

Applying Water Sensitive Urban Design Strategies in the Historical City Center of Baghdad, Iraq

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Abstract

Urban concepts that deal with the elements of the natural environment, especially water sources, have become widespread due to its great importance. However, many cities appear to neglect the water resources despite the fact that they are present in abundance. Baghdad is no exception. Indeed, it has grossly neglected its water sources. This research examines the absence of water sensitization strategies in the urban design of the historical center of Baghdad. It proposes a theoretical basis based on the concept of water urbanism, its importance and the principles on which the concept is based. The focus is on the concept of a water sensitive city that engages the concept of water sensitive urban design, its goals and principles.

The paper examines international projects and discusses several principles of water urbanism. It produces a set of indicators extracted from the most applied principles as strategies and then applies them to a case study: the historical city center of Baghdad.

The study proposes five strategies for water balance between the city center and the river in order to improve the efficiency of the water distribution system and reduce the demand for drinking water. The mixed-use strategy enhances levels of comfort in urban places by adding facilities and services and a green-blue network that supports the survival and continuity of use between the urban fabric and the natural environment. The combined use strategy involves various disciplines in the urban design process to ensure the achievement of a comprehensive urban integration at various levels of environmental, urban, construction and sustainable design.

Keywords: Water Urbanism, Blue-Green City, Water Sensitive City, Water Sensitive Urban Design (WSUD), Historical City Center of Baghdad.

Introduction

It is observed that most of the cities take rivers for granted, especially after the developments that occurred in transportation and the trend towards modern means of transportation. They have turned their back on water sources and riverfronts, even though water was the primary source for the emergence of the cities in the past. Nevertheless, rivers are considered some of the most important elements of tourist attractions. It is seen that cities are often isolated from the natural environments and there is a lack of engagement with the water resources. This is seen clearly in the historical city center of Baghdad. Despite the emergence of several urban principles such as the concept of water urbanism and water sensitive urban design that deal with water, there is a severe lack of their application in the Middle Eastern regions despite the existence of priorities that demand the application of these principles.

This study produces a theoretical framework that summarizes the concepts of water urbanism and its correlations to develop applied strategies based on the principles of water sensitive urban design applied to re-integrate water resources with the urban fabric of the city of Baghdad. Its objective is to make it a resilient, livable, sustainable city with the cooperation of various disciplines to integrate water resources and landscape architecture with the urban design of the city.

Literature Review

Rozaly (2017) examines the significance of the urban river in Kuala Lumpur as an important geographic location in the often-neglected historical cityscape. The river is often the heart of the historic center and the place that defines the city's image, identity and sense of place.

Through his case study, he found that the key to the contextual integration of neglected rivers and historical urban landscapes is to activate urban forms and elements in the cityscape through various activities to achieve vitality. He also concluded that the possibility of walking is the one factor that must be taken into account to make cities better integrated.

Rozaly's study is similar in the aspect of walkability to Haqi & Taher's study (2017), which provides a theoretical framework for the development of design principles such as function, accessibility, natural environment, culture, history, and memory. At the function strategy level, they found that mixed land uses and various services are a way to attract more people, in addition to affordable housing for low-income groups that promotes social equality. Activating an accessibility strategy is through a good design of the public transport system that connects the heart of the city and other regional areas such as extended tram services and water transport along the river. In the strategy of engaging the natural environment, protection and restoration of natural properties and recycling of water have a major role in the design of river front areas. However, they must be adapted together with the strategies of culture, history and memory achieved in public spaces that could shed light on culture and history of a site such as a park square and cultural facilities such as theatres, museums and libraries to enrich the spiritual life of the places.

Kaftangui et.al (2019) examine potential sustainable public open spaces in cities that have great historical values and have exceptional locations where the individuals can enjoy a city's skyline at the water's edge and enjoy the scenic and cultural arts. They came up with a proposal that can enhance the existing public spaces and transform them into more sustainable and interactive public spaces. This involved considering social, economic and environmental factors to design these spaces as the key to achieving sustainable outcomes that provide interactive spaces, They need more activities, a relaxed atmosphere and environmentally friendly features, through the addition of seating areas conveniently shaded, to promote social and physical activities, and to encourage small businesses (such as food carts and markets), promote tourism and cultural activities, use renewable energy (like solar energy).

