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Transformation of Urban Pondscapes in the Kolkata Metropolitan Area: A Case Study of Serampore Municipality

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Abstract: Urban ponds play a critical role in sustaining ecological balance, enhancing urban resilience, and promoting community well-being. However, the rapid expansion of urban settlements has resulted in the gradual degradation and conversion of these water bodies, leading to significant environmental impacts, including biodiversity loss. This study investigates the transformation of urban pondscapes within Serampore Municipality, located in the Kolkata Metropolitan Area (KMA). A total of 191 ponds were identified and classified using Google Earth satellite imagery, field surveys, and statistical analysis. The ponds were categorized based on their size, condition, and usage, with field observations used to assess their health. Descriptive statistical methods were employed to analyze the distribution and size variations of these ponds. Additionally, secondary data on water quality parameters, such as turbidity and chlorophyll levels, were analyzed to evaluate the overall ecological health of the ponds. The results indicate a marked decline in the number of ponds, with nine ponds having been converted into built-up areas between 2011 and 2024. These findings underscore the adverse effects of urbanization on blue infrastructure and highlight the inadequacies of current policies in safeguarding urban water bodies. The evidence calls for stronger policy interventions and the adoption of sustainable urban planning practices to protect and conserve these vital aquatic resources. Without the proper management of urban ponds, the environmental and social functions they provide will continue to deteriorate, posing further risks to urban ecosystems and human health. Enhanced governance, alongside the integration of blue infrastructure into urban planning frameworks, is crucial for mitigating these challenges and ensuring the resilience of urban landscapes.

Keywords: Urban ponds; Pondscape transformation; Urbanization; Blue infrastructure; Environmental policy

1 Introduction

On March 19, 2024, a tragic incident unfolded in the Garden Reach area of Kolkata when a five-storey building, under illegal construction in a densely populated neighborhood, collapsed at midnight. The disaster claimed at least nine lives and left several others injured. Officials from the Kolkata Municipal Corporation's (KMC) buildings department revealed that the collapsed structure was constructed on a plot that had previously been a water body [1]. The incident highlights a troubling trend in the locality. "Our area used to have a number of ponds. Now, we don't have any. All ponds were filled up, and illegal buildings have mushroomed in the locality," lamented a resident. Others echoed similar concerns, stating, "Several buildings here are built on what were once water bodies" [2]. Residents further alleged that local promoters routinely flout building regulations, with multi-storied structures being developed illegally. This situation points to a nexus involving real estate developers, government officials, and political actors. Unfortunately, such incidents are not isolated. With rapid urbanization across India, numerous cities are experiencing the loss of water bodies to the expansion of settlements, exacerbating ecological and safety challenges.

This paper explores the critical issue of pond loss in urban areas, with a specific focus on Serampore in recent years. Ponds, as inland freshwater bodies, play a vital role in supporting environmental connectivity and biodiversity [3, 4]. A significant proportion of existing ponds today are closely associated with human activities. The concept of a pondscape refers to a network of ponds interconnected biologically through the exchange of plant and animal species, along with their surrounding environments [5]. Limited research has been conducted on the pondscapes of urban areas in developing countries and the impact of urbanization pressure on these ecosystems. This paper addresses this gap by conducting a micro-level study to examine the influence of pondscapes on urbanization.

Despite facing numerous urban pressures such as pollution, loss of connectivity, and mismanagement, ponds in cities continue to harbor considerable biodiversity [6, 7]. Ponds often support diverse microhabitats such as aquatic vegetation, open water, and surrounding terrestrial areas, providing niches for various species. Many urban pond species are highly adaptable and can tolerate certain levels of pollution and habitat changes [8]. Cities hold immense potential for biodiversity conservation and can contribute to the survival of endangered species by preserving existing ponds. This requires raising awareness about the significance of green and blue spaces, restoring native flora and fauna, and creating habitats within urban landscapes that are conducive to biodiversity [9, 10]. Achieving this balance between human well-being and biodiversity preservation underscores the need for effective urban management strategies.

Building on this introductory discussion, the subsequent sections of the paper delve deeper into the analysis of urban pondscapes. The second section presents the framework used to study and evaluate the pondscape in the urban context. The third section outlines the research objectives, describes the study area, and details the methods of data collection and analysis employed. The fourth section provides insights into the current status of the pondscape in Serampore and examines the processes driving its transformation. The fifth section addresses policies related to the conservation and protection of ponds. Finally, the paper concludes by synthesizing the findings and insights drawn from the analysis.

