Blue-Green Systems

IWA PUBLISHING

Blue-Green Systems Vol 6 No 2, 198 doi: 10.2166/bgs.2024.102

An integrated framework for waterfront development to recognize nature-based solutions (NBS) in urban areas: evaluating the condition of two projects in Bangladesh

K. M. Ulil Amor Bin Zaman [a,*], Rifat Tabassoom Tumpa [a] and Imon Chowdhooree [b]

[a] Department of Architecture, Dhaka University of Engineering & Technology, Gazipur 1707, Bangladesh
[b] Postgraduate Programs in Disaster Management (PPDM), School of Architecture and Design, BRAC University, Dhaka, Bangladesh
*Corresponding author. E-mail: kmulilamor.binzaman@duet.ac.bd

KMUABZ, 0000-0002-7301-4214; RTT, 0000-0002-4091-4742; IC, 0000-0003-4884-8257

ABSTRACT

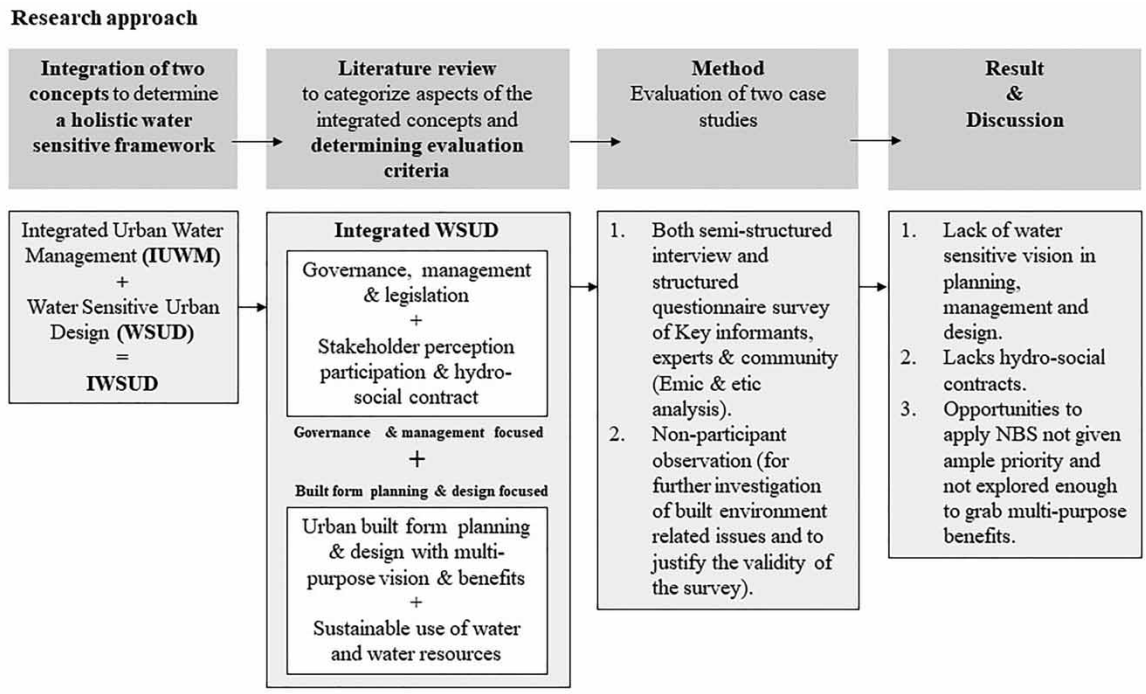
Nature-based solutions (NBS) often suggest improving the degraded urban environment through the implementation of projects for revitalizing water bodies and adjacent areas. Among various concepts of developing waterfront urban spaces, 'water sensitive urban design (WSUD)' asks for integrated design and management of urban water resources and water cycle, following a holistic approach. This research proposes a framework that assimilates the components of WSUD with the concept of 'integrated urban water management (IUWM)' that mainly focuses on governance, management, and stakeholders' engagement. This integrated approach emphasizes the need for developing a holistic framework for the management of planning and design of waterfront development projects. The framework includes detailed criteria for water sensitive approach and acts as a holistic checklist for evaluating or designing waterfront development projects. Such comprehensive guidelines that includes planning, governance, and design challenges are rare in the current body of literature. To test the framework, the research conducts a comparative study among two waterfront projects in Bangladesh and through a scored evaluation based on the proposed framework, reveals the lack of water sensitive planning, design and management processes of the projects, which has narrowed down the scope and the opportunities of practicing NBS through reviving lost urban waterbodies.

Key words: comparative study, integrated urban water management, nature-based solution, urban water body, water sensitive development, water sensitive urban design (WSUD)

HIGHLIGHTS

- Proposes the concept of 'integrated water sensitive urban design (IWSUD)'.
- Develops a holistic framework for evaluating waterfront development projects that can be used as an index or checklist.
- Framework illustrates detailed indicators for both design and management of waterfront restoration projects.
- Emphasizes the need for planning for biodiversity, and designing streamlines by applying NBS and WSUD tools integrally.

GRAPHICAL ABSTRACT



1. INTRODUCTION

Nature-based solutions (NBS) are often considered suitable means for improving the condition of urban areas by applying a series of solutions inspired by nature in a context where the natural systems are already disturbed, polluted, or deteriorated (Hsieh *et al.* 2016; Kabisch *et al.* 2016, 2017; Mariani *et al.* 2016; Mukherjee *et al.* 2022; Chowdhooree & Aziz 2023). NBS usually focuses on improving the quality of blue infrastructures that include any type of water body, i.e., streams, storm water drains, irrigation channels, wetlands, freshwater, sanitation, and public spaces that can temporarily accommodate water overflow, and green infrastructures that include trees along streets, recreation zones, playgrounds, parks, forests, greenways, and riparian strips (Mayr *et al.* 2017; Chowdhooree & Aziz 2023). The degraded conditions of water systems and water bodies due to unregulated urbanization, industrialization, and encroachments (Shukla *et al.* 2013; Chowdhooree *et al.* 2024) are often attempted to improve through implementing projects that revive and restore water bodies and revitalize the adjacent areas within an urban fabric. This kind of project, often referred to as waterfront developments (Wang & Lu 2001), usually aims to provide the benefits of blue-green networks in both environmental and functional ways (Djukic *et al.* 2020).