Tumbde (2005) addresses the importance of government initiatives to stimulate private investment and create awareness of riverfront revitalizations among the citizens by activating public-private partnerships as being critical to achieving large-scale riverside goals. He sees that with a revitalized river frontage, a city center gains vitality and more businesses begin to be established on the riverbanks. Liveliness can be restored due to more people visiting the river during evenings and weekends. Tumbde agrees with the study of Kaftangui et.al in achieving vitality through continuous and varied activities that encourage continuous use, but Kaftangui et.al did not address the importance of local and government initiatives and encouragement of private investment.

Stokman (2008) finds water flow to be one of the most important factors creating relationships with the landscape. However, modern, centrally controlled and invisible water infrastructure systems have separated urban land use from the catchment areas and have removed people from the ecological processes of the landscapes. He discusses the potential for using sewerage and water technologies as a combination of built infrastructure,

environmental functions, and green spaces for people to act as a key component of urban transformation.

According to Mowla (2013), water bodies and rivers have an important role in the spatial development, life and vitality of Dhaka city, Bangladesh. The physiological influence of water and land can be seen on the settlement pattern, which is located on the available higher ground or on artificial hills created on the floodplain. He attempted to explore the physiographic dynamics of Dhaka along with its socio-spatial context and propose guidelines that would respond well to the water-based context of Dhaka. Both Stokman and Mowla agree that water resources and water bodies have the ability to enhance the coherence of the images of the cities and improve the urban spaces through the elements of the natural environment. This is what Mowla did not address.

Rising (2015) encourages a more water-intensive approach as the initial pathway through which bio-friendly urbanism contributes to climate change adaptation and livelihood. He proposes a research design to generate an iconic image of hydroponic urbanism to make upstream cities more cohesive. Analyzes were performed to examine the relationships of: 1) intrinsic association with safe, clean water scenes and water landscape visualization potential, 2) water landscape visualization potential and city image coherence, 3) association with water-based spatial anchors and association with water-centered cities and 4) city image coherence and openness on urbanization interconnected with water. He concluded that water is the sixth element of the ability to imagine according to the principles of the theory of imagination adopted by Lynch and that the imagined structure of channels and rivers and the possibility of recognizing water features greatly affected the aesthetic cohesion of the image of the city, and the promotion of the identity of the place based on water. This helps in adapting cities and individuals to urbanization bonded with water.

Bansal et.al (2022) argue that climate change is closely related to water which is a pre-requisite for human existence. Recently, adverse effects on water resources have been observed as a result of climate change. One way to address these issues is where architects and urban planners can adopt multi-functional landscape design solutions by incorporating different water-based ecosystems into their design processes to maintain a healthy human settlement. Case studies have focused on the Adyar and Ganga rivers for the use of proactive measures that work with natural processes to improve habitats and create an impact on both physical and cultural aspects.

Byron & Reena (2009) have developed a practice and assessment model for open public spaces in residential areas that takes into account water-sensitive urban design techniques that contribute to place-making. Individual water-sensitive urban design techniques were analyzed individually to determine which place-making elements they contribute to and whether they help shape the urban environment. These techniques include swamps, live streams, compensation ponds, creek rehabilitation, natural, constructed and turf wetlands, stormwater runoff treatment, adding aesthetic quality and even wildlife enhancement. As a result, and through thoughtful design, these techniques actively contribute to both the structural and spatial elements of place making.

Nunes et.al (2011) contend that the main goal of water-sensitive urban design practice in Australia is one that combines 'integrated urban water cycle planning and management' and 'urban design' in a new form of planning. They have presented a general framework for integrating WSUD technologies into the site planning process as they were applied at street scale in the Melbourne metropolitan area, in the state of Victoria, Australia, to incorporate water-sensitive urban design systems into local urban plans. It consists of three distinct phases:

Phase I: reviewing the technical characteristics of the WSUD indicator for the region.

Phase II: reviewing the local urban planning and design regulations and processes.

Phase III: Develop criteria for integrating WSUD technologies into local urban landscapes.

