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Rethinking Urban Planning: Integrating Indigenous Technology of Wetlands in Ahmedabad's Urban Water Management and Flood Control

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Abstract: ***This study investigates the potential of integrating indigenous wetlands technologies into Ahmedabad's urban water management and flood control strategies. The objective is to assess how traditional ecological knowledge can contribute to addressing contemporary hydrological challenges in rapidly urbanizing cities, with a specific focus on Ahmedabad, India. The research adopts a qualitative methodology involving a comprehensive literature review, analysis of policy frameworks and examination of successful case studies such as Singapore's Bishan Ang Mo Kio Park. Additionally, spatial and ecological insights from historical and current wetlands systems in Ahmedabad are critically analyzed. Findings indicate that indigenous wetlands systems- comprising stepwells, tanks, and natural floodplains- historically played a significant role in regulating urban hydrology, supporting groundwater recharge and mitigating floods. However, the erosion of these systems due to urban expansion has resulted in increased flood risks, inefficient drainage and ecological degradation. Comparative analysis with contemporary landscape infrastructure models reveals that hybrid approaches, which combine traditional knowledge with modern urban planning, offer resilient and cost-effective alternatives. The study concludes that integrating indigenous wetlands technology into Ahmedabad's urban fabric has the potential to enhance water retention, reduce flood vulnerability and support urban biodiversity. Policy reforms, interagency coordination and community engagement are essential to operationalize this integration. This research contributes to the discourse on water-sensitive urban design by emphasizing the relevance of localized knowledge systems in shaping sustainable and adaptive urban environments.***

Keywords: wetlands, urban planning, water management, flood control, nature-based solutions, sustainable urbanization

1. Introduction

Ahmedabad, being one of the fastest-growing cities in India, faces challenges in water management and flood control due to rapid urbanization, climate change, and poor Infrastructure management. Historically, Ahmedabad's lakes and wetlands played a crucial role in flood mitigation and groundwater recharge, but urban expansion has led to their degradation. Modern development patterns that prioritize land expansion over ecological suitability have ignored the preservation of natural and engineered water systems such as Stepwells (Vavs), Lakes (Talavs), and Wetlands. As a result, Ahmedabad has been experiencing frequent floods and water shortages, creating a paradox of water mismanagement.

Wetlands have been known for their versatile use in managing water resources among many civilizations, including those in India. Indigenous water management systems in Ahmedabad and other regions of Gujarat integrated wetlands as part of a larger network of reservoirs, lakes and stepwells. These systems acted as rainwater catchment areas, stored monsoon water and helped in mitigating monsoon floods. Wetlands were natural water purifiers and allowed surface water to percolate into the ground, replenishing the ground water levels.

2. Research Problem

Increasing Urban Flooding and Inefficient Drainage Systems

The significant reduction of lakes over time in Ahmedabad has led to urban floods and water scarcity. Ahmedabad had 630 lakes in 1999, but only 122 remain due to urban expansion. (Vishwa & R., 2023). This loss has led to increased flooding, declining ground water levels and higher urban temperatures. Even now, many of the lakes are excluded from the official list of lakes because they were made available for agriculture, construction and development of infrastructure and buildings (Parmar J. , Times Of India, 2023)

Loss of Traditional Ecological Solutions in Modern Planning

Historically, Ahmedabad depended on Stepwells, Lakes and Wetlands for water conservation and flood mitigation. However, the loss of these traditional ecological solutions in today's modern Urban planning has led to disrupted natural water cycles, leading to inefficient flood control and increased dependency on artificial drainage systems. Integrating traditional ecological solutions into urban planning is essential for sustainable management.

Research Paper Objectives

- To explore Indigenous Wetland technology practices used globally
- To assess their applicability in Ahmedabad's urban planning

Research Questions

- How can traditional wetland management techniques help in modern urban planning?
- What are the social and environmental benefits of integrating indigenous water technologies?

3. Study area

Ahmedabad is located in the state of Gujarat, India, between 23.225°n and 72.3714°e, with the Sabarmati River flowing through the city. The city is spread over 505 sq km, and its population is approximately 55,77,94. The city has experienced an exponential rise in population (1.58 million in 1971 to 5.5 million in 2011), giving rise to a dramatic increase

in Urban growth in the last 50 years (28% to 76% from 1991 to 2010). This has resulted in a change in the Urban landscape of Ahmedabad, which led to an increase in impervious area, increasing the surface rainwater runoff. The Sabarmati River divides the city into two parts. The western area's terrain slopes in two directions: North to South and West to East. Meanwhile, the Eastern area's slope is directed westward towards the Sabarmati River. (Kaur & Gupta, 2022)

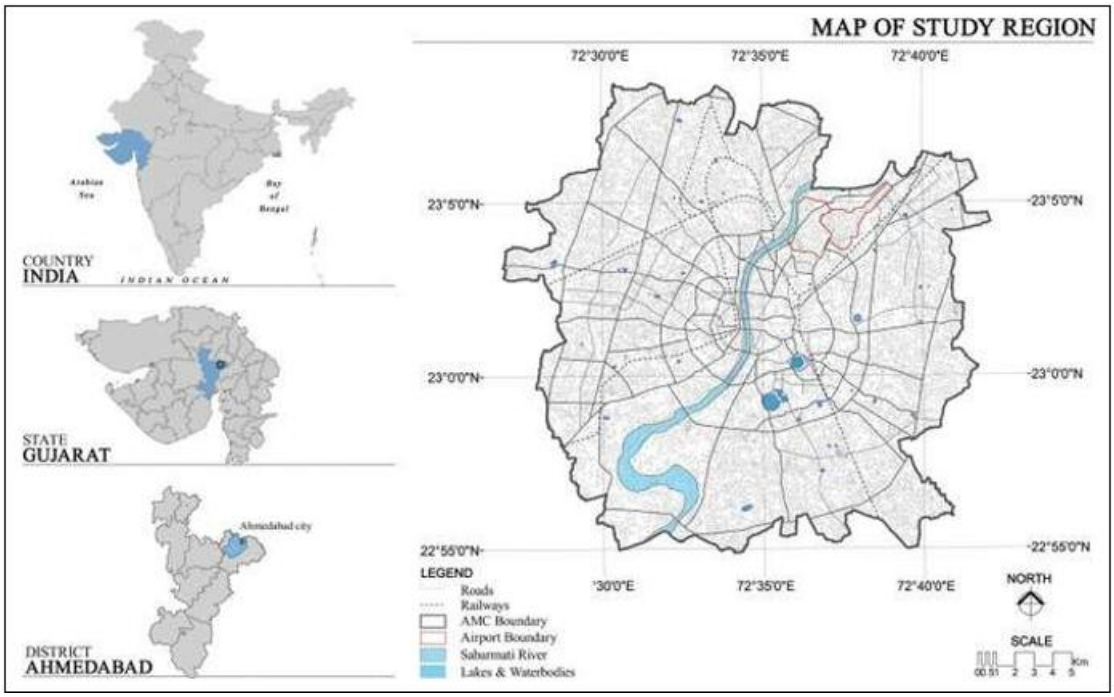


Figure 1: Geographical overview of the Location of Ahmedabad
Source: (Kaur & Gupta, 2022)