A growing number of concepts and approaches have been developed to design blue-green networks for enhancing urban resilience by alleviating a series of critical issues and reducing multiple urban risks (Kabisch *et al.* 2017; Mayr *et al.* 2017; Ahmed *et al.* 2019; Mukherjee *et al.* 2022). Some mentionable concepts are sustainable urban water management (Gleick 2003; Mitchell 2005; Pahl-Wostl 2008), integrated water resources management (Mitchell 2005, 2006), water sensitive urban design (WSUD); (Wong & Brown 2009; Bach *et al.* 2015; Wella Hewage *et al.* 2016; Zaman & Chowdhooree 2022), water sensitive cities (Brown *et al.* 2009; Floyd *et al.* 2014; Rogers *et al.* 2020), sustainable urban drainage systems (Fryd *et al.* 2012; Ellis & Lundy 2016), sponge city (Jiang *et al.* 2017; Wang *et al.* 2017; Chan *et al.* 2018), etc. The concept of water sensitive cities suggests introducing more sensitive urban water services and systems for developing a livable, sustainable, productive, and resilient urban environment that allows improving degraded ecosystems and aging infrastructures (Brown *et al.* 2009; Floyd *et al.* 2014; Rogers *et al.* 2020). Similarly, the concept of WSUD suggests having integrated management of the three urban water systems: potable water, wastewater, and stormwater (Wong 2006; Zaman & Chowdhooree 2022), following a holistic approach where technical, social, economic, and environmental factors are addressed at their respective scales (Kuller *et al.* 2017). Integrated urban water management (IUWM) is another approach that also suggests improving the quality of vital ecosystems and

maximizing the resultant economic and social benefits by coordinating the development and management of water, land, and related resources (*Integrated Urban Water Management (IUWM): Toward Diversification & Sustainability* 2013). While both concepts (i.e., WSUD and IUWM) are integrated in nature, their focuses vary. Gersonius *et al.* (2016) argue that the IUWM concept largely focuses on the integration of governance and management, whereas WSUD is more focused on integral planning and design of sustainable technology and the natural built environment (Dolman *et al.* 2013). As a result, a potential shortcoming exists whereby projects might overlook certain aspects of either WSUD or IUWM. Therefore, there is a need for a comprehensive and integrated framework that includes detailed and precise water sensitive planning, management, and design criteria that can be used as a checklist and can be followed by practitioners or organizations for evaluating or designing waterfront development projects worldwide. For this purpose, this article aims to develop a research framework, integrating components of WSUD and IUWM and to evaluate selected projects based on the proposed framework to mark their success. Such comprehensive guidelines that combine water sensitive planning, governance, and design elements in a single framework are rare in the current body of literature.

To test the proposed framework, through a scored evaluation, the research conducts a comparative study among two waterfront projects in Bangladesh and evaluates the projects to mark their success in reviving the waterbodies as practices of NBS. The cases are 'Integrated Development of Hatirjheel Area, Including Begunbari Canal (HJP)' in Dhaka city and 'Sheikh Rasel Nagar Park (SRNP)' in Narayanganj city. This article follows a double-case study-based mixed research approach that includes a literature review, structured and semi-structured interviews (experts and community), and site observation.

2. CONCEPTS OF WSUD AND IUWM

The concept of WSUD suggests using water resources to improve the quality of the urban environment by reducing the amount of storm water runoff and hydrological impacts of urbanization, improving water quality through integrating ecological systems with human needs, the urban water cycle, urban design and built form, and improving landscape amenity, urban aesthetics, biodiversity, and microclimates (Ashley *et al.* 2013; Lennon *et al.* 2014; Salinas Rodriguez *et al.* 2014; Fletcher *et al.* 2015; Sharma *et al.* 2016; *Introduction to WSUD | Melbourne Water* 2017; Directorate 2023). It specifically focuses on efficiently managing, reusing, and recycling water from different sources (Ashley *et al.* 2013; Fletcher *et al.* 2013, 2015; Sharma *et al.* 2016, 2018; Zaman & Chowdhooree 2022).

On the other hand, the concept of IUWM suggests integrating water supply systems, sanitation systems, and storm and wastewater management systems with land use planning and economic development. It relies on coordinating urban development and basin management to achieve sustainable economic, social, and environmental goals (*Integrated Urban Water Management (IUWM): Toward Diversification & Sustainability* 2013). Gersonius *et al.* (2016) argue that the WSUD concept largely contains all aspects of IUWM; the IUWM focuses on the integration of governance and management, whereas WSUD is more focused on integral planning and designing of sustainable technology and the natural built environment (Dolman *et al.* 2013). According to Sharma *et al.* (2016), both concepts suggest including stakeholders in planning and decision-making; however, how stakeholders can actively participate in these actions is not being explained, as it is often hard to incorporate the diversified desires and perspectives of various stakeholders in each context without a common structure or strategy. To implement an IUWM plan, it seems necessary to integrate it with WSUD plans for stakeholders' active participation according to definite strategies (Buurman & Padawangi 2018), like a 'hydro-social contract' (the government's contract with the public) (Wong & Brown 2009), which is still lacking in many countries' local neighborhood plans. Fletcher *et al.* (2015) also suggest linking the scope of WSUD with the principles of IUWM to include supplementary built environment benefits.

Four major aspects can be identified from the available literature (Figure 1) on IUWM and WSUD (Brown *et al.* 2009; Van Leeuwen *et al.* 2012; Chin *et al.* 2013; Dolman *et al.* 2013; Pickett *et al.* 2013; Rodríguez *et al.* 2015; Yang *et al.* 2015; Dhar & Khirfan 2016; Sharma *et al.* 2016; Kuller *et al.* 2017; Maurya *et al.* 2020; Ranta *et al.* 2021; Hasan & Dhar 2022; Zaman & Chowdhooree 2022). The four aspects are:

(i) Governance, management, and legislation;
(ii) Stakeholder participation with hydro-social contract;
(iii) Urban built form planning and design with multipurpose vision and benefits; and
(iv) Sustainable use of water and water resources.