1.1 Framework for Analyzing the Pondscape

Several frameworks exist for analyzing pondscapes in urban settings, each offering unique insights into their significance and transformation. The first framework conceptualizes urban ponds as essential components of city waterscapes, functioning as a "composite resource" that integrates water, land, and public space [11]. These ponds are critical for providing ecosystem services and are central to "blue infrastructure," which has gained prominence in discussions on urban resilience and climate adaptation [12]. With their ability to mitigate droughts and floods, improve water quality, and support biodiversity, ponds and interconnected pondscapes hold immense potential as nature-based solutions (NBS).

Building on this, the Urban Political Ecology (UPE) framework provides a socio-ecological perspective, examining how urban pondscapes are shaped by power, politics, and scale [13]. UPE views cities as dynamic spaces where environmental, social, economic, and political forces converge, influencing the transformation of waterscapes. By framing ponds not only as physical entities but also as cultural and symbolic landscapes, UPE highlights the role of power dynamics in shaping urban environmental governance [14, 15].

The concept of pondscape can also be analyzed through the lens of environmental justice and gentrification. Environmental justice addresses the unequal distribution of environmental risks and benefits, emphasizing fairness and accountability in protecting vulnerable populations. Historically focused on the disproportionate impact of environmental hazards on marginalized groups, the environmental justice movement has evolved to consider broader social inequalities, such as disparities in environmental conditions between wealthy and poor communities [16]. In contrast, environmental gentrification highlights how urban development near water bodies—such as constructing high-rise buildings or reclaiming land by filling water bodies—can lead to neighborhood transformations. While these changes may enhance urban infrastructure, they often result in rising property values that displace less affluent residents, exacerbating inequities and conflicting with the principles of environmental justice [16].

Together, these frameworks underscore the multifaceted nature of urban pondscapes, illustrating their ecological, social, and political dimensions. They highlight the need for inclusive policies that balance urban development with social equity and environmental preservation, ensuring that pondscapes are managed in a sustainable and just manner.

2 Methodology

Details of the methodology are discussed in the following sub-sections.

2.1 Study Sites

The KMA (Figure 1) encompasses a diverse administrative structure, including 4 municipal corporations, 41 municipalities, 70 non-municipal urban areas, 14 outgrowths, and 422 rural areas. Spanning an area of 1,851.41 square kilometres, KMA had a population of 14.69 million in 2011, which is estimated to have grown to 19.93 million by 2023. The Hooghly River, flowing through the center of KMA, divides the region, with municipal corporations and municipalities located on both its eastern and western banks. These urban and rural settlements are distributed across six districts: Kolkata, North and South 24 Parganas, Howrah, Hooghly, and Nadia. This river-centric distribution highlights the region's reliance on the Hooghly as a natural and cultural axis for development.

Serampore, a historic town in the Hooghly district of West Bengal, India, is located on the western bank of the Hooghly River, approximately 24 kilometres (15 miles) north of Kolkata, the state capital. Its strategic geographic position has historically established it as a significant hub for trade, culture, and education. The Serampore Municipality (Figure 1), encompassing an area of 17.60 square kilometres, is divided into 29 administrative wards.

Historically, Serampore was first a Danish colony before becoming a British colonial settlement, remaining under British rule until India's independence. The town is known for its industrial heritage, with several jute mills and medium-sized factories contributing to its economy. In 2011, Serampore had a population of 0.18 million, which is estimated to increase to 0.25 million by 2024, reflecting a growth rate of 3.17%. This marks one of the highest population growth rates among the municipalities within the KMA.

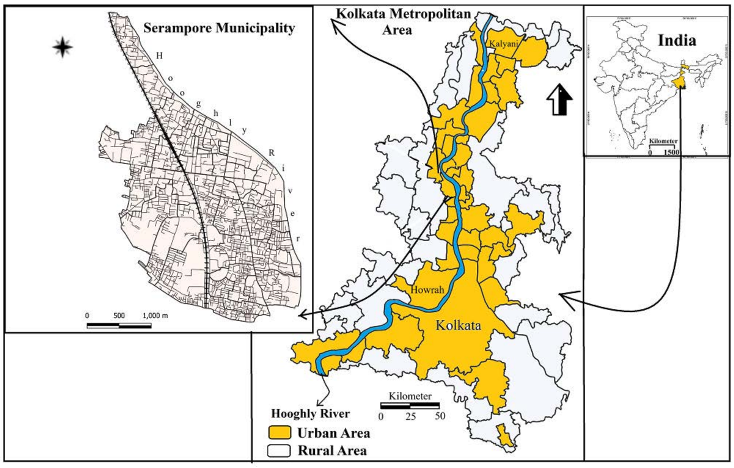

Figure 1. Study area: Serampore Municipality

2.2 Objectives and Data Source

This paper addresses four primary objectives. First, it seeks to identify and map the spatial distribution of ponds within the town. Second, it aims to assess the condition of ponds by classifying them into three categories: degraded, eutrophic, and thriving. This classification is crucial for identifying ponds at risk of being repurposed for new building construction, as degraded ponds are often targeted for such developments. The third objective is to examine the relationship between pond locations and the construction of new high-rise buildings. Understanding this relationship sheds light on how environmental gentrification has influenced the transformation of Serampore's pondscape. Finally, the paper analyzes existing policies and regulations designed to prevent and protect the degradation of pondscapes.