Mohamed et.al (2019) propose that water-sensitive urban design is a tool consisting of three dimensions that can be used to:

- 1) identify specific issues facing residential water demand.
- 2) identify factors affecting these issues.
- 3) water sustainability goals and standards related to.

The WSUD tool can be used by urban designers and planners to assess the water performance of residential urban areas and to study their suitability for the Egyptian context. A survey has been conducted with 41 researchers and professionals in the field of water and urban design. The survey included the most common water-related issues facing the residential sector, factors affecting school performance, especially water consumption in residential areas, especially urban density and housing type, defining sustainability goals and standards by reviewing global sustainability agendas and assessment indicators, and identifying the most common water-related sustainability goals. It has been found that incorporating water into landscapes improves the quality of urban spaces and helps mitigate the impact of climate change.

Rodríguez et.al (2015) propose a more sustainable urban design in which natural water flow is restored. It seeks to integrate water into urban processes, to reach 'water-sensitive urban design', by developing methodologies that help planners plan water-sensitive cities. Among these methodologies are ensuring the management of water sensitive to hydrological and environmental processes, restoring the natural flow of water cycles in cities, integrating urban planning into the management, protection and conservation of the environment, and involving social agents in the planning process in order to ensure the success of the proposals that are implemented as well as to preserve the measures adopted.

This study was similar to both Stokman and MOWLA in restoring water resources and water bodies within the urban fabric, but it was distinguished by the involvement of different disciplines in the design and planning process to reach a water-sensitive urban design. In so doing, it aligns with Bansal's (2002) vision of engaging urban planners and designers, architects, and landscape architects. Thus, supporting the main goal of water-sensitive urban design emphasized by Nunes et.al. (2011).

The previous studies presented have dealt with the concepts of the subject of research in different ways, namely the development of city centers through water sources, the development of riverfronts, the activation of urbanism and urban design that is sensitive to water. What we see in most of our historical city centers is the separation of the built environment from the natural environment, especially after the change of means of transportation, the distance of cities from the natural resources and riverfronts and the direction of growth towards the interior, which have caused the neglect of the areas adjacent to the river and its use for the industrial purposes, landfills and the parking lots. This is what has determined the knowledge gap of this research. The importance of the research is how to use water sensitive urban design, which is represented in the multi-disciplinary cooperation between water management, urban design and landscape architecture, as a major strategy that has a role in integrating the natural environment within the urban environment and achieving the vision of the water sensitive city in the triple interdependence of space, people and water.

The Theoretical Basis

The theoretical basis defines water urbanism, its capabilities and design principles as well as the relations of this concept to urban design. It also examines the concept of water sensitive cities, which leads to water sensitive urban design. It establishes the connections and the levels of application while extracting the most important principles the concept offers.

Water Urbanism

Water urbanism is a progressive step in development because it provides mechanisms for urban interventions by blending with environmental components rather than impeding them.

Many studies have provided definitions of the concept of Water urbanism. For example, it has been defined as an innovative approach to urban design that includes the study of social, physical, health infrastructure, and ecosystems and departs from the traditional

practices that isolate the natural elements from the urban systems. It proposes a common and natural environment based on a deep understanding of social life, the political context and spatial thinking (Orff, 2016).

Rising (2015) defines water urbanism as the systematic and comprehensive integration of water landscape with the urban fabric to produce water-based environments to improve urban forms, increasing their cohesion, and supporting the health outcomes of a community. Seward (2009) points out that it is of great importance in increasing biodiversity, reducing flood risks and helping cities in their economic and financial conditions, by converting the rainwater runoff chains into a series of wetlands and a network of green infrastructure. He also points out that it reduces pressure on the traditional infrastructure system in a city while encouraging investment in infrastructure. Water urbanism also creates a city of water giving rise to imagination, which Lynch (1960) explained in the study of *The Image of the City*. He has shown that the Dutch cities of Venice and Boulder may be two environments that can be imagined as a "whole scene", which makes it easier for the users to identify their parts and their interconnectedness as a whole, because waterbodies are major contributors to the aesthetic cohesion of cities centered around them. Indeed according to Lynch (1960), this makes the cities characterized by the systematic integration of urban fabric with waterscapes.