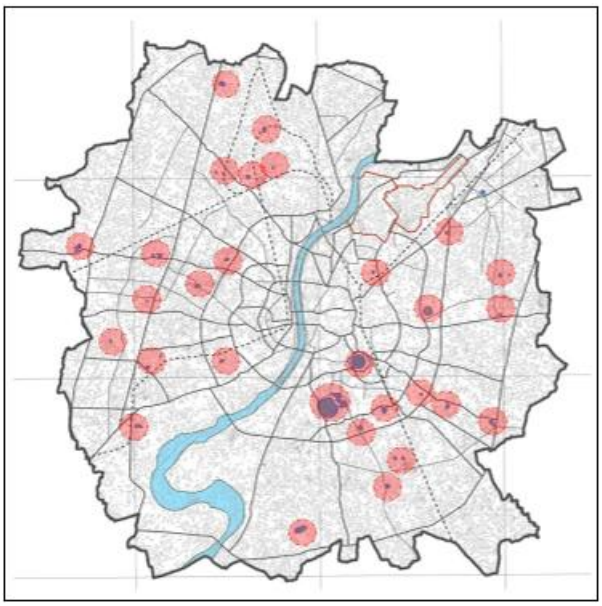


Figure 2: Ahmedabad Map showing big and small waterbodies
Source (Smile, n.d.)

4. Methodology

- Literature review of the status of wetlands in Ahmedabad and study of the indigenous technology of traditional wetlands system through different research papers, Websites of News channels, national and international organizations and press reports
- Used Google maps to evaluate and compare the current status of wetlands and comparison with past years
- Case study of successful natural water system projects executed globally

This paper explores how wetlands can be integrated into urban planning to enhance resilience while leveraging indigenous knowledge for sustainable wetland conservation.

5. Literature Review

The literature review examines the intersection of the indigenous knowledge system and urban water management, focusing on Ahmedabad's wetlands and flood control. Key areas of exploration include:

Section 1: Historical role of water systems in Ahmedabad's water management
This section will discuss how the water systems were developed originally and their role in the city's water management.

Section 2: Status of Wetlands Conservation and its consequences in Ahmedabad.
This section will examine the existing literature on the current status of the wetlands and lakes of Ahmedabad. This study utilizes Google Maps to conduct a comparative analysis of selected lakes in Ahmedabad, tracing changes over time. By evaluating satellite imagery from past to present, the study highlights shift in lake boundaries, water quality and surrounding land use, providing insights into the dynamics of urban bodies. This section also explains the waterlogging issue in Ahmedabad during monsoons. This study essentially highlights the data of waterlogged areas and the reasons for

the same. It will establish the connection between the missing lakes of the city and waterlogging areas.

Section 3: Governmental and Non-Governmental Initiatives for Wetland Restoration.
This section focuses on the Governmental and NGO efforts in conserving Wetlands. The literature will examine policies, initiatives, and programs focused on wetland protection and restoration, emphasizing the contributions of various stakeholders in the restoration of wetlands.

Section 4: The Importance of a Collaborative Approach in Wetland Conservation
This section will capture the importance of the Indigenous Knowledge System in efforts of conserving wetlands and community participation. The study will explain the collaborative wetland conservation approach, explaining the role of Indigenous Knowledge and Traditional Practices.

Section 5: Integrating Indigenous knowledge systems in Wetlands conservation practices
This section will cover different traditional technologies used to restore and construct wetlands and lakes in India. It will touch upon the benefits of individual technology and how it is executed.

Section 6: Case Studies and Models of Implementation
This section will cover the current situation of government initiatives in Ahmedabad to conserve the water systems. It will also show comparisons with the study of the global water system practices with successful examples.

The Evolution of Wetlands in City Water Systems: A Historical Analysis
The City of Ahmedabad has seen a deeply embedded historical evolution of water infrastructure that echoes its understanding of variable climatic conditions. Most of these water systems like wetlands, lakes and stepwells were decentralized and managed by surrounding communities. The Sabarmati River has been serving the dual purpose of potable water supply and flood moderation along with its supporting networks of manmade lakes such as Kankaria, Chandola and Vastrapur lakes. As described by Shah (2019), these systems had way better "Water Wisdom" as they were based on sustainable practices of reuse, recycle and recharge, unlike today's modern engineered and fragmented infrastructure. (Shah, 2019). Post 20th century, Ahmedabad had lost most of its historic water bodies to construction projects. The consequences of wetland loss have become increasingly evident. Rising flood incidents, declining groundwater levels, and urban heat island effects have intensified. (KucharaÂ[1], Charan, Mankad, & Solanki, 2023).

Figure 3: Ancient map of Ahmedabad
Source: (Hope, Cracraft, & Biggs, In Architecture at Ahmedabad, the capital of Goozerat, 1866)

Timeline of water structures in the city
Ahmedabad's historical water system has been evolving with the centuries parallelly with political and Climate Shifts. As researched by Tushar Bose and Utkarsh Patel in the article Building flood resilience through interlinking of lakes – The case of Ahmedabad, in 1411, the city of Ahmedabad was founded by Sultan Ahmed Shah I near Sabarmati River. (Shastri, 1964). As the city developed further, the city's planning incorporated water structure as the center of development. Eventually, Ahmedabad was centered around different types of water bodies called Talavdis or ponds (Tayyibji, 2016). Apart from Lakes and ponds, series of reservoirs and gardens were built by the Sultan, such as Hauz-I-Qutb (Kankaria Tank), Malek Saban Lake and Sarkhej Lake with a Roza adjacent to it. Some of the *Hauzs* were controlled through a supply sluice and were interlinked at the surface level for rainwater harvesting as well as for stormwater (Biggs, Hope, & Fergusson, 1866).

