of empirical studies on the awareness levels regarding the functions and values of these ecosystems, a “second category” of literature have emphasized on the economic valuation of wetlands for their sustainable management and conservation, both in the urban and rural context. The importance of wetland valuation both for balanced decision making and public awareness has been stressed upon by [19]. [11] recommend doing economic value studies of wetlands using basic quantitative approaches. [9] stress "non-market" advantages when appraising urban wetlands. [15] stress valuation methodologies (market price, impacts on output, travel cost, Hedonic pricing, replacement cost, etc.) relevant to wetland ecosystem services and their relevance in water management decision making. Various valuation techniques have been used to value freshwater wetlands in the Zambezi Basin, South Africa, flood attenuation benefits in Eastern Madagascar, urban wetlands in the US, wetland water quality services in Nakivubo Swamp, Uganda, wetland flood attenuation Ghosh et al. provide approaches for estimating the East Kolkata Wetlands' economic value for conservation and management.

A “third type” of literature recognizes ecotourism as an important technique for protecting and managing wetlands. In the context of Sango Bay Wetland in Uganda, [7] argues that ecotourism development may alleviate poverty and promote socio-economic development while attaining the 3 Ps of sustainability: Profits (economic), People (social cultural

benefits to locals and visitors), and Place (biodiversity conservation). [13] suggest ecotourism as a way to protect Deepor Beel, Guwahati, a Ramsar site with abundant biodiversity. Conservation efforts would improve the water quality of Sukhna Lake in Chandigarh, a popular destination for outdoor leisure and tourism in northern India, according to [12], which will increase visitor arrival and income.

A "fourth type" of literature focuses on urban wetland parks as an efficient approach to conserve, rebuild, and utilize wetland. Caiyun Wetland Park, China, will be a demonstration and instructional foundation for national urban artificial wetland wastewater purification, ecological conservation, and sustainable use. [43] emphasized the ecological significance of urban wetlands in terms of water storage, purification, water content of the city's foundation, the role of vegetation in climate regulation, biodiversity conservation, and the educational value of the ecological environment, especially in the context of two urban wetland parks, the Water Garden, Portland, USA, and the Living Water Garden, Chengdou, China, that have been successful.

The fifth category of literature includes individual studies and recommendations by many authors on urban wetlands management, including ecological and functional assessment, plant communities on urban wetlands, avian diversity, aquatic species, ecotourism carrying capacity, tourists' motivations, satisfaction, and attitudes, etc. [27] analyzed 14 wetlands in Ohio to see how urbanization impacts amphibian ecosystems. [16] studied the influence of soil conditions, human activity, and vegetation structure on alien invasion in New Jersey wetlands. [34] evaluated native and imported plant species in Teaneck Creek Wetlands for a future restoration strategy. [10] discusses the features of urban wetland vegetation and highlights the direct and indirect consequences of urbanization on species composition and diversity.

III. THE PROPOSED METHOD

A. Proposed Methodology

The methodologies adopted have been decided upon after an extensive literature survey relevant to the respective indicator. Once the existing values of the indicators as per existing site conditions are obtained, A 5-point scale for scoring is adopted to determine the level of each indicator (for e.g., 1.0 – very low, 2.0 – low, 3.0 – moderate, 4.0 – high and 5.0 – very high). The scoring is based on the measurable value derived from findings and data analysis with respect to each indicator at the case study sites, interpreted against a measuring scale developed for each indicator. A similar scoring methodology has also been adopted for the assessment of management effectiveness of National Parks and Wildlife Sanctuaries for evaluation of Protected Area governance in Thailand. To achieve the goal of conservation, relevant policy implications for long term sustainability and management of these ecosystems have been derived. Fig.1 represents the methodology that has been followed.