Rising (2015) has sought to fuse water with the urban fabric and the suburbia to evoke a more cohesive image of the city by fostering genius sites, by enabling to create a water-based sense of place that might in turn evoke a dedicated aquaphilia¹. This structural effect of aquaphilia on tophophilia² is a form of water-based spatial attachment, as the bonds between Man and the urban environment are centered around water. He has linked the concept of water urbanism to the five elements of the theory of urban image articulated by Lynch (1960)—landmarks, paths, nodes, and edges—and sectors and its three cognitive components—structure, identity and meaning. In this, the possibility of imagination can be attributed to the combination of identity and structure provided by the landmarks as well as the uninterrupted paths and edges.

Lynch (1960) also points out that the participants' preferred views were usually panoramic images with water and spatial openness. He attributed people's preferences for water scenes to the visual properties of water and the innate emotional bond people have with safe, clean water or environments centered around water. This is because it provides comfort, which affects people's emotional attachment to networks of open spaces and waterways. Rising (2015) also adds spatial anchors based on water as a sixth element of the possibility of imagination. He says that it predicts the emergence of waterscapes in cognitive maps as spatial anchors that contribute to the possibility of imagining water cities and facilitate the formation of cognitive maps and images. They enhance the aesthetic cohesion of water urban expansion and thus make them more attractive as tourist destinations and places of residence (Rising, 2015).

Thus, the main objective of the study by Rising (2015) was to investigate the feasibility of a multi-site research design to examine how urban waterscapes contribute to the perceived coherence of the water city image for visitors and residents of different baselines and socio-economic characteristics, taking into account sensitivity to gender, age, education, and income. It has reached to design models of schematic maps that has generated reliable coherence measures to study the spatial perception of the environmental image as a mixture of views from top to bottom and at the eye level. It was found that the prominence of channels in the two-dimensional diagrams is an important element for the integration of the two perspectives associated with the image of the water city. It helps the use of canals as water-based spatial

¹ Aquaphilia "water lover" from Latin (aqua) and Greek (philein) may refer to a love of water sports such as kayaking, a preference for water power, as well as a medical condition characterized by adults who love to indulge in recreation or therapy in water such as rivers and lakes.

² Tophophilia from the Greek "topos" "place" and "-philia" "love" is a feeling of love and a strong attachment to a place, and the feeling of cultural identity is usually mixed with some people, and it is accompanied by a love for certain aspects that remind and resemble specific places.

anchors for navigating different terrains making the cities more adaptable to the visitors by facilitating the creation of a more cohesive image of the city.

It is also possible to limit the importance of urban water in the urban environment within two different interrelated levels: the first is related to spatial planning that ensures the inter-dependence of people and place with Nature, and the second is reflected in the multiplicity of urban functions that include environmental, social and even economic functions (Nada et.al, 2019).

It is thus found that water urbanism is an approach to urban development that relies on the water elements. It aims to create sustainable cities far from urban and environmental problems, by achieving a comprehensive integration between the water landscape and the urban fabric while creating an integrated healthy environment through a system of open urban spaces, relying on spatially interconnected system of networks. The flow of water within this system on the one hand and human and natural processes on the other hand achieve multiple levels of urban functions.

1.1. Principles Design of Water Urbanism

The principles of design related to water urbanism approach are usually based on networks and water links, integrated design and versatility of uses. These are as follows.

Networks and Water Links

Networks must be thought of because they are considered necessary connections that result from the flow of water. Thus, urban design is directed according to the flows of both people and water. The types of flows include the flow of people in the physical city, the flow of water in the water network, and the flow of people and other types in the green network. The vision of the network is considered the first principle in water management, as the city is an interconnected water system consisting of surface and ground water. In addition to that, there are separate but intertwined water networks such as surface water and sewage networks (XIU et.al, 2016)

These networks produce interrelated design principles that could be employed to achieve a greater impact on the people and the city. They include: linking water with the green surfaces, water and plant ponds in parks, and using a flowing urban channel. They increase biodiversity and improves water quality downstream, where the flow of people is directly connected through the urban green-blue corridors by using the principles of social interaction (Gehrels, Hans & et.al, 2016). According to CRC's vision, a basis for physical and visual interdependence can be achieved to connect people and place through several principles that can be used to achieve water links between water, people and place.