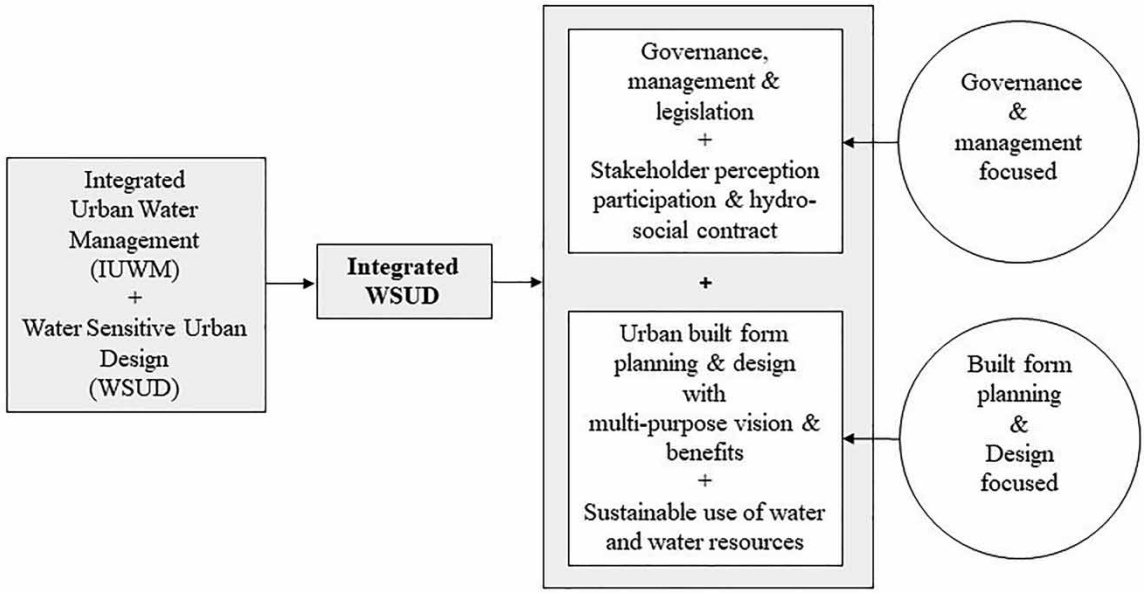


Figure 1 | Proposed theoretical framework for evaluating urban waterfront development project.

Here, the first two aspects are broadly focused on governance and management and the latter two are focused on planning and design of the built environment. Waterfront development projects can be accessed based on this proposed concept of IWSUD.

3. RESEARCH METHODOLOGY

3.1. Research tools

The methodological pluralism (Patton 1980; Hirschheim 1985; Chowdhooree 2019; Chowdhooree *et al.* 2024) used in this double-case study research permits the freedom to choose appropriate data collection tools for addressing particular research objectives (Cooper 1997) without guaranteeing certainty and universal generalization (Patton 1980). It employs multiple research tools that include a literature review, semi-structured and structured interviews of research participants, experts and key informants, and non-participatory observation. The two cases of urban waterfront development projects are 'Integrated Development of Hatirjheel Area, Including Begunbari Canal (HJP)' at Dhaka and 'Sheikh Rasel Nagar Park (SRNP)' at Narayanganj.

Initially, relevant scholarly peer-reviewed journal articles, government documents, and newspaper articles are reviewed to develop the research framework for assessing the features of waterfront development projects. In total, 51 pieces of literature, published from 2001 to 2023, were reviewed, employing the content analysis method to understand the concepts and approaches regarding urban water bodies and preparing the research framework for this study. The details of the search criteria are presented in Section 3.2.

From an epistemological perspective, to understand the perceptions of users of the spaces, structured and semi-structured interviews of the local people are conducted (Heath 2001; Chowdhooree 2019). Visitors, vendors, passersby, and residents from surrounding neighborhoods participated in the interview sessions. In this instance, adult users in the surrounding region who had previously experienced the project site before it was implemented and who lived no more than 25 m from the project site line or visited the place regularly were randomly approached to participate in the study. One hundred local people from each case study area participated in interview sessions that had a semi-structured and a structured part. Notes were taken during the interviews and their opinion-based responses were recorded in the Likert chart-based list of structured questions, according to the research framework. Additionally, six key informants and six experts consisting of three representatives from the consulting firms (appointed by the city council for designing the project), three representatives from each city council, and six urban planning and design experts (two natural resource managers, two landscape architects, and two urban designers) are interviewed by using a questionnaire set asked in a semi-structured way to find out the goals and objectives and the planning, design, and management processes of the projects. However, only a few questions were put to the key informants and experts as the questions were particularly and closely associated

with the design and planning of the project which requires expert knowledge. The survey answers, derived from structured interviews, are also averaged accordingly and indicated in the Supplementary material.

The idea of emic and etic analysis is used to capture the perspectives of both insiders and outsiders (Chowdhooree & Das 2021; Chowdhooree & Aziz 2023). Experts who are 'outsiders' with project knowledge enable etic analysis, whereas local users as well as key informants who are 'insiders' contribute the content for etic analysis. While the insiders' perspective as the etic analysis provides users with insights, the outsiders' perspective as the etic analysis guarantees cross-examination and impartial opinions of the situations and their impacts (Smith 1999; Chowdhooree & Das 2021; Chowdhooree & Aziz 2023). A Likert scale is used to reflect the triangulated views of both emic and etic analysis.

The study used interviews and non-participatory observation to conduct emic and etic analysis. Local participants engaged in active conversations with research team members, who explained identified attributes of the research framework based on systematic observation and understanding of project outcomes. Participants' experiences influenced the researchers' etic analysis. Participants expressed their understanding on a 5-band Likert scale, with 1 indicating the most unsuccessful performance and 5 indicating the most successful performance. The cumulated average number provided the final value of each attribute under each category, allowing comparison and evaluation of the success level of each criterion of the proposed framework. The non-participatory observation provided empirical evidence about the planning and design elements of the projects that assisted in justifying the validity of the overall findings (Figure 2).

3.2. Research framework

In total, 51 pieces of literature, published from 2001 to 2023, were selected based on search terms like 'water sensitive urban design', 'integrated urban water management', 'evaluating WSUD', 'indicators of WSUD', 'attributes of IUWM', and 'measuring criteria of IUWM'. Literature directly related to the two concepts and their measuring criteria are selected for further review. Different researchers have identified different criteria and indicators to assess these concepts and their aspects. Hence, we have categorized the criteria and their respective indicators under four basic aspects classified in the above literature. Finally, a review of selected literature (Brown *et al.* 2009; Coombes 2009; Van Leeuwen *et al.* 2012; Dolman *et al.* 2013; Pickett *et al.* 2013; Rodríguez *et al.* 2015; Yang *et al.* 2015; Dhar & Khirfan 2016; Kuller *et al.* 2017; Maurya *et al.* 2020; Allan *et al.* 2021; Ranta *et al.* 2021; Hasan & Dhar 2022; Zaman & Chowdhooree 2022; Chowdhooree & Aziz 2023) allowed us to identify detailed criteria as well as attributes of four aspects for the proposed framework.

Table 1 shows the list of detailed attributes under each criterion of each aspect of the proposed framework.