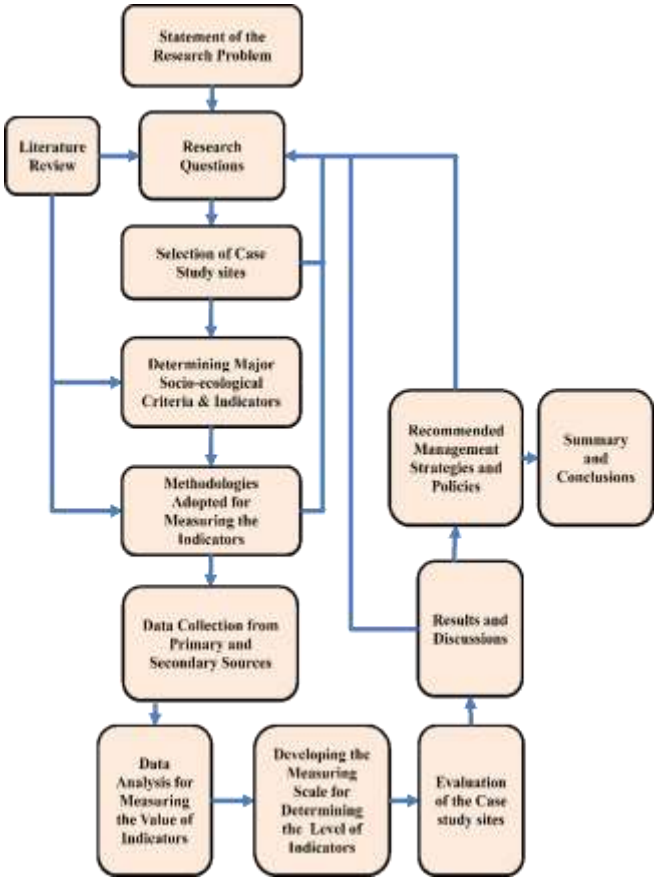

Figure 1: Proposed Flow

IV. RESULT ANALYSIS

Park management say visitors are an important aspect of water body or wetland-based parks in urban and peri-urban regions, adding to their social character. Long-term sustainability depends on the parks' carrying capacity in terms of visitor numbers to avoid overcrowding and lower visitor contentment. Their knowledge of wetland functions, motivations for going, degree of pleasure after trips, perspectives on resource management, etc. may differ from place to destination.

Since environmentalist's stress conserving water bodies and wetlands, visitors' willingness to pay an admission charge or otherwise influences the survival of these habitats.

A. Relevant Criteria and Indicators in the Context of the Present Study

With the above background, an extensive literature survey comprising of articles by various researchers, technical reports, unpublished thesis, information from websites, national and international standards have been explored. Moreover, the opinions of park authorities, stakeholders and experts have been considered while selecting relevant criteria and indicators for application at the case study sites. The relevance of the following criteria as discussed below, followed by identification of pertinent indicators in the context of the case study sites are enumerated as follows:

- ***Vegetation***

Vegetation, a vital feature of any park, has major influence on "ecosystem services" given by water bodies and wetlands, such as regulating the water table, temperature, and urban air quality. Vegetation also helps selected bird groups. Vegetation is a key requirement for case study settings. A native plant species exists naturally in an area, state, ecosystem, and habitat without direct or indirect human activity, according to the Federal Native Plant Conservation Committee (1994). Non-native or alien species are those brought by accident or design (Morse et al., 2000). Non-native plant incursions affect ecological processes, native species, and gene pools (Bossard et al., 2000). Exotic plants compete with indigenous for light, space, and nutrients, altering the natural environment and requiring costly upkeep. [2] say parks are a vital aspect of urban forestry and should be established and maintained as hubs for conserving local trees and herbaceous plants to operate as a local knowledge base giving scientific and technical data and ecological recommendations. In parks, exotic trees are attractive, but native trees are better suited to local circumstances and can survive insect infestations. Most park tree variety is restricted to one park, distorting the view. Diverse species must be equally dispersed in parks to produce a healthy urban tree population. Another important aspect of vegetation in a park developed around an urban or peri-urban water body or wetland is the species diversity of plants, which has two basic components: species richness and the plant species evenness or equitability distributed within the vegetation community. [41] propose that a region with numerous unique or uncommon species has better conservation value than a comparable area with common and widespread species. Also, researchers such as [18] have attempted to document the bird diversity and threats by human activities in urban wetlands of India through indices.

- ***Water Quality***

According to [31], various anthropogenic activities responsible for the degradation of water quality can be grouped into two: the in-lake activities and those in the catchment.

In-lake activities

- Direct or indirect disposal of solid wastes (includes religious offerings- ash, flowers etc.)
- Immersion of idols and similar material, particularly those with toxic and non-degradable substances.
- Bathing and washing (especially the use of detergents).
- Recreation and navigation –using motorized boats.
- Construction along the lake- recreational facility too close to the shoreline often obstructs the inflow of runoff/storm water from the catchment.

B. Catchment Based Activities

Water Quality Index (WQI) is a useful measure of water quality in this context. It's a grade that reflects the composite effect of several water quality characteristics and is computed for human consumption [3]. It's a single number that reflects water quality based on physico-chemical factors. Estimating the WQI from water's physico-chemical parameters is a prerequisite for determining surface water quality. [23,28]. have assessed water bodies for rainy, winter, and summer seasons, whereas [36] have evaluated monthly variations in water quality metrics and WQI. According to park sources and personal observations, since visitations and recreational activities are intense during the winter, Pre-monsoon WQI of the water bodies just after the winter season and Post-monsoon WQI before the winter season are the most important and apt indicators for study in such parks, also suggested by water quality experts.