To study the pondscapes of Serampore, data were collected from Google Earth satellite imagery for two distinct periods: 2011 and 2024. High-rise building data for 2024 were also obtained from satellite imagery to explore the spatial relationship between pondscapes and newly developed construction areas. Additionally, population data were sourced from the 2011 Census of India to contextualize the analysis. Field visits were also conducted to observe the current condition of the ponds and to measure the depth of select ponds within the area. These on-ground observations provided critical insights to validate the satellite imagery data and to understand the actual status of pondscapes in Serampore. Combining satellite imagery, census data, and field observations allows for a comprehensive analysis of the interplay between urban development, pond health, and environmental policies in the town. This integrated approach ensures a more accurate representation of the pondscape dynamics and their socio-environmental implications.

2.3 Methods

The study employs a combination of remote sensing and field observations to assess the pondscapes of Serampore. Ponds were first identified and mapped using Google Earth Pro satellite imagery, supplemented by field visits to validate the findings. Additionally, data from the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) on water bodies and their water quality parameters has been utilized. Data were collected for two time periods, 2011 and 2024, to analyze changes in the pondscapes over time. This period was selected due to the significant surge in real estate development in suburban Kolkata [17]. This approach allowed the identification of ponds that have been filled and transformed into settlement areas.

In 2024, the health of the remaining ponds was evaluated and categorized into three classes: degraded, eutrophic, and thriving. This classification is primarily based on visual observation of the ponds. However, secondary data, including chlorophyll levels for a few ponds, was also utilized to assess their health. Chlorophyll value above 0.028 mg/L is considered high and indicative of eutrophication. Additionally, several high-rise buildings (having 4^{th} floor or more) constructed till 2024 were identified using field visits and Google satellite imagery to assess the relationship between pondscapes and newly developed built-up areas. This analysis aimed to understand the spatial dynamics of urban expansion and its impact on pondscapes in Serampore.

3 Results and Discussion

The following subsections examine the current state and the transformation of pondscapes within the Serampore Municipality.

3.1 Current Status of the Pondscape in Serampore

Ponds play a vital role in urban areas by contributing to ecological balance, urban resilience, and community well-being. This study identifies 191 ponds (Figure 2) in Serampore that existed between 2011 and 2024, with their presence continuing to date. These ponds vary in size and are distributed across different locations within the Serampore Municipality. Their sizes range from 179 square meters to over 2,000 square meters, prompting the categorization of ponds into different size groups (Figure 3) for analysis.