The Pols of Ahmedabad (traditional housing clusters) were designed with Tankas or Underground tanks where each household would store rain water from the terrace to tanks through pipes. Since there was a limitation in the capacity due to their size British began to build better water services with modern reservoirs and a piped water supply network. Eventually, the dependency on the lakes, ponds and Hauz reduced over the years, and the sustainable practice of harvesting rainwater and stormwater management waned off. (Bose & Patel)

Table 1: Time line of water structure in Ahmedabad

Year	Governance	Types of lakes and their functions
11th-15th Centuries	Solanki and Vaghela rulers	Stepwells (like Adalaj and Dada Harir) for storage and cooling.
15th -17th Centuries	Sultanate Rulers	Interconnected lake systems – Kakariya, Sarkhej, Vastrapur- for water supply as well as ceremonial use.
19th century	British rulers	Masonry canals and irrigation channels reduced the use of local water perception.
1950s-1990s		Rapid Urbanization increased dependency on the piped water network and degraded wetlands.
2001 onwards		Wetlands remained overlooked; the restoration of lakes started focusing on beautification.

Figure 4: Howz-i- Kootub, Kankaria Tank- The Supply-Sluice
Source: (Hope, Cracraft, & Biggs, Architexturez, 1866)

Figure 5: Howz-i-kootub, or Kánkaria Tank- The Strainer of the Supply-sluice
Source: (Hope, Cracraft, & Biggs, Architexturez, 1866)

Status of Wetlands in Ahmedabad

Wetlands in Ahmedabad, like any other globally, have traditionally operated as multiutility ecosystems, recharging ground water, purifying water, supporting biodiversity and mitigating flood. Unfortunately, they have been overlooked in city planning and have been ignored, mainly as wastelands rather than necessary urban infrastructure. As per Manvita Baradi, over 200 lakes have been encroached upon, disrupting groundwater recharge and water quality. (Snigdha, 2024).

The Decline of the Historic Lake: Makarba's case

Among the most prominent lakes, Makarba Lake, which is the largest lake in Ahmedabad, has not even been listed in PIL as a lake due to its degraded condition. Makarba Lake, an integral part of the Sarkhej Roza complex (hub of Sufi Culture), is a historic natural lake, since AD 1451 in Makarba village, 8 km southwest of Ahmedabad. Upon the guidance of Shaikh Ahmed Ganj Baksh, Sultan Ahmed Shah established Ahmedabad along the Sabarmati River. Makarba Lake use to collects rainwater runoff from the surrounding area, which then overflows into an artificially created historic water body around Sarkhej Roza. (Desai, 2020).

Due to intense construction activity in the surrounding 5km, the lake has become a dumping yard, blocking the gates of rainwater drain and degrading the natural tendency of ecological services it could have provided – ground water recharge, flood mitigation and water purification. Bhavna Ramrakhiani, a longtime advocate for Sarkhej Roza's development, notes that initially, stormwater pipelines were installed (2014-2015) to direct monsoon runoff from nearby areas to Makarba, aiming to replenish Sarkhej Roza. However, the site now receives sewage instead, prompting renewed discussions with authorities (Desai, 2020).

Figure 6: Sewage and untreated wastewater flowing into Makarba Lake
Source: (Darshan Desai, 2020)

Vastrapur Lake restoration- Concrete over nature

Likewise, Makarba Lake, Thaltej Lake (notifies waterbody), which is 8-9 km away from Makarba, has become a filthy, foul-smelling, fertile breeding ground for mosquitoes due to unrestricted encroachments and construction activity surrounding it. (Desai, 2020). Ahmedabad's neglect of waterbodies in the master plan and strict implementation of regulations have been degrading those historic waterbodies' capability of acting as Sponge infrastructure that absorbs runoff and mitigates localized flooding.

As revealed by Urban Acres in one of their articles, the city largely depends on the stormwater drainage network for redirecting excess rainwater runoff. However, only 480 sq km of Urban area is covered through the 950 km stormwater network, which is mostly the western part (30%) and eastern part (70%). In addition to this, whenever the rainwater runoff is diverted through the Sewage lines, the Sabarmati River gets contaminated water, increasing the pollution issue. Since AUDA (Ahmedabad Urban Development Authority) approves development projects before confirming the installation of necessary drainage infrastructure. (Urbanacres, 2024)

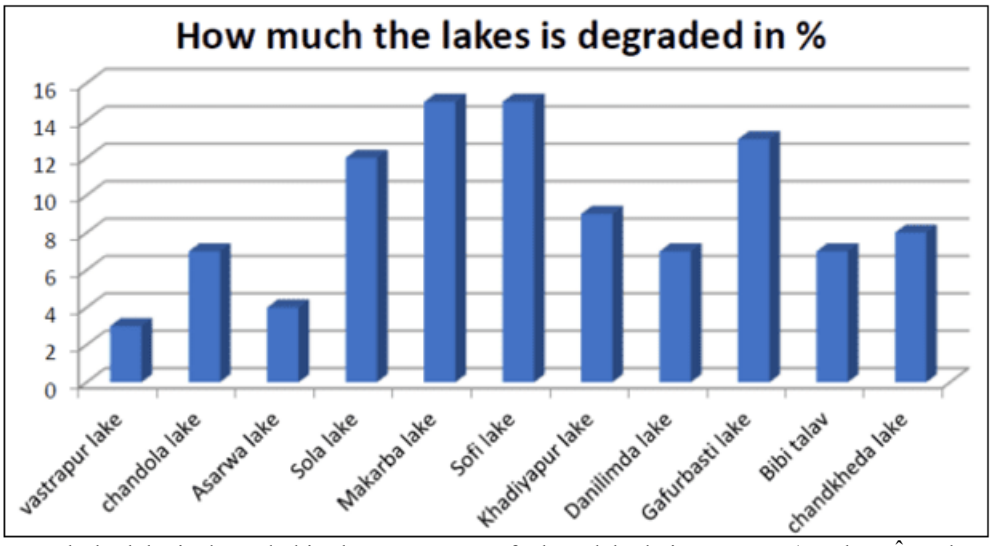
Urban Planner Mansee Bal-Bhargava, an expert on the Lake's conservation, sheds light on Vastrapur Lake, mentioning that the lake, instead of being filled with rainwater runoff, is being filled with treated sewage water from the nearby residential areas. Urban Planner Mansee further argues that the restoration of Vastrapur Lake became more of a real estate Project than the vital infrastructure that collects stormwater and water recharger. Since the lake was concretized from all sides, reducing the capacity of the lake to recharge water, it has also created a waterlogging issue in the area due to blocked drains.

Figure 7: Concretized Vastrapur Lake
Source: (Darshan Desai, 2020)

As per the study carried out by researchers, the status of some of the lakes was analyzed on the basis of Google Earth between the years 2000 to 2022. (Vishwa & R., 2023). Some of the notable wetlands include Kankaria Lake, Vastrapur Lake, Makarba Lake, and Sola Lake etc. Most of these lakes are shrieked, polluted and degraded or lost to concrete infrastructure.