Some major physico-chemical characteristics evaluated for estimating WQI, which may also affect fish productivity at case study locations, are addressed below. pH measures water acidity and runs from 0 to 14. Pure water is pH 7, neutral. Below 7 is acidic, over 7 is basic. CPCB (2007-2008) and BIS (2012) suggest 6.5-8.5 for drinking water. In most water investigations, the pH ranges between 6 and 9. Table 1 shows pH values and fish culture affects.

Table 1: pH Tolerance Levels and its Effects on Aquaculture

pH Levels	Effects on Warm Water Pond Fish
<4.0	Acid death point
4.0-5.0	No production
6.5-9.0	Desirable range for fish production
9.0-11.0	Slow growth
>11.0	Alkaline death point

C. Dissolved Oxygen (DO)- DOI

Levels in untreated chlorinated drinking water should be 6mg/L or above. It affects most metabolic processes and community architecture in aquatic habitats. Sources include air diffusion and water photosynthetic activity. Lack of dissolved oxygen causes most pond fish deaths. Aquatic plant and algae growth and aeration equipment may frequently solve problems. Table 2 shows DO's effects on aquatic life.

Table 2: Effects of DO Levels on Aquatic Life

DO Levels	Impacts
0-2mg/L	Not enough oxygen to support life
2-4mg/L	Only a few fish and aquatic insects can survive
4-7mg/L	Good for many aquatic animals, low for cold water fish
7-11mg/L	Very good for most stream fish

D. Chemical Oxygen Demand (COD)

COD is commonly used to determine the number of organic pollutants found in surface water (e.g., lakes and rivers) or wastewater. [1] found the COD of some ponds to be high because they are being maltreated by their host communities, namely through, dumping of refuse, washing cloth, irrigation, using as source of drinking water for animals, fishing, discharge of domestic sewages, decaying and death of flora and fauna etc.

E. Biochemical Oxygen Demand (BOD)

BOD is a parameter to assess the organic load in a water body. BOD determines the amount of oxygen required for biological oxidation of organic matter with the help of

microbial activities. [42] observed the BOD concentration of an urban water body in Shimoga town, Karnataka to range between 28mg/L and 33mg/L and called the water eutrophic.

The recommended level of Sulphate for drinking water is 400 mg/L (BIS, 2012). High sulphate levels, above 250 mg/L, are indicative of a pond that is impacted by acid mine drainage or acid rain. These ponds usually have a low pH and high levels of metals (iron, manganese or aluminium).

Phosphate stimulates the growth of plankton and aquatic plants which provide food for fish, causing an increase in the fish population and improving the overall water quality.

Carbon Capture Potential

"Carbon Sequestration" describes natural and purposeful mechanisms by which CO2 is taken from the atmosphere or diverted from emission sources and deposited in the ocean, terrestrial habitats (vegetation, soils, and sediments), and geologic formations. According to the Intergovernmental Panel on Climate Change, increased GHGs, especially CO2, in the atmosphere may lead to a 0.17°C per decade rise in average earth surface temperature and 0.5-1% of precipitation each decade in much of the Northern Hemisphere and 0.3% in tropics and subtropics. Sequestration of atmospheric carbon is a climate change mitigation method owing to excessive greenhouse gas emissions. Despite occupying just 6-8% of the land area, inland wetlands store 33% of the soil carbon pool.

Guest Capacity

According to the U.S. Department of the Interior, National Park Service (2008), visitor trampling affects a wetland's function and water quality in every water body it services. A tourist walking across a marsh tramples foliage and crushes or burying insects. Standing water stirs bottom sediments into the water column. Re-suspending sediments affects water quality and biota suitability. Swimming, bathing, and motorized boats pollute the water with petroleum products, soaps, and other pollutants, reducing water quality. WTO defines Tourism Carrying Capacity as "the maximum number of people who may visit a tourist location at the same time without destroying the physical, economic, socio-cultural environment and reducing visitor happiness." [25] estimated the Tourism Carrying Capacity of van Vihar National Park based on biophysical, biological, sociological, and climatic elements that affected public usage of the site and addressed ecotourism management. [39] estimated the tourism carrying capacity of two tourism sites in Vietnam that attract a large number of visitors - Phong Nha (with cave sightseeing, ecotourism forest trail hiking, cable car riding) and Dong Hoi Tourism Centre (with local beaches) - and says they can be used as preliminary benchmarks for later tourism planning of the two centres. [37] assessed the Recreational Carrying Capacity of a Turkish National Park utilizing bio-physical resources and found that the average visitor is lower than the recreational carrying capacity. [24] calculated Fandoqloo's carrying capacity. The research found that tourist activities are at a lower level than their carrying capacity, which is an issue since tourism might become unstable owing to a lack of sustainability criteria. [30] assessed the carrying capacity of Khorma forest in Iran. The findings revealed that the effective carrying capacity was low and may be enhanced by providing the appropriate infrastructures, facilities, services, and qualified manpower.