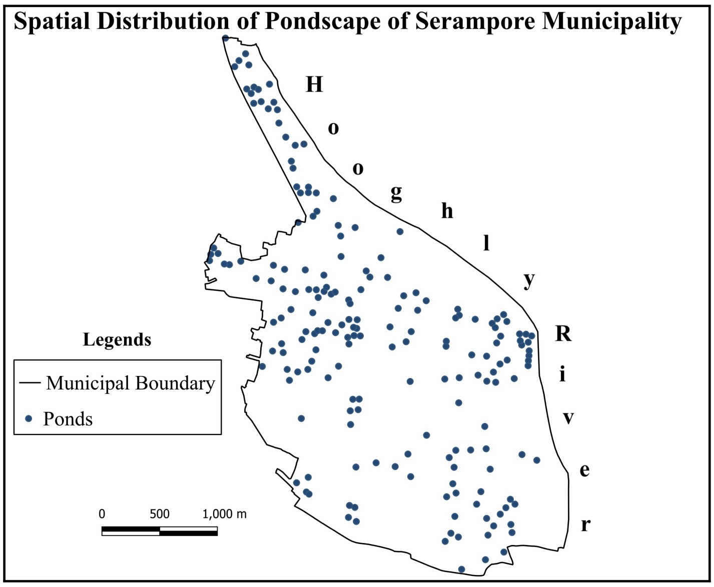

Figure 2. Spatial distribution of ponds of Serampore Municipality

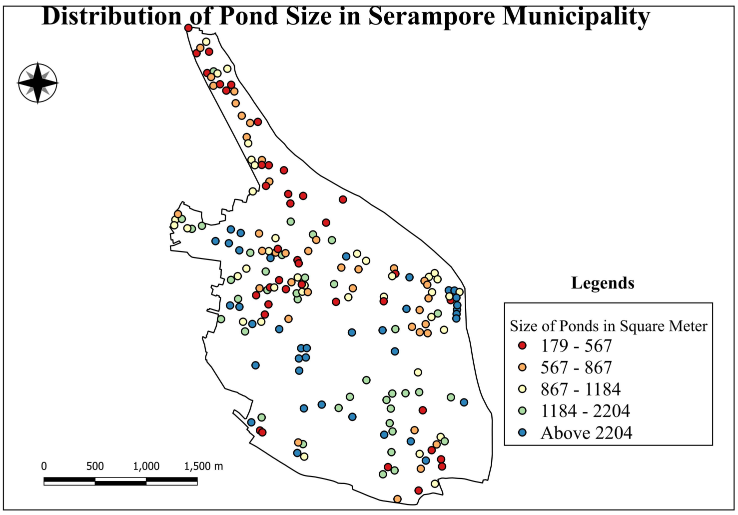

Figure 3. Size of the pond in Serampore Municipality

Note: Prepared by the author based on Google Earth image in 2024

The municipality has a total of 38 very small ponds, ranging in size from 179 to 567 square meters. Similarly, 39 ponds are classified as small, with sizes between 567 and 867 square meters. The medium-sized category includes 37 ponds measuring between 867 and 1,184 square meters. Additionally, there are 38 large ponds, ranging from 1,184 to

2,204 square meters, and 39 very large ponds exceeding 2,204 square meters. The largest pond spans an impressive 57,930 square meters. The average size of the pond in the municipality is 1,927 square meters (Table 1).

Table 1. Descriptive statistics of pond size in Serampore Municipality

ULB	Mean	Median	SD	CV (%)	Maximum	Minimum	First Quartile	Third Quartile
Serampore	1,927.69	1,045	4,491.1	2.32	57,930	179	612.5	1,855.0

Note: SD-Standard Deviation, CV-Coefficient of Variation

Google Earth and field visit in 2024

The large ponds are predominantly located in the western part of the municipality, while smaller ponds are concentrated in the older sections of the towns. Altogether, the ponds occupy 0.368 square kilometres, accounting for 2.09% of the municipality's total area. Most of these ponds are used for non-commercial purposes or serve as natural water reservoirs. A few, however, are utilized as drinking water reservoirs for the municipality.

To analyze pond health of the municipality, we have categorized ponds into three categories, which include eutrophic, degraded, and thriving. A eutrophic pond is a body of water with high nutrient levels. These nutrients promote excessive growth of algae and aquatic plants, leading to low oxygen levels in the water. This condition harms aquatic life and results in poor water quality. Eutrophic ponds are often characterized by cloudy, green water due to algal blooms. A buildup of organic material on the bottom. A degraded pond refers to a pond that has experienced significant ecological deterioration. This can be caused by pollution, siltation, invasive species, or habitat destruction. Key characteristics include poor water quality, limited aquatic vegetation, and reduced populations of fish and other wildlife. A thriving pond is a healthy and well-balanced ecosystem with clear water, diverse aquatic life, and abundant native vegetation. These ponds support a variety of species and maintain good water quality through natural processes. Features of thriving ponds include clean water with balanced nutrient levels and high biodiversity, with fish, amphibians, insects, and birds.

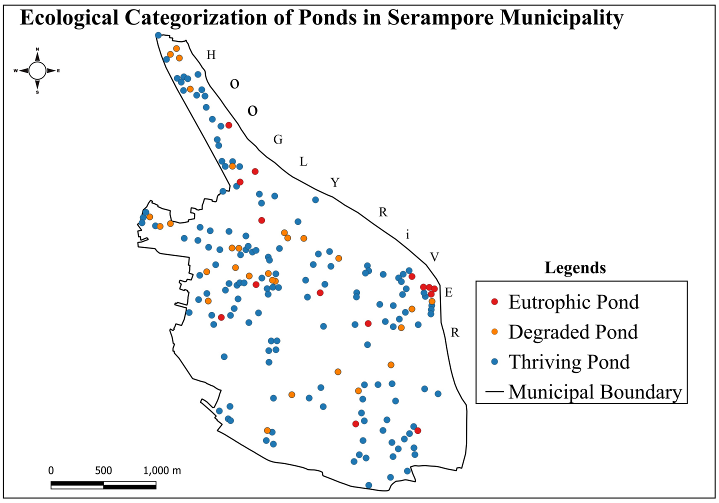

Figure 4. Ecological categorization of ponds

Note: Prepared by the author based on field observation and Google Earth image in 2024

Analysis reveals that, out of the 191 ponds in Serampore, 11 ponds (5.75%) are classified as eutrophic, while 32 ponds (16.7%) fall into the degraded category (Figure 4). However, the majority—148 ponds—are thriving (Table 2). These ponds are distributed across various parts of the municipality, with degraded ponds predominantly located in the northern areas, where the concentration of ponds is also higher. It is worth noting that secondary data from the AMRUT program, published by Bhuvan, indicates that out of the four ponds they surveyed, chlorophyll levels were high (above 0.028 mg/L) in two of them. This water quality parameter aligns with and supports the findings of this paper. The table below provides a ward-wise breakdown of the ecological health of these ponds.