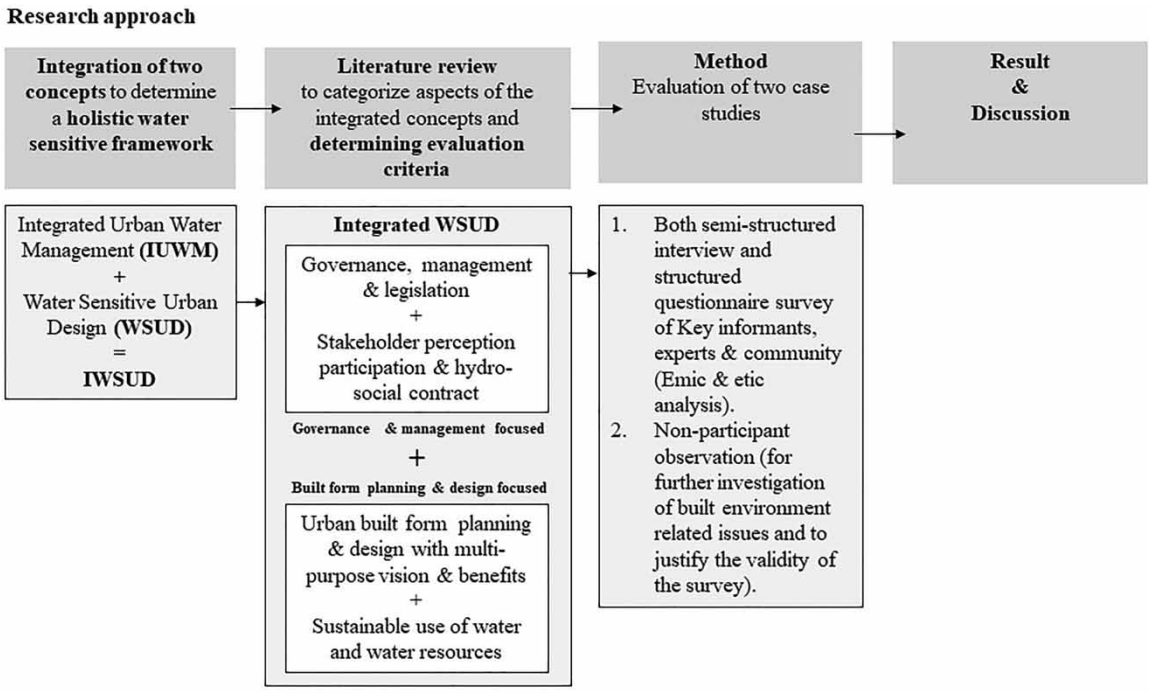


Figure 2 | Research approach.

Table 1 | List of detailed attributes under each category under each aspect of IWSUD concept (1 and 2 aspects indicate governance and management-based approaches while 3 and 4 aspects mostly indicate planning and design-based criteria)

Aspects	Criteria	Detailed attributes	Sources
1. Governance, legislation, and management	Institutional integration and multidisciplinary approach	Involvement of multidisciplinary organizations or collaborative planning Coordination of entitled bodies through integrated guidelines Existence of an observatory to follow up the integrated approach	Rodríguez *et al.* (2015)
	Laws and legislation	Existence of planning codes and guidelines for waterbody restoration Circulation of proposed/decided master plans for user's concern Cease of illegal land over and surrounding the waterbody	Rodríguez *et al.* (2015), Kuller *et al.* (2017)
	Stakeholder engagement scope	Acceptance of stakeholder's proposals during planning Promotion of events to be engaged in the process Involvement in projects conduction and monitoring	Rodríguez *et al.* (2015)
	Management and action plan	Proposal and progress on action plans Completion of proposed actions	Van Leeuwen *et al.* (2012)
	Infrastructure for solid waste dumping system	Existence of defined dumping system for different solid wastes Frequent monitoring of dumping service Recycling and reusing solid waste to the possible extent	Van Leeuwen *et al.* (2012), Kuller *et al.* (2017)
2. Stakeholder perception, participation, and hydro-social contract	Stakeholder participation	Number of events to include public, number of presentations of design to public, and groups involved in proposal preparation	Rodríguez *et al.* (2015)
	Public awareness	Awareness and engagement program to protect waterbody Use of waste dumping bins by public Knowledge of WSUD and benefits Public willingness toward WSUD	Van Leeuwen *et al.* (2012), Kuller *et al.* (2017)
	Social cohesion and hydro-social contracts	Encouragement of public participation by the authority Volunteering participation in implementation and management Existence of community clubs for managing and monitoring	Brown *et al.* (2009), Rodríguez *et al.* (2015), Kuller *et al.* (2017), Maurya *et al.* (2020)
	Political stability	Political responsiveness Government control	Kuller *et al.* (2017)
3. Urban built planning and design with vision of multipurpose benefits	Integrated planning and design	Assigning multidisciplinary expertise to coordinate the integrated approach Implementation and integration of WSUD with existing infrastructure	Zaman & Chowdhooree (2022)
	Aesthetics	Enhanced visual quality of urban landscape through WSUD tools (green walls, wetlands)	Van Leeuwen *et al.* (2012)

(*Continued.*)

Table 1 | Continued

Aspects	Criteria	Detailed attributes	Sources
		Attractive as a place of public gathering	
	Water transport system	Demand of water transports in the area and existence of water vehicles	Coombes (2009)
	Recreational water-based facilities	Presence of recreational activities required by the users	Stevens (2020)
		Enhancing connection with water (telescope, water robot, games)	
	Integration with terrestrial environment	Watershed and stream's network (whole of a water cycle)	Allan & Castillo (2021), Pickett *et al.* (2013), Rodríguez *et al.* (2015), Kuller *et al.* (2017), Ranta *et al.* (2021), Hasan & Dhar (2022)
		Green network for continuation of ecosystem	
		Provision of natural/soft surfaces to allow infiltration, hydrological cycles, and biochemical cycles	
		Non-structural buffer zone	
	Preserving natural flow of waterbody	Avoiding straightening stream and allow stream's natural activity	Allan & Castillo (2021), Yang *et al.* (2015), Hasan & Dhar (2022)
		Provision of floodplain	
	Preserving biodiversity	Designed streambed for enabling pool and riffle effect for better aquatic biodiversity	Allan & Castillo (2021), Van Leeuwen *et al.* (2012), Ranta *et al.* (2021), Hasan & Dhar (2022)
		Provide soft surface and maintain water quality for algae growth and biochemical cycle	
		Providing zones for aquatic, riparian, and terrestrial ecosystem	
		Buffer for safeguarding stream ecosystem	
	Connection of built environment with waterbody	Public access to waterbody and its infrastructures	Dhar & Khirfan (2016), Ranta *et al.* (2021), Hasan & Dhar (2022)
		Connectivity of surrounding environment and community with water	
		Representation of local history and cultural elements through program and design	
	Microclimate	Responsive surface design to mitigate urban heat island	Chin *et al.* (2013), Rodríguez *et al.* (2015), Hasan & Dhar (2022)
	Water quality	Application of WSUD tools to maintain water quality	Dolman *et al.* (2013), Maurya *et al.* (2020)
4. Sustainable use of water and water resources	Water harvesting, reuse and recycling using WSUD tools	Application of WSUD tools for water harvesting, reuse, and recycling in planning, and design (bioretention, swales, rainwater tank)	Dolman *et al.* (2013), Rodríguez *et al.* (2015)
		Practice of rainwater collection (WSUD tool) in the community	
		Practice of reusing grey water	
		Initiatives to recycle wastewater (within site)	
	Water efficiency	Use of water efficient fixtures (within the structures)	Rodríguez *et al.* (2015), Sharma *et al.* (2016)
		Encouraging behavior change to reduce water waste conserve water	