Table 2: Conditions of selected Wetlands in Ahmedabad
Source (Vishwa & R., 2023)

Wetlands	Zone	Condition
Vastrapur Lake	Northwest Zone	Shrink, reconstructed and polluted
Chandola Lake	South Zone	Available but not properly conserved and polluted
Sola Lake	Northwest Zone	Fragmented, reconstructed and polluted
Makarba Lake, New Police Headquarters	Southwest Zone	Dried and degraded
Sofi Lake, Ramol	East Zone	Wetland lost due to concrete infrastructure
Khadiyapur Lake, Vejalpur	Southwest Zone	Dried and Shrink
Danilimda Lake	South Zone	Degraded, Shrink and polluted
Gufurbasti Lake, Ramol	East Zone	Shrink and polluted
Babitalavdaragah , Vatva	South Zone	Shrink, degraded and polluted
Chandkheda LAke	West Zone	Degraded, Shrink and polluted



Graph 1: How much the lake is degraded in the percentage of Ahmedabad city. Source (KucharaÂ¹, Charan, Mankad, & Solanki, 2023)

Figure 8: Sola Lake in 2015
Comparative study of Sola Lake profile in 10 years

Figure 9: Sola Lake in 2024
Source (Google Maps)

Figure 10: Lakes at Thaltej gam in 2011
Comparative study of Thaltej Lake profile in 10 years

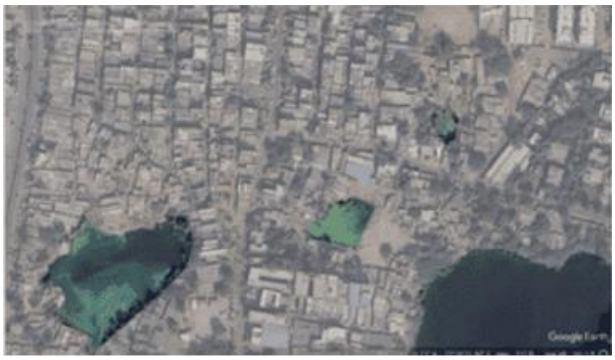


Figure 11: Lakes at Thaltej gam in 2023
Source (Google Maps)

Sabarmati Riverfront Project: A Missed Opportunity

The Sabarmati River has been the main source of water body, around which Ahmedabad was built. According to a November 2022 report submitted by the Union Ministry of Jal Shakti, the Central Pollution Control Board (CPCB) announced that the Sabarmati River ranks as India's second most polluted river, as cited in Times of India. The report said that the BOD (Biochemical Oxygen Level) in the Sabarmati River was 292mg per liter, which indicates more oxygen is required. (Parikh, 2023) This also suggests lower water quality with less Oxygen, eventually endangering the habitat that it survives in. It also indicates that the stretch of Sabarmati with the highest BOD content is lined with various textile manufacturing industries. The Sabarmati River collects not only city runoff but also industrial discharge. According to the Water Quality Management Division's report on polluted water nationwide, the capacity of current STPs is not enough to treat all the sewage that reaches pumping stations. (Snigdha, 2024) Out of 1693mld, 613 MLD gets bypassed directly into the Sabarmati River. (Phukan, 2023).

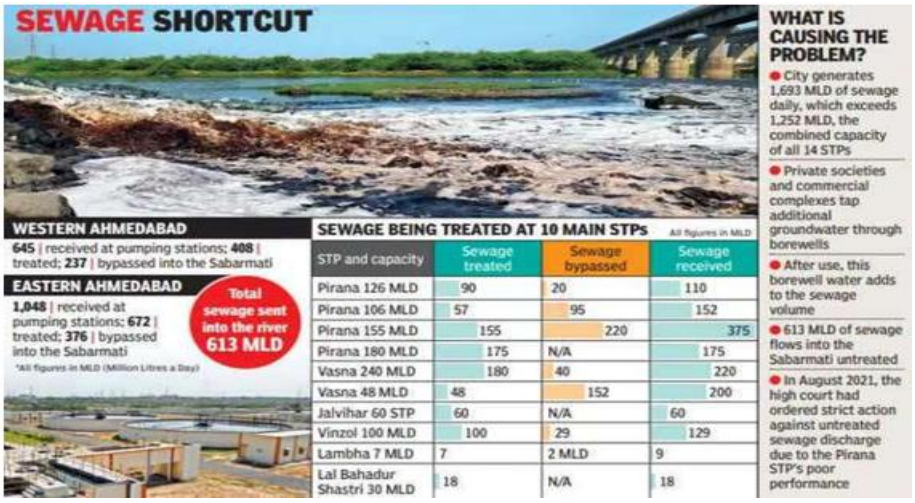


Figure 12: Overview of Sewage disposal from industrial waste in Sabarmati River
Source (Parmar J. , Times Of India, 2023)

Table 3: Water quality investigation by Paryavaran Samiti and Gujarat pollution control board
Source: (Mongabay, 2019)
Investigation by Paryavaran Suraksha Samiti and Gujarat Pollution Control Board on 12 March 2019

S. No.	Parameter	Colour Pt. Co. Scale	TDS mg/l	NH3-N mg/l	Chloride mg/l	Sulphate mg/l	DO mg/l	COD mg/l	BOD mg/l
1	Railway Bridge	30	668	4.31	153	96	4.66	98	28
2	Danilimda- STP (60- 106 MLD STP)	50	732		186	108		337	139
3	Danilimda Storm Water Drain	150	3135	10.13	933	462		1301	536
	New Pirana 182 MLD STP							587	218
4	MEGA	450	9813	30.18	4025	863		1052	210
5	Narol NTIEM	200	5290	79.91	1600	743		1126	427
6	Sabarmati	150	4368	68.04	1665	612	BDL	1009	447
7	River Downstream								
8	Miroli Village		1466	31.97	491	188	BDL	151	33
	Effluent Discharge Norms	100	5000 mg/l	50 mg/l	600 mg/l	1000 mg/l		250 mg/l	30 mg/l
	River Norms	NIL	500 mg/l	NIL	NIL	NIL	>=5 mg/l	NIL	<=3 mg/l

Additionally, due to unrestricted bore well construction, private residences and commercial complexes extract additional ground water, depleting the water. As per the Gujarat Samachar report, the Congress MLA, Shailesh Parmar, raised a question regarding the actions taken against the 42 complaints registered for the release of polluted water into the Sabarmati River. Mukesh Patel, the Minister of state of forest, environment and climate change, responded by stating that a total of 61 notices were issued during two years' time (2022-23) to the units in Ahmedabad and nearby areas. Patel also stressed the point that police cases have also been levied along with units seizing for untreated water disposal. He highlighted that from 9 polluted rivers in 2018, Gujarat has only two in 2022.