The classification of pond ecology further reveals that in certain wards, such as Ward 6 and Ward 13, there are higher concentrations of thriving ponds, with totals of 21 and 20, respectively. Conversely, some wards, like Ward 18, have no ponds of any classification. Wards with a mix of ecological statuses include Ward 13, where there are 13 thriving, 5 degraded, and 2 eutrophic ponds. In contrast, smaller totals are observed in wards like Ward 9 and Ward 24, with only one thriving pond each. The data suggests an uneven distribution of pond health across the wards, reflecting varying environmental or anthropogenic influences. Analyzing the average depth of the ponds shows that the existing water bodies collectively have the capacity to hold 736.39 million liters of water. This highlights their crucial role as natural sponges during the rainy season, helping to mitigate flooding and prevent inundation in the town.

Table 2. Classification of ponds ecology

Ward No.	Pond Types			Total
	T	D	E	
1	12	4	0	16
2	8	1	1	10
3	4	0	2	6
4	12	3	0	15
5	10	2	0	12
6	14	7	0	21
7	0	2	1	3
8	4	0	0	4
9	1	0	0	1
10	0	1	0	1
11	2	1	0	3
12	4	0	0	4
13	13	5	2	20
14	2	0	0	2
15	2	0	0	2
16	2	0	1	3
17	3	2	0	5
18	0	0	0	0
19	4	0	0	4
20	5	0	1	6
21	4	0	0	4
22	6	0	1	7
23	3	0	0	3
24	1	0	0	1
25	5	1	0	6
26	4	1	1	6
27	9	0	0	9
28	9	0	1	10
29	5	2	0	7
Total	148	32	11	191

Note: T-Thriving, D-Degraded, and E-Eutrophic

Prepared by field observation and Google Earth Pro satellite image in 2024

The above trend underscores a concerning link between pond ecology and urban development, where the size and health of ponds are closely tied to the expansion of the real estate market. Degraded ponds, in particular, often become vulnerable to conversion as they are perceived as less valuable for ecological purposes, making them easy targets for high-rise construction. Over time, prolonged degradation accelerates their transition into potential sites for urban development. The following subsection delves into the mechanisms and implications of pond conversion for real estate projects within the KMA, highlighting the intersection of environmental degradation and urbanization pressures.

3.2 Transformation Process of Pondscape

In KMA, rapid urbanization and the relentless growth of real estate developments have led to the large-scale destruction of water bodies, particularly urban ponds. This issue is symptomatic of a broader trend where ecological assets are sacrificed for infrastructural and commercial expansion, often driven by the collusion of real estate developers, local authorities, and other stakeholders. The transformation of ponds typically occurs in distinct stages. Initially, ponds are filled illegally using construction debris, soil, and waste, laying the groundwork for building foundations. This activity, often carried out without public awareness or proper environmental clearances, constitutes the phase of illegal filling. Following this, the lands surrounding the ponds are progressively encroached upon. Over time, the water body is entirely consumed by expanding settlements, marking the phase of encroachment. The absence of strict monitoring further enables unauthorized developments, allowing ecologically sensitive areas to be converted into high-rise buildings or commercial complexes. The images from two different periods illustrate how ponds and adjacent agricultural land have been transformed into settlements, with new roads constructed over these areas.

Figure 5. Existence of ponds before settlement
Note: Google Earth satellite image

Figure 6. Transformation of ponds
Note: Google Earth satellite image

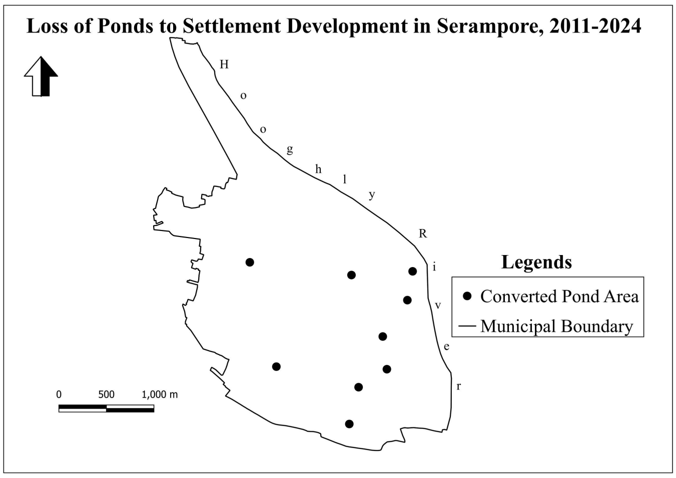

Figure 7. Ponds lost due to settlement development
Note: Google Earth satellite image in 2011 and 2024