3.3. Case study projects

- *Integrated Development of Hatirjheel Area Including Begunbari Canal (HJP), Dhaka*: It is mainly a wetland restoration project in Dhaka, the capital of Bangladesh. It aims to solve urban flooding and drainage congestion problems by reviving the natural drainage system, easing vehicular traffic congestion by providing vehicular roads, streets, and bridges, operating a water-based mass transportation system, retaining water during the monsoon season, managing wastewater, restoring ecosystems and biodiversity in the area, and to provide recreational, civic, and social facilities. It has increased green and open space, covering 311 acres of land in the capital. The project was started in 2008, and its major components were finished by 2015 (Jalal 2012; Khan *et al.* 2015; Unb 2015; Irfanullah 2021; Jahan 2023).
- *Sheikh Rasel Nagar Park (SRNP), Narayanganj*: It is located in Narayanganj, a significant historic town not far from Dhaka. It is both an industrial town and a river port. The SRNP is part of a big water channel restoration project that is officially titled 'Restoration of Baburail Canal with landscaping, beautification, and lighting features'. The planning of the project started in 2011, and the SRNP was completed and opened to public access in 2022. The green recreational park is developed around an existing lake called Jimkhana, covering almost 18 acres of land. Jimkhana Lake was previously abandoned and used as a dumping zone. The lake is now being restored, expanded, and designed as a retention pond of approximately 670 m by 75 m. It aimed to develop a water body that would stimulate a socially inclusive public space (VITTI Shtapati Brindo Ltd 2017; Chowdhooree & Aziz 2023; *Bangladesh Forms* n.d.). Figure 3 shows the locations of the selected case studies.

4. RESULTS: DEVELOPMENT PROCESS AND CURRENT CONDITIONS OF TWO WATERFRONT DEVELOPMENT PROJECTS (HJP AND SRNP)

The results of non-participatory observation and semi-structured interviews are presented in this section.

4.1. Development of HJP

From the semi-structured interviews and questionnaire survey, it became clear that the main purpose of this project was to revive the water body as a retention area for stormwater to reduce the risk of inundation and other environmental hazards. The water body was in disrepair and was not performing its drainage role well prior to the project. The degraded environment of the whole area was improved by transforming the wastewater channel into a freshwater lake through the installation of a large-diameter wastewater diversion sewer along the periphery of the project area. The overall road network of Dhaka city was also improved by introducing vehicular roads along the water periphery and establishing an east-west ring connection between two major north-south arterial roads in Dhaka city.

Multiple and multidisciplinary organizations were involved in the project planning and implementation process. Rajdhani Unnayan Kartipakkha (RAJUK), the main development authority of the capital city, was in charge of the major planning and implementation of the project. Besides RAJUK, the Local Government and

Figure 3 | Location of HJP (left) and SRNP (right).

Engineering Department (LGED), Dhaka WASA (Water and Sanitation Authority), and the Special Work Organization (16 Engineer Construction Battalion) of the Bangladesh Army were involved in the implementation of the project. Nationally renowned consulting firms were appointed for architectural design, site planning, structural design, and electro-mechanical design. Expert academics from the Bangladesh University of Engineering and Technology (BUET) also assisted in developing the master plan. The National Water Policy, the National Water Management Plan, the National Water Body Protection, and Preservation of Open Space and Playground Act of 2000 were consulted and followed for this project. However, the key informants admit that there was a lack of coordination in developing integrated guidelines for easing the coordination among different organizations, and the project often suffered due to a lack of coordination among different urban, environmental, and social planning experts.

Key informants claimed that at the beginning of the planning stage, it was attempted to get opinions from different urban stakeholders. However, it was not possible to maintain the active participation of stakeholders in the final design process. Even the research participants from the vicinity cannot recall any attempt to engage any of them in the design, planning, and implementation process. There is even no plan to engage the stakeholders or the project's direct beneficiaries in management, maintenance, and improvement or alteration works or projects. Governmental organizations (i.e., RAJUK, LGED, and Dhaka WASA) are now jointly responsible for the maintenance and monitoring of the project. There are some formal community clubs that often get involved voluntarily in cleaning and monitoring the neighborhood, but these clubs are not actively involved in waterbody maintenance works.

From the non-participant observation, it is seen that there are no separate cycling or running tracks and the pedestrian walkway is used for walking, jogging, and running (Figures 4 and 5). It has a narrow terrestrial buffer zone with limited vegetation. A water-based mass transport system has been introduced here and it has been used as one of the successful water-based mass transportation of the city. Besides, some parts are used for recreational paddle boating. Restoring the waterbody has allowed generation of some aquatic life in the water and urban animals in the adjacent green spaces. Decorative and synchronized water fountains were also installed, and these became points of attraction for the people. The area also has an open-air theater for arranging

Figure 4 | Existing condition of HJP.