The CRC for Water Sensitive Cities (2016) outlines them as follows:

- **Connected:** The water links (blue and green fairways), along with high-quality open spaces support physical and social connectivity.
The expression of water in landscapes supports people's connection to Nature and place, and provides opportunities for interaction.
- **Accessible:** Water links support the provision of “new, green, open meeting spaces” through the creation of green and blue corridors and nodes.
Connected green and blue corridors support ease of movement throughout the area.
- **Resilient:** Water is used purposively to maintain healthy, high quality urban landscapes in an arid climate.
Blue and green corridors with multifunctional compensatory ponds contribute to the improvement of the urban landscape.
- **Vital:** Creating a vibrant and attractive public realm and associated positive investment climate through the innovative use of water in landscaping.
- **Re-energized:** The blue and green corridors and nodes provide opportunities for people to stay, continue, and have fun.

Integrated Design and Versatility

One of the principles of planning and design of water urbanism and water restriction is to improve the functions of urban places by enhancing the performance of urban infrastructure such as pedestrian paths, roads, parking areas and buildings. They purify the air and increase tourism and visits by offering initiatives and planning in parallel with the main city and attraction gates. According to Nada et.al, (2019), they improve the drainage systems by:

- Using areas of natural resources to provide shade,
- Cooling and storm water management,
- Benefiting from alternative water supplies locally by
- Taking advantage of alternative water resources such as rain or storm water or sewage for irrigation purposes to support green areas and trees,
- Using plant systems such as wetlands or biological filters to provide alternative water supply treatment for local use and
- Reducing the effects of floods by increasing permeability by
- Increasing the proportions of green space to reduce the volume of storm water runoff and its direct access to cultivated areas to create storage and increase filtration and evaporation,
- Providing cooling and a pleasant environment during hot weather by
- Increasing vegetation on the ground, moist soil, water surfaces and designated areas for pedestrians to provide shade and natural cooling in the urban environment.

The concept of water urbanism includes multiple areas such as water management, urban planning and urban design, and the architecture of outdoor spaces. Therefore, integration must be achieved in the planning and design process at different levels, which provides the most satisfactory and potential solutions. References are made to the principles of water urbanism through sustainability of cities ecologically, environmentally and economically, as urban water management must be closer to Nature aesthetically and functionally. Five main principles of water urbanization can be identified, as it is considered necessary to integrate these principles to meet all the different aspects. According to Hoyer et.al. (2011), these principles are:

- **Water Sensitivity:** Decentralized methods should be used to bring urban water management closer to the natural water cycle.
- **Aesthetics:** It should be used to provide an aesthetic benefit wherever possible, and to adapt to the design of the surrounding area.
- **Functionality:** It should be used in an appropriate manner and adapted to the local conditions and intended use. Maintenance requirements must be taken into account, in addition to considering the possibilities of adapting to uncertain and changing basic conditions.
- **Usability:** It should be used to create usable spaces for recreation and Nature conservation purposes.
- **Public Perception & Acceptance:** The demands of all the stakeholders should be considered and included in the planning process. The costs should be comparable to the costs of traditional solutions.

From these, several concepts can be extracted that could pave the way for water-sensitive urban design, and they can be represented as follows.