Between 2011 and 2024, nine ponds in Serampore were transformed into settlement areas, accompanied by the development of road infrastructure. The affected ponds were located in Wards 5, 13, 15, 17, 19, 22, 23, and 29, as depicted in Figure 5 and Figure 6 which illustrates the transformed water body and its surroundings between 2011 and 2024. Figure 7 highlights the locations of these converted ponds, showcasing the significant land use changes driven by urban expansion. The size of the converted ponds ranges from 384 square meters to 4,300 square meters, with the largest water body conversion occurring in Ward 29. Despite these changes, Serampore still retains approximately one and a half ponds per 2,000 residents.

A correlation analysis was conducted to explore the relationship between ponds and the development of high-rise apartments across various wards of the Serampore Municipality (Figure 8). The results reveal a moderate positive correlation between the number of ponds and the presence of high-rise buildings. This suggests that areas with a greater concentration of water bodies are more likely to witness the construction of apartment complexes. The findings underscore a concerning trend in urban development, where ecologically significant water bodies are increasingly being targeted for construction projects. This highlights the urgent need for sustainable urban planning and conservation strategies to safeguard these critical resources. Protecting water bodies is not only essential for maintaining ecological balance but also for addressing broader urban resilience challenges, particularly in the face of climate change.

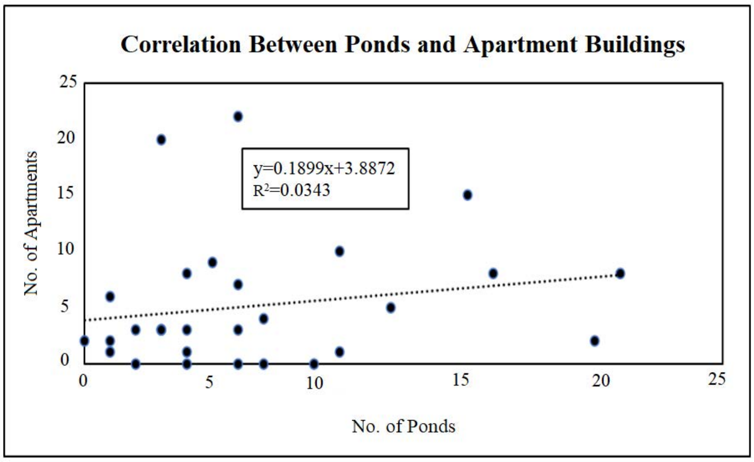

Figure 8. Relationship between ponds and apartment development

Note: Prepared by the author based on compiled data

Adapting to climate risks requires coordinated efforts from national and local governments, encompassing both structural measures, such as infrastructure investments, and non-structural measures, like disaster preparedness and early warning systems for floods. While traditional gray infrastructure—such as concrete walls, dikes, and drainage systems—has historically dominated, there is a growing recognition of the value of green infrastructure and NBS. These approaches are increasingly employed worldwide to enhance urban resilience by leveraging natural systems to complement conventional infrastructure [18]. A compelling example of NBS in practice is the concept of sponge cities, which absorb and retain excess rainwater, filter it, and release it gradually, mimicking the function of a sponge. Sponge cities incorporate features like wetlands, greenways, parks, rain gardens, green roofs, and bioswales. Ideally, green and gray infrastructure are integrated to mutually reinforce each other, enabling resilience by, for example, storing rainwater during wet periods for use during dry spells. The following section explores the policies and legislative measures designed to conserve and protect blue infrastructure in urban areas, emphasizing the critical need to balance development with environmental stewardship.

3.3 Policy Approaches to Pondscape Management

In the context of pond conversions in the KMA, the state environment department has established rules to protect water bodies and maintain ecological balance. The West Bengal Inland Fisheries Act of 1993, prohibits the conversion of water bodies without prior approval from the Land and Land Reforms Department. According to this act, any water body, including embankments, measuring at least 5 cottahs (0.035 hectares) and retaining water for six months annually, cannot be converted for settlement purposes unless an equivalent-sized water body is created nearby by the individual undertaking the conversion [19, 20].

Despite this regulation, urbanization pressures in KMA have rendered the act ineffective in preventing the conversion of water bodies. In response, the West Bengal government proposed a new pond policy aimed at consolidating all water bodies under a single framework, allowing private entities to manage them for profit. This move has faced strong criticism from the All-India Fisheries and Fisheries Workers Federation (AIFFWF), which argues that it jeopardizes the livelihoods of over 37 lakh fisherfolk across the states who rely on these water bodies [21].