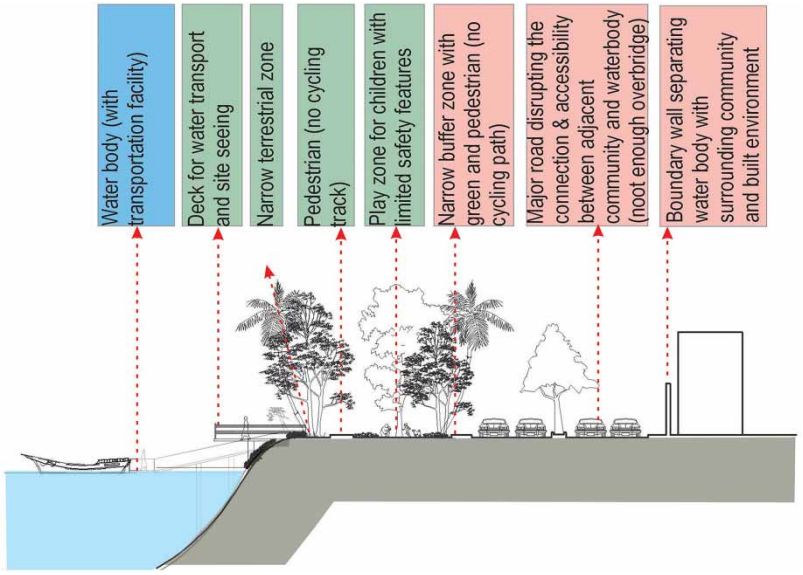


Figure 5 | Existing typical section of HJP.

any sort of cultural performance for a large number of spectators however, public access to it is restricted to scheduled events which occur infrequently throughout the year leaving the amphitheater unused most of the time. The area also has multiple restaurants, cafes, food carts, and children's play areas. The child play zone located adjacent to the major vehicular roads on the north side of the project has limited safety features.

The city corporations regularly collect solid waste from the defined dumping zones although the project area lacks enough dumping zones at appropriate locations and sustainable management of waste considering the life cycle of the waste. The retail shop owners and vendors found the project beneficial to their business, however, they, along with the community, are not happy with the waste management system. HJP is the city's largest natural stormwater detention basin of the city, but the reuse or recycling of water is not carefully planned and operated. No regulation is imposed for harvesting rainwater at the individual building level and therefore neither stormwater collection nor recycling of wastewater is practiced. The water body receives contaminated stormwater from adjacent urban lands and inlets are not properly controlled and terrestrial zones are not designed carefully to save the water from contamination. The challenges of wastewater management and drainage systems are still present here. The special sewage diversion structures (SSDS) are installed, but it has some defects (i.e., discharge of domestic sewage gets mixed with storm sewers). Therefore, it is a challenge to maintain the desired water quality, especially during the monsoon season.

Although the people residing in the HJP area are detached from the waterbody by a boundary wall and major vehicular roads (Figure 5), all respondents found themselves privileged because of this project's close proximity. They are happy to see the area being developed as a public space away from encroached slums and dirty dumping zones. Figure 4 shows the existing condition of HJP.

4.2. Development of SRNP

Key informants and research respondents conveyed the message that there was a public demand for reviving the Baburail canal with adjacent Jimkhana Lake, Nimtola Lake, and other water bodies and re-excavating their connections with the major rivers of the city. The Jimkhana Lake area has been developed as an urban green park with a children's art school, public toilets, a fitness center, skating areas, a swimming pool, children's play areas, play fields, water fountains, viewing decks, an amphitheater, various seating arrangements, walk-ways, cycling lanes, streetlights, and public art installations. The funding for this project was handled by the Local Government Engineering Department (LGED)'s Municipal Government and Services Project (MGSP), which is funded by the World Bank Group's International Development Association (IDA). Multiple consulting firms were involved in site planning, architectural design, structural design, and electro-mechanical design. The key informants confirmed that there were no integrated guidelines for coordinating the involvement of different urban, environmental, and social planning experts for this project.

Prior to the project, the area experienced flooding, air and water pollution, and the loss of its natural ecosystem because of encroachment by locals, businesses, and squatters as well as by government agencies like the city corporation. Key informants asserted that the project planning team scheduled central public consultation meetings and focus group discussions with local residents to make important decisions on the project. However, it was found that the detailed design of the project was not shared with all stakeholders, and their input and engagement were totally absent in the design finalization and implementation stages. Scopes of community engagement are also absent for managing and maintaining the water body, adjacent green areas, and other functional public spaces.

From the non-participant observation, the lack of proper solid waste management is also found in this project area. Like HJP, no cycling or running tracks and narrow territorial zones are found in SRNP. Some of the pedestrian zones are occupied by food carts which obstruct human movement. Additionally, the carts generate solid waste which is dumped into undesignated areas, especially into the territorial zones ultimately polluting water. Vehicular roads and their adjacent land-use hinder community accessibility and connectivity with the waterbody (Figures 6 and 7). Despite these issues, every respondent from the neighborhood of SRNP is very satisfied with the intervention. They valued the project as a place for relaxation, recreation, and social interaction. It boosted the biodiversity of the surrounding ecosystem by incorporating greenery along the water body. As continuous water flow is ensured in the lake by connecting them with running canals, water pollution has been reduced, and aquatic life is found in some parts. However, no recycling or reusing of water has been observed in the project area yet. Water control devices are placed at both ends of the Baburail canal (which is connected to Jimkhana Lake) to protect the water from contamination from polluted river water. Besides, a separate regulated side surface drainage system is installed for discharging the wastewater into the nearby rivers instead of canals. It is not good for the river, though. Figures 6 and 7 show the existing condition of SRNP.

4.3. Scoring of categorized aspects

In the next phase of the survey, it was attempted to identify the rate of success of each detailed attribute under each criterion and under each aspect of the proposed framework, as shown in Table 1. As explained in Section 3.2, the scored values were generated using the 5-band Likert chart, and the scores are presented in Table 2.

The HJP scored 1.89, and the SRNP scored 1.76. The average scores of four aspects for the HJP are respectively 2.00, 1.91, 2.66, and 1, and for the SRNP are 1.79, 1.82, 2.44, and 1.

Figure 6 | Existing condition of SRNP.

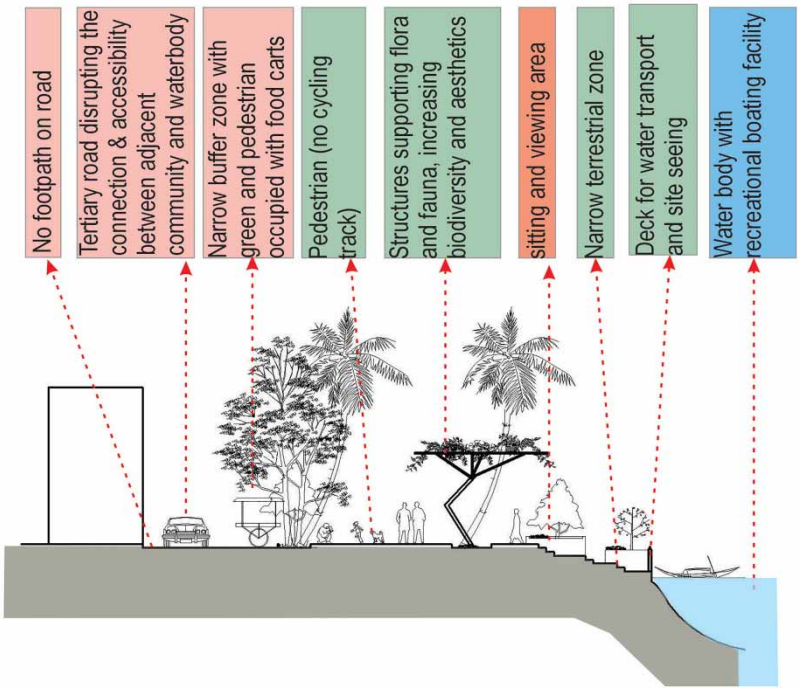


Figure 7 | Existing typical section of SRNP.