While the Sabarmati Riverfront project successfully connected citizens back to the river, it may have failed in the ecological aspect of the restoration. The activist Mudita Vidrohi points out that the dry Sabarmati river's condition was worsened by riverfront development with concrete embankments and surroundings, resulting in inefficient groundwater recharge and increased dependency on the Narmada River. They also mentioned that the Riverfront has become a pool of stagnant, polluted water that comes from the industrial sewage disposal.

The press release reported on 27 March 2019, by joint investigations by Paryavaran Suraksha Samiti and Gujarat Pollution Control Board, on the contamination levels in the main water source of Ahmedabad District showed their concern on the worsening of the Sabarmati River saying that it affects the people and habitat in and around the riverfront who depends on it for their daily livelihood. High pollution levels have severe direct and indirect impacts, including groundwater contamination, food pollution, health risk habitat destruction, decreased ground water recharge and loss of biodiversity. (Mongabay, 2019)

Figure 13: Activist Mudita Vidrohi investigates pollution surrounding Sabarmati River front
Source: (Mongabay, 2019)

Figure 14: Activist Mudita Vidrohi captured polluted water entering river during her investigation

Lakes unused, City under water: Ahmedabad's Paradox

Ahmedabad has been facing waterlogging for more than a decade now. As per the report in Times of India, Jignesh Parmar highlights that with an average rainfall of 10 inches in Ahmedabad in the month of August, waterlogging was seen in over 300 locations. 157 spots remained waterlogged for more than an hour while 10 spots remained in water for about one to four days. (Parmar J. , Times Of India, 2023)

In another report by Jignesh Parmar, he states that Ahmedabad's civic body identified 142 lakes in 2020 as potential stormwater sinks, which could become natural containers for rainwater runoff, but these lakes were deemed unfit for public use. When requested by Ahmedabad's Municipal Corporation to convert 33 lakes that were near 45 waterlogged areas into stormwater collectors, they realized that the collector never considered them as lakes. Further, the revenue department approved the use of twenty-six of these lakes for projects, including transportation infrastructure, Government facilities, and housing developments. AMC officials also said that the rejected 33 lakes covered 9,29,690 sq m, which was enough to divert rainwater runoff to these lakes and could have saved water logging problems. (Parmar J. , Times Of India, 2023)

Figure 15: 157 Water Logging spots identified with more than one hour water accumulation Source ((Parmar J. , Times of India, 2024)

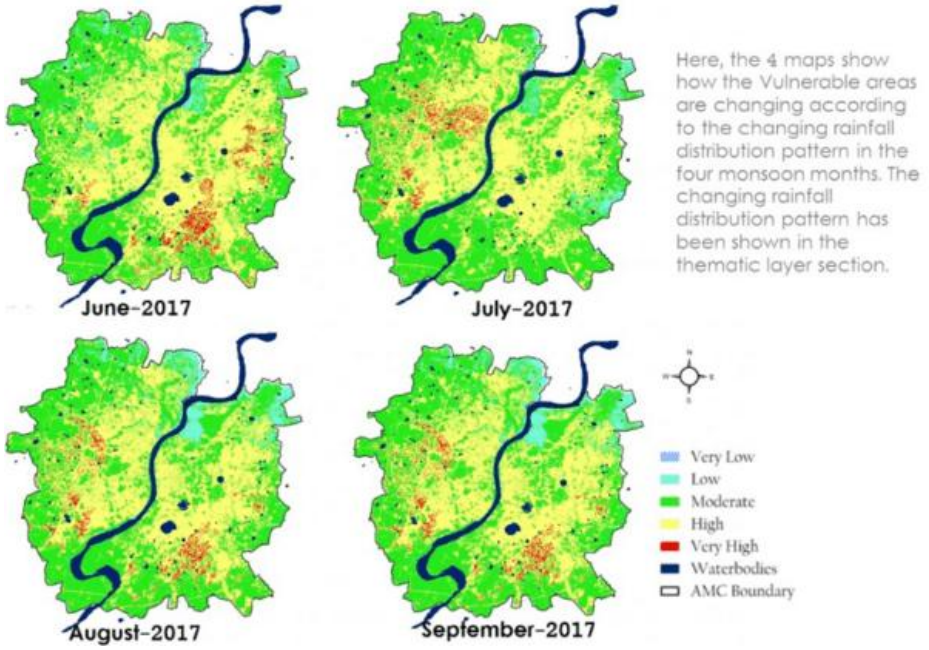


Figure 16: Maps showing vulnerable areas for floods during rainfall Source: (Diti, 2018)

Wetland conservation by Governmental and non-governmental Initiatives in Ahmedabad

There have been various initiatives taken by both Government and Non-Government agencies to conserve and restore the existing water structures after realizing the ecological and hydrological importance of wetlands. However, the question would be how effective are those interventions in terms of balancing the ecology, recharging ground water, mitigating flood by collecting excess rainwater runoff and also purifying the polluted water.

Government Initiatives

At the Government level, the Ministry of Environment, Forest and Climate Change (MoEFCC) launched the National Plan for Conservation of Aquatic Ecosystem (NPCA) in 2013 to restore degraded wetlands and promote sustainable management. In Partnership with the Gujarat Ecological Education and Research Foundation (GEER), NPCA conducted the "Wetland Rejuvenation" Program, where several lakes in Gujarat, like Kankaria Lake and Vastrapur Lake in Ahmedabad, received funding for restoration and rejuvenation. (Ministry of Environment,forest and climate change, Government of India, 2023-24)

According to the experts, the problem with the restoration is making the lakes concrete pools by removing the soil for making more depth in the lake. An environmentalist from Madhya Pradesh also points out the issue with Vastrapur Lake, saying that while the place looks beautiful for morning walkers and picnickers but it loses its natural capacity of flourishing aquatic life, aquatic plants, recharge water, or even building up water-holding capacity. (Darshan Desai, 2020)

As reported by the Times of India, the state Government constituted the Gujarat State Wetland Authority (GSWA), comprising 24 members, for a term of three years, for the conservation of wetlands and notifying new ones as required by Wetlands Conservation and Management Rules, 2017. The purpose of the authority is to map, monitor and manage wetlands of the state. (Kaushik, 2024) Ahmedabad Municipal Corporation has already submitted a detailed project report for developing 16 lakes out of 137, including Shilaj, Makarba, and Ramol, to the center, according to the Times of India. (Times of India, 2023). The reason still remains unidentified regarding the other lakes that were left out. Times have also reported that GSWA have identified 8 lakes in Gujarat as nationally important wetlands under NPCA of MoEFCC, among which are Nal Sarovar and Thol Lake, which is situated around the boundary of Ahmedabad city. The other 19 lakes of Gujarat are recognized as an Important Bird and Biodiversity Area (IBAS).