F. Criteria for Visits

1) Motivation for Visits

Visitors' Perceptions on Resources Management [20] opines that park and natural resource managers are often charged with the dual responsibility of protecting the natural resources for future generations as well as providing appropriate public enjoyment of these resources, which has the potential for conflict as managers struggle to evaluate and define standards of quality that both safeguard the natural resources and provide a positive visitor experience. [26] studied the value of local parks and the impact of park upgrades through renovation using visitor perceptions at LARA Park, Lewisburg. Park visitations had increased after renovation as visitors opined that the park has a great atmosphere, is a great place to stay, is a safe play space, reduces playground fatigue and has meaning for all ages. [33] also used visitor perceptions to investigate the physical and emotional motivation of park areas and the prevailing problem of unlimited visitations at Diyatha Uyana Urban Park, the most popular park of Colombo, Sri Lanka. Significantly, tourist attractiveness of the Ramsar label was studied by [17] using tourist perceptions at the two Ramsar lakes of Champagne Humide (France) and Comana Natural Park (Romania) and found that communication activities on this label need to be boosted to increase tourism frequency. From the above discussion, it is inferred that in the context of sustainability of parks developed around urban and peri-urban water bodies or wetlands, "Visitors' perceptions on resources management" is a significant criterion.

[12] underline the significance of water quality indicators for fostering tourism and biodiversity in Sukhna Lake, Chandigarh. Ban building in catchment regions and prevent waste water from entering the lake to improve water quality and recreational and scenic value. According to Parks Canada (2013), ecosystems have integrity when their natural components are preserved. e.g., water, rocks), biodiversity (composition and number of species and communities in an environment, e.g., tundra, rainforest, grasslands), and ecosystem processes (the engines that makes ecosystem work; e.g., fire, flooding, predation). Visitors who feel safe are more inclined to return. Many studies, such as [6] have stressed the importance of "Interpretation," an educational activity that transfers information, knowledge, meanings, and connections to visitors about the locations they visit. [40] examined local and international tourists' Willingness to Pay (WTP) for development of facilities/services and protection of the Hurulu Forest Reserve and estimated ideal admission charge to fund changes suggested in Hurulu Development Program. [14] studied WTP for biological diversity conservation in Kegsugl and Kundiawa, Papua New Guinea. Many studies have used the Contingent Valuation Method (CVM) with willingness to pay the maximum fee for admission permission to gauge visitor support for conservation in the Indian setting. In India, several parks are free. NP, EP, JP, and MSP all charge Rs. 20/- to enter. It remains to be seen whether visitors to case study locations have a good attitude toward conservation. In the context of

the present research, the relevant indicators for evaluation are "Percentage (%) of visitors willing to pay admission fee (where there is no entry charge) or higher entry cost" and "Difference between the current entry fee and the average entry fee that visitors are prepared to pay.

Table 3: Estimated Visitor Carrying Capacity of the Case Study Sites

Case Study Sites	PCC (visitors /day)	RCC (visitors /day)	ECC (visitors /day)
NP	1400	1170	1170
RS	42467	38447	28720
EP	59508	39477	39477
JP	5920	5014	3810
MSP	4332	2478	2478

The estimated Visitor Carrying Capacity for all the case study sites which has been calculated using Park Carrying Capacity PCC, Real Carrying Capacity (RCC) and Effective Carrying Capacity (ECC) is shown in Table 3. Moreover, site conditions with respect to visitor numbers are also discussed.

V. CONCLUSION

All urban and peri-urban water bodies and wetlands should be considered as extremely important water management infrastructure and hence they should be embedded in the early planning process and policies of cities and its periphery. This will be possible only when socio-ecological planning becomes a tool for metropolitan planning. Hence, inclusion of wetland management strategies, their implementation at local and metropolitan level, should be recognized as crucial for sustainability of urban and peri-urban water bodies and wetlands and they should be integrated with the policy making process. However, it is imperative that exploration and implementation of all future strategies should be carried out with the active participation of stakeholders at all levels for proper management of these threatened water bodies and wetlands.

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