4.4. Analysis of scores

Both projects were initiated to revive the lost water bodies within densely developed urban fabric as an attempt to practice NBS and WSUD by introducing urban open spaces with water bodies, trees, pavement, and some other functional spaces. Both attempts can be appreciated as development projects where the lost water bodies were revived by reclaiming encroached lands, excavating water channels, introducing green vegetation areas, and providing public functional areas within an organically developed urban fabric. The average score of all four aspects of the HJP is 1.89, and the same score is 1.76 for the SRNP. Though the HJP scored higher than the SRNP, the difference is not significant, and both scores are very low. Due to their lack of consideration for many of the framework's aspects throughout the project planning and design, both projects received low scores in this assessment.

The lowest scores in the fourth aspect of 'sustainable use of water and water resources' prove that there was no consideration for rainwater harvesting and using the rainwater, reusing, and recycling grey water, using water efficient fixtures (within the structures), and encouraging change in community behavior to reduce water waste and conserve water. These aspects are important for making any waterfront development project successful and sustainable (Pahl-Wostl 2008; Ellis & Lundy 2016; Chan *et al.* 2018; Zaman & Chowdhooree 2022; Chowdhooree & Aziz 2023).

Both projects scored the highest in the third aspect of 'urban built planning and design with a vision of multipurpose benefits'. But the scores are around half of the total score, so they cannot prove the project's success in this sector. Both projects missed incorporating some details which are important for practicing NBS and WSUD for mitigating urban risks, like maintaining vegetation for improving the water quality (Djukic *et al.* 2020), introducing responsive surface design to mitigate extreme heat and maintain hydrological flow (Jiang Zevenbergen & Fu 2017; Chan *et al.* 2018; Hasan & Dhar 2022), restoring tangible and intangible heritage (Kabisch *et al.* 2017), designing floodplain and buffer zone to safeguard riparian and terrestrial ecosystem, designing streambed for enabling pool and ripple effect for improved aquatic biodiversity (Van Leeuwen *et al.* 2012; Ranta *et al.* 2021; Hasan & Dhar 2022), and integrating stormwater, water supply, water reuse, recycle, and sewage management (Ahmed *et al.* 2019; 'Water Sensitive Urban Design (WSUD)' n.d.).

Both projects scored below 2.00 in the second aspect of 'stakeholder perception, participation, and hydrosocial contract'. There is neither any scope for engaging the community in managing, maintaining, or monitoring the project nor any program for raising awareness among the community. In the first aspect of 'governance,

Table 2 | Scoring categorized aspects of IWSUD

Aspect	Criteria	Detailed attribute	Score		Average score		Overall average score	
			HJP	SRNP	HJP	SRNP	HJP	SRNP
1. Governance, legislation, and management	Institutional integration and multidisciplinary approach	Involvement of multidisciplinary organizations or collaborative planning	3.00	2.00	1.66	1.33	2.00	1.79
		Coordination of entitled bodies through integrated guidelines	1.00	1.00				
		Existence of an observatory to follow up the integrated approach	1.00	1.00				
	Laws and legislation	Existence of planning codes and guidelines for waterbody restoration	2.00	2.00	2.33	2.33		
		Circulation of proposed/decided master plans for user's concern	1.00	1.00				
		Cease of illegal land over and surrounding the waterbody	4.00	4.00				
	Stakeholder engagement scope	Acceptance of stakeholder's proposals during planning	1.00	1.00	1.00	1.00		
		Promotion of events to be engaged in the process	1.00	1.00				
		Involvement in projects conduction and monitoring	1.00	1.00				
	Management and action plan	Proposal and progress on action plans	3.00	3.00	3.50	3.00		
		Completion of proposed actions	4.00	3.00				
	Infrastructure for solid waste dumping system	Existence of defined dumping system for different solid wastes	2.00	1.00	2.00	1.33		
		Frequent monitoring of dumping service	3.00	3.00				
		Recycling and reusing solid waste to the possible extent	1.00	1.00				
2. Stakeholder perception, participation, and hydro-social contract	Stakeholder participation	Number of events to include public	1.00	1.00	1.00	1.00	1.91	1.82
		Presentation of design to public and groups involved in proposal preparation	1.00	1.00				
	Public awareness	Awareness and engagement program to protect waterbody	1.00	1.00	2.25	1.75		
		Use of waste dumbing bins by public	3.00	2.00				
		Knowledge of WSUD and benefits	2.00	1.00				
		Public willingness toward WSUD	3.00	3.00				
	Social cohesion and hydro-social contracts	Encouragement of public participation by the authority	1.00	1.00	1.00	1.00		
		Volunteering participation in implementation and management	1.00	1.00				
		Existence of community clubs for managing and monitoring	1.00	1.00				
	Political stability	Political responsiveness	3.00	4.00	3.50	4.0		
		Government control	4.00	4.00				
3. Urban built planning and design with vision of multipurpose benefits	Integrated planning and design	Assigning multidisciplinary expertise to coordinate the integrated approach	3.00	3.00	2.0	2.0	2.66	2.44
		Implementation and integration of WSUD with existing infrastructure	1.00	1.00				
	Aesthetics	Enhanced visual quality of urban landscape	4.00	4.00	4.0	4.0		
		Attractive as a place of public gathering	4.00	4.00				
	Water transport system	Demand of water transports in the area and existence of water vehicles	4.00	3.00	4.0	3.0		
	Recreational water-based facilities	Presence of recreational activities (children playing zones, games, etc.)	3.00	3.00	2.0	2.0		
		Enhancing connection/interaction with water (telescope, water robot, water plaza, etc.)	1.00	1.00				
	Integration with terrestrial environment	Watershed and stream's network (whole of a water cycle)	3.00	4.00	2.75	2.75		
		Green network for continuation of ecosystem	3.00	3.00				