Additionally, concerns have been raised about potential disruptions to the local food chain, particularly as fish is a vital and affordable protein source for the state's population. Increased commercialization may lead to a significant rise in fish prices. Furthermore, apprehensions exist about the possibility of a portal facilitating access for real estate agents, enabling them to exploit water bodies for tourism, construction, and other activities, potentially exacerbating the issue of water body conversions [21].

4 Conclusion

Urban ponds, often overlooked as ecological assets, play a crucial role in maintaining environmental sustainability, urban resilience, and biodiversity in rapidly expanding cities like Serampore. This study comprehensively analyzed the transformation of pondscapes in Serampore Municipality, part of the KMA, over the period from 2011 to 2024. The findings reveal alarming trends in pond degradation and conversion driven by urbanization pressures, real estate expansion, and ineffective governance. Despite their ecological, cultural, and social significance, ponds are increasingly under threat, necessitating immediate action to protect and conserve these vital water bodies. In Serampore, the identified 191 ponds vary in size and ecological health, highlighting their diverse roles in urban ecosystems. However, this study identified a concerning pattern of pond loss and degradation, with nine ponds converted into settlement areas and infrastructure projects during the study period. Such transformations compromise their ability to support environmental connectivity and community well-being. Moreover, the ecological health of ponds was categorized into thriving, degraded, and eutrophic states. While the majority of ponds were found to be thriving, the presence of eutrophic and degraded ponds underscores the impact of pollution, siltation, and urban neglect. Degraded ponds, in particular, are more susceptible to conversion for real estate projects, further accelerating their loss. This phenomenon not only disrupts local ecosystems but also exacerbates urban challenges such as water scarcity, reduced green spaces, and increased flood risks.

The study highlights a direct correlation between urban development and the decline of pondscapes. High-rise apartment buildings and road infrastructure have increasingly encroached upon pond areas, as seen in Serampore. The moderate positive correlation between the number of ponds and apartment buildings indicates that areas with a higher density of ponds are more likely to witness real estate expansion. This trend reveals a troubling pattern where ponds are targeted for construction, reflecting the commodification of urban spaces at the cost of ecological balance. Between 2011 and 2024, Serampore experienced a population growth rate of 3.17%, one of the highest in KMA. This rapid urbanization has heightened the demand for land, leading to the conversion of water bodies. The absence of effective enforcement mechanisms and monitoring systems has allowed illegal filling and encroachment of ponds to proliferate. The study also observed that degraded ponds, perceived as less valuable for ecological purposes, are often the first to be targeted for urban development.

Despite the existence of regulations like the West Bengal Inland Fisheries Act of 1993, which prohibits the conversion of water bodies without prior approval, the implementation of such policies remains inadequate. Urbanization pressures, coupled with collusion between real estate developers and local authorities, have rendered these protections largely ineffective. The study underscores the need for stronger policy enforcement and governance frameworks to safeguard ponds and prevent their exploitation for commercial purposes. The West Bengal government's recent proposal to consolidate water bodies under a single policy framework has sparked debate. While it aims to streamline governance and management, it has also raised concerns about potential privatization and the adverse impacts on fisherfolk and local communities who depend on ponds for their livelihoods. The commercialization of water bodies risks exacerbating social inequalities and undermining the ecological functions of ponds.

To address these challenges, a multi-pronged approach is essential. First, stringent enforcement of existing regulations must be prioritized to prevent illegal filling and encroachment. Second, community involvement in the management and conservation of ponds can foster a sense of ownership and accountability. Third, urban planning must integrate blue infrastructure as a key component, recognizing ponds as vital ecological assets rather than vacant lands for development. Additionally, technological interventions such as GIS mapping and real-time monitoring can enhance the effectiveness of pond management. Policies should also address the socio-economic dimensions of pond conservation, ensuring that livelihoods dependent on these water bodies are protected. Public awareness campaigns can further highlight the importance of ponds in sustaining urban ecosystems and inspire collective action for their preservation.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] "Midnight disaster: 9 killed and 17 injured in Garden Reach building collapse," *Times of India*, 2024. https://timesofindia.indiatimes.com/city/kolkata/under-construction-kolkata-building-collapse-tragedy/articleshow/108599019.cms

[2] "Kolkata building collapse: Residents lament illegal construction 'continuing'," *The Economic Times*, 2024. https://economictimes.indiatimes.com/news/india/kolkata-building-collapse-residents-lament-illegal-construction-continuing/articleshow/108595063.cms?from=mdr