Non-Governmental Initiatives

Looking at this situation, non-governmental organizations (NGOs) and activists came together as vital stakeholders in Wetland Conservation. Organizations like VIKSAT (Vikram Sarabhai Center for Development Interaction) and the Centre for Environmental Education (CEE) have been doing workshops and seminars actively for the promotion of community-based conservation models. The CEE is actively emphasizing Environmental studies in school, educating Urban Planners and other related stakeholders through workshops and Participatory Governance. (CEE, n.d.)

The Importance of a Collaborative Approach in Wetland Conservation

Globally, the priority of conservation of wetlands has been increasingly recognized due to their ecological significance and versatility. It is important to bring back the indigenous knowledge systems for their restoration and conservation and actively involve local communities for effective conservation strategies.

As cited by Anushri Barman, Fulena Rajak and Ramakar Jha in their research paper, in India, the National Wetland Conservation Program (NWCP) leads and works for the wetland management by focusing on community participation and integration of Traditional Knowledge. Further, they advocate that government agencies like the Ministry of Environmental, Forest and Climate Change (MoEFCC) play a major role in framing policies while also supporting indigenous knowledge systems in wetland conservation. They also highlighted how international organizations like the Ramsar Convention provide a wide framework for promoting traditional knowledge systems and community sharing in wetland conservation. (Barman, Rajak, & Jha, 2025)

Non-governmental organizations (NGOs) and business groups equally play a vital role in restoring and conserving the wetlands. For example, India Times reported an initiative taken up by the Hinduja Foundation (HF) in collaboration with NGOs for conservation of Wetlands. One of its examples is a 12-acre Marsh wasteland at Hannikallu, Wellington, Coonor, which was HF CSR program, Jal Jeevan, along with Care Earth Trust and various other stakeholders, including the Madras Regimental center of Indian Army. The wetland, which was degraded due to encroachment, sewage and garbage disposal, was restored. NGO Care Earth Trust played an important role in ensuring biodiversity conservation. They cleared the area of invasive plants in about 33,167 sqm and reseeded it with native vegetation to sustain fauna. They also helped in linking organizations like HF and local communities. The community members were given stewardship for the marsh by making them active participants in the projects through educational programs and workshops. It also generated employment for the local communities by making them work for the wetland. The successful restoration of Hannikallu Marsh Eco Park's Biodiversity and water systems makes it a valuable model for future conservation initiatives. (Indiatimes, 2025)

Figure 17: Trails surrounding Hannikallu Marsh eco park
Source: (Indiatimes, 2025)

Integrating Indigenous knowledge systems in Wetlands conservation practices

The need for integrating indigenous knowledge systems into wetland conservation is more than just cultural recognition. The strategies used are more ecological in nature and resilient, especially in a city like Ahmedabad. Traditionally, local communities have been managing Wetlands using time-tested practices based on local hydrology, biodiversity and seasonal cycles. This knowledge becomes imperative to deal with the current urban challenges of depleting ground water, polluted water and urban flooding.

Many researchers have studied and validated the efficacy of IKS (Indigenous knowledge system) in managing wetlands function for nutrient cycling, water purification and balancing biodiversity.

Indigenous Strategies for Wetland Conservation

Different types of traditional construction and restoration techniques which are used in India have been researched and detailed out in the following section.

Use of natural and sustainable materials

Traditionally known as **Johads** in Rajasthan, some NGOs have initiated and successfully executed the revival of age-old water harvesting systems, essentially made of stone and mud barriers to collect rain water. Keeping the three sides of the embankment high, they let the rainwater flow through the fourth side. Since the construction material is porous, it helps the rain water to penetrate below the ground, recharging the ground water. (Borthakur, 2008). They also make sure that the vegetation that grows in the periphery is not water water-intensive crop. Under the guidance of NGO Tarun Bharat Sangh and its leader Rajendra Singh, the Water Man of Rajasthan, a total of 8600 Johads were built in 1086 villages of Alwar District in Rajasthan. This resulted in a hike in the water table from 100-120m depth to 3-14 m at present due to shallow aquifer recharge. There was growth in the crop production from 11% to 70% in single cropping and 3% to 50% in double cropping. Fisheries also developed due to Johads. Due to water recharge, Arvari and Ruparel Rivers also got rejuvenated, which was the biggest achievement. (Das, 2010) (Sharma, 2006)

Installing floating wetlands

Floating wetlands are artificial platforms that mimic the natural wetlands, planted with wetland vegetation with roots submerged in the water below, designed to float on water surfaces. The wetland plants and the associated microorganisms function as pollutant absorbers, purifying the water while also providing a habitat to aquatic species. Floating wetlands work by absorbing excess nitrogen and phosphorous from the water, preventing algal blooms. It cleans the water by stabilizing the suspended particles while also blending beauty with function.

To tackle the crisis of the lakes of Ahmedabad, floating wetlands provide a nature-based solution that not only deals with pollution from untreated sewage and water runoff but also cuts off algal growth and protects against the loss of biodiversity. Apart from that, it is also very cost-effective compared to any other modern-day mechanical treatment system. An example of such a lake with floating water installations is Annapurna Lake, Indore. The water quality of the lake and biodiversity improved within a week, making it a prototype for another lake to follow. (Cleanwater, n.d.)

Traditional irrigation system

There has been research on traditional agricultural practices for wetland conservation, which talks about how indigenous agriculture techniques practiced by rural communities help in sustainably managing wetland ecosystems. They emphasize the importance of crop rotation along with organic farming and water management strategies that align with wetland environments. (Singh, Kumar, & Patel, 2020) (Gupta, Sharma, & Singh, 2018).

WWF India published an example of the Bangaluru Rural district, where the people shifted from less water-absorbing original crops (Millets) to cash crops (Fruits and Vegetables) that need more water. Since surface water bodies were not enough to serve the purpose four decades ago, it had to depend on groundwater. Additionally, industries in the rural areas also depended on groundwater for its use and ultimately disposed sewage waste in the nearby water bodies, contaminating the same. WWF India, along with other stakeholders, including local government, state-level Authorities, experts, other NGOs and the local community, prepared a plan after doing all necessary studies and developed strategies for actual implementation and monitoring work. They removed the water-invasive plants from the area and reseeded plants that require less water. Floating wetlands and fountains were installed to aerate the water and purify the water. The result was they saw 5km of catchment area restored and water holding capacity increased by 60%, and water quality improved with levels rising by at least 100 ft. (WWF, n.d.)

Sacred water bodies

Many traditional communities considered lakes and ponds sacred, ensuring their protection. Involving the communities in the placemaking or for maintaining gives them a sense of ownership of the places. Many national and international agencies, along with NGOs, advocate to involve community participation for managing and conserving wetlands. UNESCO, NWCP, NAPWC (MoEFCC), ICMAM (MoES), CSE, and WWF India have mentioned in their website the importance of community-based initiatives.