(*Continued.*)

Table 2 | Continued

Aspect	Criteria	Detailed attribute	Score		Average score		Overall average score	
			HJP	SRNP	HJP	SRNP	HJP	SRNP
		Provision of natural/soft surfaces to allow infiltration, hydrological cycles, and biochemical cycles	3.00	3.00				
		Non-structural buffer zone	2.00	1.00				
	Preserving natural flow of waterbody	Avoiding straightening stream and allow stream's natural activity	5.00	5.00	3.50	3.0		
		Provision of floodplain	2.00	1.00				
	Preserving biodiversity	Designed streambed for enabling pool and riffle effect for better aquatic biodiversity	2.00	2.00	2.50	2.00		
		Provide soft surface and maintain water quality for algae growth and biochemical cycle	3.00	2.00				
		Providing zones for aquatic, riparian, and terrestrial ecosystem	3.00	2.00				
		Buffer for safeguarding stream ecosystem	2.00	2.00				
	Connection of built environment with waterbody	Public access to waterbody and its infrastructures	4.00	3.00	2.33	2.33		
		Connectivity of surrounding environment and community with water	2.00	3.00				
		Representation of local history and cultural elements through program and design	1.00	1.00				
	Microclimate	Responsive surface design to mitigate urban heat island	1.00	1.00	2.50	2.00		
		Landscape design to reduce urban heat island	4.00	3.00				
	Water quality	Application of WSUD tools to maintain water quality	1.00	1.00	1.00	1.00		
4. Sustainable use of water and water resources	Water harvesting, reuse and recycling using WSUD tools	Application of WSUD tools for water harvesting, reuse, and recycling in planning and design (bioretention, swales, rainwater tank)	1.00	1.00	1.00	1.00	1.00	1.00
		Practice of rainwater collection (WSUD tool) in the community	1.00	1.00				
		Practice of reusing grey water	1.00	1.00				
		Initiatives to recycle wastewater (within site)	1.00	1.00				
	Water efficiency	Use of water efficient fixtures (within the structures)	1.00	1.00	1.00	1.00		
		Encouraging behavior change to reduce water waste and conserve water	1.00	1.00				

legislation, and management', the HJP performed slightly better than the SRNP. The HJP performs a little better in the case of involving multidisciplinary organizations in planning, completing all proposed actions within the timeframe, and disposing of different types of solid waste. The poor scores in most of the aspects prove that the projects lost many opportunities for integrated water sensitive urban design (IWSUD) because they did not have a clear vision, targets, or framework for achieving the potential goals of NBS.

5. DISCUSSION

From the empirical study, it is evident that the country's major waterfront development projects lack a water sensitive vision in their planning and design strategies. The targets of the studied projects were to revive the natural drainage system, mitigate waterlogging problems, make the waterbodies free from encroachment, and revive their navigability. However, the projects did not explore other potential and relevant aspects to get the full benefits of ecosystem services. There was not enough scope for engaging the community in managing, maintaining, or monitoring the project. Planning for biodiversity, designing streamlines and streambeds targeting to improve aquatic ecosystem, and controlling non-point water pollution sources by applying NBS and WSUD tools (i.e., swales,

bioretention basin, wetlands, etc.) are not even considered in these cases let alone involving and ensuring stakeholder participation in different planning stages through proper hydro-social contracts.

Water-related issues are complex and diverse, and often city dwellers interpret water as an element to neglect, pollute, and encroach on its banks indiscriminately without any concern for environmental impacts on the overall city landscape (Ahmed *et al.* 2019; Chowdhooree *et al.* 2024). In this context, the studied cases can be appreciated as an attempt to realize the importance of water in the urban context. But the question is how to enjoy the full benefits of water bodies. The importance and benefits of applying NBS, combined with the aspects of WSUD and IUWM in waterfront projects, need to be realized by the communities as well as by the concerned authorities for conscious planning and designing with a holistic perspective shown in the proposed framework. This study attempted to provide such a framework that can be used as both an index or checklist and a guideline to restore waterbodies integrally and assist concerned authorities in future water sensitive development. Assessing certain projects with this framework can easily reveal the weaknesses and strengths of waterbody restoration projects.

Worldwide, there are not many integrated waterbody restoration guidelines, and this study is an example of an integrated one where the design and management of both spectrums have been considered. Therefore, a more holistic outcome can be ensured through this framework. The evaluation of the projects, and especially the low scores for every aspect, allow us to criticize the intention and process of the waterfront development projects, where the scopes and opportunities of practicing NBS through better urban design practices are missed in multiple ways. Because of the limited vision and intentions of the decision-makers, the projects have been implemented without exploring multiple opportunities, along with reviving the water bodies as NBS.

The robustness, integrated vision, and strategies of the proposed framework will assist planners and policymakers in implementing this in reviving or developing waterbodies while cooperating with stakeholders. The integrated framework by considering possible water-related governance, management, planning, and design-related issues and by specifying detailed indicators or criteria, which will obviously differ from context to context and with the behavior, culture, and norm of the stakeholders, allows the framework to be placed in any context. It clearly indicates the governance, planning, and design criteria that need to be addressed for a comprehensive water sensitive development. Therefore, this holistic framework can be perceived as a novel contribution to the field of evaluating waterfront projects in detail. The authors acknowledge that the proposed framework might encounter various on-site challenges during hands-on application. Hence, further research is needed to focus on the contextual, technical, and financial details and complications of the practical implementation of the framework.

6. CONCLUSION

While the application of WSUD and IUWM strategies is gaining traction globally with the aim of achieving water sensitive cities, a universally recognized example of a fully realized water sensitive city remains elusive. There are many reasons behind it. One of the major reasons is that there are no comprehensive framework or evaluation criteria for the projects that consider possible challenges from planning, design, and implementation to monitor, evaluate, and maintain. It is hard to identify or manage all issues in a single waterfront development project, however attempts need to be made to identify a comprehensive framework that considers all aspects including pre-planning and post-implementation goals.

This research proposes a framework which emphasizes the need for a holistic framework for the management of planning and design of waterfront development projects. Such comprehensive guidelines that include planning, governance, and design challenges are rare in the current body of literature. The study further reveals the lack of water sensitive planning, design, and management processes of the projects, which has narrowed down the scope and opportunities of practicing the NBS through reviving lost urban waterbodies. Additionally, the study shows how potential multipurpose benefits can be achieved through this framework and how this framework can also be used to judge an existing project's water sensitivity recognizing the context-specific challenges.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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First received 23 January 2024; accepted in revised form 12 July 2024. Available online 23 July 2024