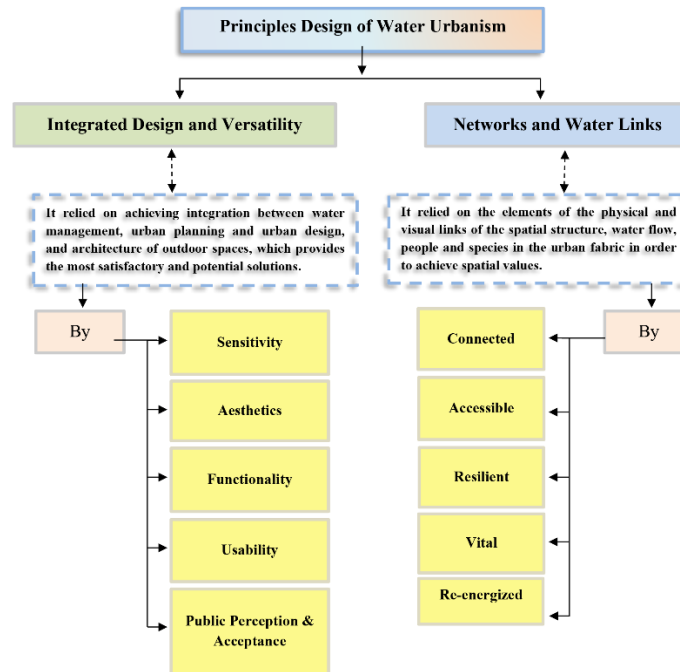


Diagram. 1: Principles Design of Water Urbanism
Source: Author based on Nada et.al. (2019)

1.3. Water Urbanism Correlations

According to previous studies, the concept of water urbanism, which is directly associated with water, has been associated with other concepts and approaches, including: the concept of development or the blue city, the concept of blue-green city, the concept of sponge cities, the concept of green networks, and the concept of water-sensitive urban design. These concepts are clarified briefly, as related to the concept of urban design that is sensitive to water. The aim is to study the possibility of applying them to the historical center of the city of Baghdad.

1.3.1. Blue Development Cities

This concept is defined as a development that seeks to restore natural functions by developing designs for the built environment that deals with the water cycle by identifying water-specific problems such as pollution, floods, and water scarcity. It is intended to improve the health of urban water by using high technologies and low technology elements such as rain gardens that use rainwater in watering parks and gardens. Blue development goes beside with green development. Thus, the blue city combines several technologies such as low-impact development and buildings, green infrastructure, green corridors, and rainwater management. The blue cities approach provides a way to solve problems and build a sustainable urban future using water as a design basis that brings many benefits such as the most interactive streets, integrated public open space and flexible infrastructure (Charles River Watershed Association, 2012).

3.2. Blue-Green Cities

An urban area intended to successfully integrate natural systems that provide ecological values and amenities associated with urban greening, provide rainwater management, and benefit from infrastructure through deliberate planning of blue-green infrastructure that achieves several goals and more benefits and cooperation is known as a 'blue-green city'. The term blue-green infrastructure may refer to the use of soil, vegetation, and natural processes in the urban context to serve outdoor spaces and manage water. Naturally, effective planning for a green and blue city needs integrating diverse planning and implementation approaches from the unit and neighborhood level up to the city level (Victoria State Government, 2017).

3.3. Sponge Cities (SPC)

Sponge cities are defined as being comprised of re-imagining of the urban environment, as they follow the ‘philosophy of innovation’ in that the city can solve water problems instead of creating them. This philosophy relies on four main principles: urban water saving, environmental water management, green infrastructure, and the use of materials permeability in urban areas. Its construction usually includes three parts: natural environmental protection concerned with preserving natural forests, green spaces, rivers and lakes, and ecological restoration, which is the repair of weak and destroyed ecosystems during the urbanization process with high environmental technologies, promotion of the low-impact development system (LID). This means minimizing damage inflicted on the environment due to rapid urbanization (Li et.al, 2016).

3.4. Green Networks

Green networks focus on green and blue connectivity in urban areas and include a network of green spaces and the surface water system in and around the settlements. They depend on the relationship between people and Nature. Urban green networks are defined as a set of networks of social and ecological functions linked to a spatially coherent entity through the flows of organisms, and the interaction with external spaces. They constitute three categories of networks: the river or blue network used as corridors and lines, the green spaces network as patches of areas and points, and the transport networks are greened as corridors and lines. The ultimate goal is to combine the three networks as a comprehensive green network used in the urban areas to achieve two goals: upgrade and connect the green and blue spaces in the urban fabric and linking habitats, wildlife and the people (Xiu et.al, 2016).

3.5. Water Sensitive Cities (WSC)

A water sensitive city is a perfect sustainability model. A place must aspire to and work for it, so that water is often essential in defining the identity of the place. The relationship between the places we live in and the water resources we depend on the design and development of these places are not given priority, as water defines the places through several principles, including vitality, identity, activity, health, and landscapes, as shown in the Fig. 1. Water strategies of sensitive cities aim to help practitioners to find ways to strengthen the connections between water, urban design and landscape architecture (South East Queensland Healthy Waterways Partnership, 2009).