Research conducted by Verschuuren suggests the nonmaterial value of wetlands and how it impacts conserving the wetlands. These wetlands have sociocultural values and provide spiritual services in many communities. A few of the strategies that work for community participation are:

a) Presence of Sacred Sites or features of wetlands
b) Role of wetlands in religious ceremonies and sacred texts
c) Oral traditions, songs, chants, and stories centered around wetlands
d) Ritualistic use of wetlands flora and fauna
e) Traditional healing practices linked to wetland systems. (Verschuuren, 2007)

By involving the non-material value of wetlands, like the spiritual services and religious aspects, we can make sure of community participation, which may also safeguard the place.

Another way of making the community more involved is to make them dependent on the wetlands for their economic growth. This will also make sure the community in the surrounding is well involved and will protect their source of income. Along with recreational development around the lake, which provides the local community of all ages a space to entertain, it also helps them with employment opportunities. As stated by Paul Abraham, President of the Hinduja Foundation, Wetlands restoration is not just about bringing back the ecology, but also empowering people who depend on them. NGOs play a vital role in bridging the gap and turning ecological challenges into opportunities for community growth and development. (Indiatimes, 2025). Indiatimes also states that by constructing a check dam and creating a peripheral walkway in the Hannikallu Marsh Project, the foundation ensured the recreational and

educational opportunities for visitors, certifying its long-term sustainability.

Case Studies: Successful Wetland Conservation Models

Worldwide, several cities have successfully integrated wetlands into urban planning. Ahmedabad can take inspiration from these models

Singapore's Bishan-Ang Mo Kio Park

Like any other cities, in the 1960s-1970s, Singapore also experienced rapid urban development leading to the use of concrete drains and canals for flood management, which was then directed to Concertized Kallang River. The river that served as the only source of water supply for the city was obstructed by the impermeable infrastructure. Additionally, the park built in 1988 connected two residential towns separated by this canal, restricting the citizens' access to the green.

In 2006, Singapore's national water agency, PUB, launched the Active, Beautiful and Clean Water Program, whose target was to restore the urban water structure into community-centric spaces. Bishan-Ang Mo Kio Park is an amalgamation of urban development and ecological restoration. This park is a perfect model for tropical urban hydrology that integrates water management, flood control, biodiversity, and recreation, satisfying Singapore's crisis of water supply and flood management. A former rigid concrete drainage canal, Kallang River, acted as urban divide, which was transformed into a wetland, reducing floods and improving urban connection and aesthetics. By adding meander forms, bridges and recreational spaces, the flowing river became the part of the park connecting the citizens back to the water and ensuring environmental responsibility. Within a year the park saw the changes in biodiversity with the increase in variety of birds, dragonflies, along with the Otters migrating and making it their home. This park has become a vital social space for the citizens while fulfilling their responsibility of ecological and social commitment.

Natural Stabilization embarkment

The Park was transformed using the Indigenous knowledge system of **natural stabilization embankment,** which not only supports wildlife but also regulates stormwater. In place of rigid linear construction, they built meander ways, which reflected the naturalized river floodplain concept. This traditional type of construction not only decreased the cost of construction by 15% but also exceeded its intended capacity by 40% to hold water as the river expanded during heavy rains. The project was guided under the collaborative efforts of different experts and authorities who ran rigorous hydrological modelling, supplemented by Soil-Bioengineering techniques for the tropical context. The project offered the citizens a connection to the natural environment while solving the crisis of the city. (American society of Landscape Architects, 2016)

Multi-agency collaboration

The project was meticulously planned by inter-agency collaboration, including Singapore's National Parks Board and Public Utilities Board for detailed and successful planning and implementation of a multi-functional public realm. Public protection was ensured with safety measures like flood warnings and sensor systems.

Figure 18: Before and after view of Kallang River (American society of Landscape Architects, 2016)

Figure 19: Before and after of storm event (American society of Landscape Architects, 2016)

East Kolkata Wetlands, Kolkata

The East Kolkata Wetlands, a Ramsar site, showcase sustainable urban planning by naturally treating wastewater and supporting aquaculture-based livelihoods. (Ghosh, wordpress, 2019). This wetland is world-renowned for its multiple uses. The site's resource recovery system, rooted in the indigenous knowledge developed by locals over centuries, has eliminated the need for costly water treatment plants. The wetland treats the city's sewage water, which then is reused for Pisciculture and agriculture, after efficiently recovering the nutrients. 4000 ha of fishponds act as solar reactors, which completes most of their biochemical process with the help of solar energy. This locally adopted system stands out as a rare example of successful environmental protection and resource management. The wetland is responsible for providing livelihood for 50,000 beneficiaries directly and others indirectly through fishing and vegetable production. (Ramsar, 2002)

Bio-remediation of waste water

Municipal corporation supplies the city's waste water through small inlets into the wetlands. The fishery cooperative controls the inflow of the waste water, which settles down, and the clear top layer of water enters the shallow wetlands. The parabolic fish gate lets the wetland water in, keeping wastewater at bay. The organic waste settles down and decomposes in warm shallow water, eventually becoming fish feed. Several natural processes like soil bacteria, macro algae,

plant roots microorganisms remove nitrate and absorb phosphate and heavy metals in the presence of sunlight and clean water in twenty days. This decontaminated nutrient-rich water flows into the ponds called Bheris in the local language, which is the habitat of fish and Algae. This treated water is then used for paddy fields and vegetable fields.

Sponge-like Infrastructure

This wetland serves as a natural container, like an enormous sponge that absorbs excess water of the city during rainfall fall saving the city from the flood. The city drainage system takes advantage of their natural gradient from West to East, where the water from the west is directed towards the East, where this wetland acts as a natural flood control system.

Restricting construction with the help of local experts

Dhrubajyoti Ghosh, an engineer turned environmentalist, has been fighting against all odds and has been nearly successful in restricting constructions of any kind on the wetlands while also saving the livelihood of the people who depend on wetlands. He applied his borrowed traditional knowledge from local communities who were managing the wetlands to design more wetland systems in the state and also won many awards for the same. (Pal, 2017)

Figure 20: Kolkata's framed Bheris: Wetland fisheries

Figure 21: Fishing community of East Kolkata Wetlands

Figure 22: Ecosystem at East Kolkata Westland

Figure 23: Graphic presentation of bird's eye view of East Kolkata Wetlands
Source: (Pal, 2017)

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Proposed strategies for the context of Ahmedabad

Traditional Irrigation System

- Growing diversified crops and organic farming makes sure of nutrient-rich soil.
- Seasonal crops and less water-based crops to be cultivated
- Use of organic fertilizers and natural pest management techniques keeps soil and water pollution-free.