[3] B. Oertli, J. Biggs, R. Céréghino, P. Grillas, P. Joly, and J. B. Lachavanne, "Conservation and monitoring of pond biodiversity: Introduction," *Aquat. Conserv.: Mar. Freshw. Ecosyst.*, vol. 15, no. 6, pp. 535–540, 2005. https://doi.org/10.1002/aqc.752

[4] J. Persson, "Urban lakes and ponds," in *Encyclopedia of Lakes and Reservoirs*. Dordrecht: Springer Netherlands, 2012. https://doi.org/10.1007/978-1-4020-4410-6_15

[5] J. Boothby, "Pond conservation: Towards a delineation of pondscapes," *Aquat. Conserv.: Mar. Freshw. Ecosyst.*, vol. 7, no. 2, pp. 127–132, 1997.

[6] C. Hassall, "The ecology and biodiversity of urban ponds," *Wires Water*, vol. 1, no. 2, pp. 187–206, 2014. https://doi.org/10.1002/wat2.1014

[7] B. Oertli and K. M. Parris, "Review: Toward management of urban ponds for freshwater biodiversity," *Ecosphere*, vol. 10, no. 7, p. 2810, 2019. https://doi.org/10.1002/ecs2.2810

[8] M. C. Pelletier, J. Ebersole, K. Mulvaney, B. Rashleigh, M. N. Gutierrez, M. Chintala, A. Kuhn, M. Molina, M. Bagley, and C. Lane, "Resilience of aquatic systems: Review and management implications," *Aquat. Sci.*, vol. 82, no. 44, 2020. https://doi.org/10.1007/s00027-020-00717-z

[9] J. Beninde, M. Veith, and A. Hochkirch, "Biodiversity in cities needs space: A meta-analysis of factors determining intra-urban biodiversity variation," *Ecol. Lett.*, vol. 18, no. 6, pp. 581–592, 2015. https://doi.org/10.1111/ele.12427

[10] H. B. Shaffer, "Urban biodiversity arks," *Nat. Sustain.*, vol. 1, no. 12, pp. 725–727, 2018. https://doi.org/10.1038/s41893-018-0193-y

[11] N. Cornea, A. Zimmer, and R. Véron, "Ponds, power and institutions: The everyday governance of accessing urban water bodies in a small Bengali city," *Int. J. Urban Reg. Res.*, vol. 40, no. 2, pp. 395–409, 2016. https://doi.org/10.1111/1468-2427.12377

[12] D. L. Childers, M. L. Cadenasso, J. M. Grove, V. Marshall, B. McGrath, and S. T. A. Pickett, "An ecology for cities: A transformational nexus of design and ecology to advance climate change resilience and urban sustainability," *Sustainability*, vol. 7, no. 4, pp. 3774–3791, 2015. https://doi.org/10.3390/su7043774

[13] E. Swyngedouw and N. C. Heynen, "Urban political ecology, justice and the politics of scale," *Antipode*, vol. 35, no. 5, pp. 898–918, 2003. https://doi.org/10.1111/j.1467-8330.2003.00364.x

[14] E. Swyngedouw, *Social Power and the Urbanisation of Water: Flows of Power*. Oxford: Oxford University Press, 2004.

[15] N. Heynen, "Urban political ecology I: The urban century," *Prog. Hum. Geogr.*, vol. 38, no. 4, pp. 598–604, 2014. https://doi.org/10.1177/0309132513500443

[16] K. Khoday and L. Perch, "Green equity: Environmental justice for more inclusive growth," *Int. Policy Cent. Incl. Growth*, no. 19, 2012.

[17] J. Karmakar, "Urban centers trend, pattern and key challenges for sustainability: Case of West Bengal, India," *Int. J. Soc. Sci.*, vol. 6, no. 3, pp. 181–190, 2017. https://doi.org/10.5958/2321-5771.2017.00021.7

[18] S. Rau, "Sponge cities: Integrating green and gray infrastructure to build climate change resilience in the People's Republic of China," *ADB Briefs*, no. 222, 2022. https://doi.org/10.22617/BRF220416-2

[19] *The West Bengal Inland Fisheries (Amendment) Act 1993*. Law Department, Government of West Bengal, 1997. https://wbllroa.in/wp-content/uploads/2021/01/LLRO_09_POND-FILLING_Sisirbabu.pdf

[20] *West Bengal Fisheries Policy 2015*. Department of Fisheries, Government of West Bengal, 2015. https://faolex.fao.org/docs/pdf/IND170539.pdf

[21] S. Chakrobarty, "West Bengal: Govt moots new pond policy at the cost of fisherfolks," *News Click*, 2023. https://www.newsclick.in/west-bengal-govt-moots-new-pond-policy-cost-fisherfolks