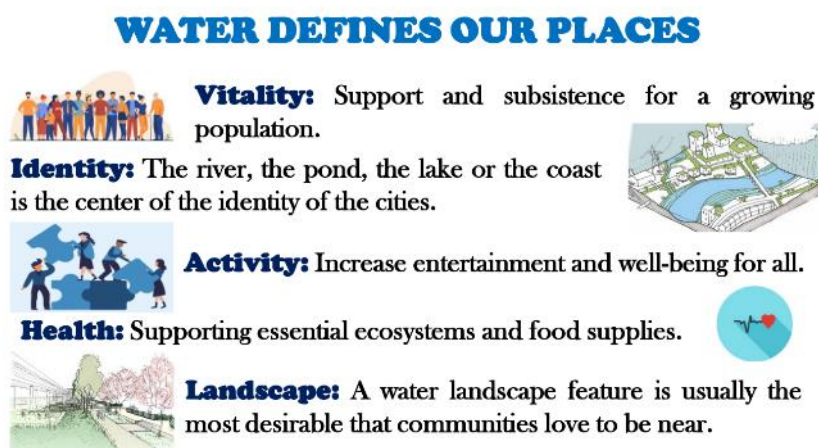


Fig. 1: Water defines the places
Source: Morgan et.al. (2013)

Through the study of CRC for Water Sensitive Cities, it is found that water-sensitive cities depend on the principles of water links (connected, accessible, resilient, vital, re-energized) to connect people and places. They aim to enhance unique identities of places by utilizing water bodies borrowing a water-based story in the region by enhancing opportunities for people to interact with water and the natural environment. This is done by providing effective recreational opportunities and better communications for the residents and travelers, and securing wildlife for the community through a network of high-quality linear parks based on water elements. Further, it also aims to integrate the contextual concept of the region including indigenous cultural plurality, ecosystems, and the blue-green corridors.

Thus, through CRC's vision, a water-sensitive city can be described as a flexible, livable, productive and sustainable city, as shown in the Fig. 2 (CRC for Water Sensitive Cities, 2016).



Fig. 2: Water Sensitive City
Source: CRC for Water Sensitive Cities (2016)

3.5.1 Water Sensitive Urban Design (WSUD)

Studies differ on the definition of water-sensitive urban design. Thus, there are several definitions of this term. Mouritz (1991) describes it as an approach to an environmentally sustainable urban form that responds to regional landscapes and environmental resources, to create cities in an urban form that responds to natural environmental processes to create local landscapes through waterways and recreational spaces.

The Joint Committee on Urban Drainage of the International Water Association (IWA)/International Association for Engineering and Hydrological Research (IAHR), defines water sensitive urban design as 'the integration of urban design with the management, protection, and maintenance of the urban water cycle that ensures that Urban water management is sensitive to natural hydrological and environmental processes'. It includes two parts: sensitive to water, and urban design. Urban design is usually associated with planning and architectural design for urban environments and covers traditional matters far from the field of water. However, these environments can be affected by water, while the word water-sensitive gives water due importance in the urban design processes. The concept 'water sensitive' refers to the integrated management of urban water through various disciplines of engineering and environmental sciences related to water services such as the protection of water environments in urban areas, values and identity of urban places (Wong and Ashley, 2006).

Hoyer et.al. (2011) point out that water-sensitive urban design is an approach that integrates the water cycle into urban design to reduce environmental degradation, improve aesthetic and recreational demands, and support social cohesion. It links technical solutions for water management, urban design, and social and economic aspects. This approach focuses on the urban design and planning of outdoor spaces by means of water reuse at the sites, including its permanent or temporary storage.