Bio Sedimentation

- Use of aquatic plants and floating wetlands for natural filtration of wastewater or polluted water.
- Use of soil bacteria, solar energy and fish to further decompose pollutants from water.

Identifying the opportunity

- Base on geographical analysis identifying low lying areas and considering each and every deep or shallow lakes as opportunity to convert into wetlands.
- A city interlaced with such wetlands becomes a sponge-like structure that absorbs water when required

Natural Stabilization embarkment

- Integrating with natural processes such as earthen embankments and check dams in place of concrete for making porous surfaces for ground water recharge.
- This also helps flora and fauna to thrive and increase their habitat.
- A coarse embankment surface also helps in filtering larger particles when water gradually dissipates through the ground

Religious and Cultural Practice

- Associate wetlands with sacred sites by placing temples and letting local communities take care of the place.
- They can maintain the place by prohibiting certain activities like construction and dumping of waste in the wetlands.

Multistakeholder collaboration

- Collaboration between city-level and state-level organizations, experts, NGOs, businesses and local communities makes sure of well-researched, designed plans and execution.

Recommendations for Sustainable Wetland Management in Ahmedabad

It is evident from the researcher's analysis of Ahmedabad's Urban Lake landscape that existing initiatives and approaches to wetland conservation and restoration are insufficiently adaptive, inclusive or against ecology. Even with the several governmental and non-governmental initiatives that exist, the approach is very fragmented, with regulatory loopholes and a lack of community engagement. Based on this indigenous knowledge study, the following recommendations are proposed to develop more integrated, sustainable wetland conservation in Ahmedabad

Urban planning policies to recognize wetlands as essential infrastructure

Importance needs to be given to urban wetlands by reclassifying them under development and zoning laws instead of considering them as vacant or low-value land. It is

necessary to recognize wetlands legally and categorise them under an "Urban Wetland Zone" that mandates a protective buffer zone, restricts encroachment and safeguards hydrological continuity. Amendments to be made in Ahmedabad's Town planning and urban planning policies to recognize not just large-scale lakes but also smaller ponds, marshes, and seasonal wetlands contributing to ecological performance.

Training all stakeholders with Indigenous knowledge system

Policies to adapt the conservation protocols through well-researched Indigenous Knowledge systems. This can be worked out by training municipal authorities regarding the importance of the traditional knowledge system. A guideline handbook to be published on wetland management and to be distributed among local communities and engage them in the decision-making process through making Wetland Management committees ensuring co-ownership and accountability.

Well-funded project for strengthening Multi-stakeholder Governance

The newly formed Gujarat State Wetland Authority (GSWA), together with Ahmedabad Municipal Corporation (AMC), AUDA, academic institutions, NGOs and community representatives should be ensuring compliance with national and international wetland standards for inventory creation, development and implementation of restoration plans. Under different government schemes such as AMRUT, Smart Cities Mission and Jal Shakti Abhiyan, the authority should try to bring funding and resources.

Tailored made solutions

Ahmedabad can establish a comprehensive, dynamic Wetlands Information System that is developed based on GIS and remote sensing tools to map, monitor and evaluate wetlands in real time. The data should be analyzed based on water quality, encroachment intensity, biodiversity complexity and seasonal hydrological records. Keeping the records open and accessible for all will allow transparency and help researchers, activists and policymakers to do a thorough evaluation of the place and can provide solutions based on ecological, cultural and social contexts, as there is no one-size-fits-all approach.

Prioritizing Eco-restoration over Beautification

The policies should be more ecology-driven than the aesthetics towards restoration. Based on traditional knowledge systems, policies should promote the use of native flora and fauna, restoring natural hydrology, use of natural and porous material for the embankment and surrounding development, preventing proliferation of water intensive and invasive species. Implement nature-based solutions such as Permeable pavements, green corridors and floating wetlands to manage stormwater in place of concrete as advocated by Ramsar Convention Guidelines.

Promote Eco-parks around lakes

Combining eco-parks and restored wetlands with flood control measures creates urban spaces with multifunctional values that elevates biodiversity, increase ground water level and reduce flood risk. Encouraging real estate developers to be part of the wetland development and maintenance.

Public awareness and civic engagement through campaigns

For the long-term success of wetland conservation, it is essential to run public awareness. Schools, colleges, Urban Planning professionals and communities should be made aware of the vital asset of wetlands through wetland literacy campaigns, local media partnerships and social media through influencers.

Associating wetlands with cultural and religious value

For ages, many wetlands are linked to traditional practices, rituals and sacred sites. This association fosters community respect and a sense of responsibility towards the ecosystem. Encouraging local stewardship will encourage conservation efforts by all the stakeholders involved.

6. Conclusion

Historically, water structures like stepwells and interconnected lakes have served as the lifeline of Ahmedabad's urban water management system. Lakes and Marshlands play a vital role in maintaining the city's ecological and hydrological balance. They played the role of natural sponges- absorbing excess rainwater runoff, mitigating floods, purifying water and recharging ground water. These water structures, whose essence was based on Indigenous Knowledge and ecological practices, were the center of urban fabric and community life.

Unfortunately, the rapid urbanization has affected the natural forms of the lakes. The lakes were made available for constructions of infrastructure and building while engineered drainage systems completely substituted the natural infrastructure. This shift not only harmed the city's ecology but also made it vulnerable to urban floods, waterlogging and water scarcity.

In this scenario, it is essential as well as high time to rethink urban planning through the perspective of indigenous wetland technology. Considering the integration of wetlands into Ahmedabad's urban water management and flood control strategy can be beneficial at multiple levels: mitigating floods, enhancing water quality, supporting biodiversity and creating ecologically resilient public spaces.

Successful case studies like Bishan- Ang Mo Kio Park in Singapore prove that restoring natural hydrological systems within urban areas is not only cost-effective but also delivers social and ecological infrastructure. Ahmedabad, with its rich history of water infrastructures, can make hybrid models that can intersect between indigenous knowledge with modern planning tools like GIS mapping, hydraulic modeling and policy innovation. Through policy reforms, ecological restoration, and community engagement and inclusiveness, Ahmedabad can reclaim its wetlands as critical assets in sustainable urban development. Strict application of policy, land-use planning and public awareness campaigns must be integrated to protect existing wetlands and restore degraded ones.

Ultimately, wetlands are more than ecological assets; by making it an essential infrastructure in town planning, Ahmedabad can develop a more climate-resilient, water-sensitive and inclusive urban environment. The future requires a shift in perspective: embracing nature, valuing our heritage and indigenous knowledge and integrating it into urban design.

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