According to the Water Sensitive Urban Design Study by (CIRIA), water sensitive urban design is defined as the interdisciplinary collaboration of water management, urban design, and landscape architecture that takes into account all parts of the urban water cycle. It combines the function of water management with an urban design approach, and facilitates a synergy between environmental, economic, social and cultural sustainability fields. Here, water defines the places by enhancing vitality, identity, activity, health and landscapes. Thus, water

sensitive urban design aims to achieve integrated water management in urban areas and contribute to the development of water-sensitive cities that are described as sustainable, livable, flexible and productive. This can be achieved by strengthening and protecting watercourses such as rivers, seas, lakes and wetlands, reducing flood risks, sequestering carbon and reducing heat islands. It creates public urban spaces and spaces dependent on water resources integrating community and operational activities (Morgan et.al., 2013).

Based on these different definitions, water sensitive urban design can be defined as the process of integrating water cycle management with the built environment through urban planning and design. The relationship between water and our urban areas needs to be given a higher priority to provide integrated solutions to manage flood risks, use and supply water in a sustainable manner, and improve the quality of urban spaces. This priority must be applied in an integrated way by the people and partners who plan and design the urban environments. Thus, it is found that water sensitive urban design is determined by the overlay of three parts: the connection of the urban fabric with the natural aquatic environment, from public urban spaces and landscape architecture, and with the participation of various disciplines and contributors from the rest of society. Thus, water sensitive urban design is the process or tool for the production of urban water sensitive places and spaces, which is the result. Fig. 3 shows these.

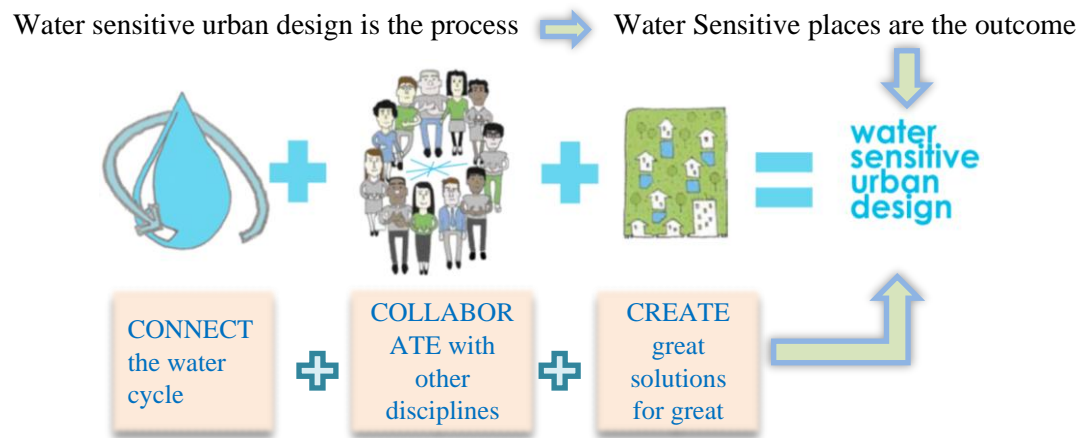


Fig. 3: Components of water-sensitive urban design
Source: Author based on Morgan & et.al. (2013)

3.5.2. Objectives and Principles of Water Sensitive Urban design

Water-sensitive urban design is considered the integration of urban design with the management and protection of the urban water cycle through the participation of various disciplines to produce places that take into account the components of the natural environment in the design process. It was found that it is based on two main principles.

- 01.** Considering all the elements of water resources and their interdependence simultaneously to achieve a result that preserves a healthy natural environment while meeting human needs by addressing water supply and demand, wastewater and pollution, precipitation and runoff, water courses and water resources, waterways and floods.
- 02.** The continuity of introducing a water element throughout the design and planning process of urban spaces to meet the expectations and aspirations to design successful places by celebrating local character, environment and society, and maximizing cost and return utilization of infrastructure and built form, while improving the quality of life for communities and resilience in the future.

Water sensitive urban design is linked to four aspects: place making, urban planning and design, and productive landscapes, through water management in urban spaces with a triple connection: water, place, and people as shown in the Fig. 4 to achieve several objectives.

According to Morgan et.al. (2013) these include:

- Integrating water into landscapes, public open spaces, and urban design to enhance visual, social, cultural, and environmental values to increase public access to recreational activities and visual amenities, while preserving essential habitats for waterways and wildlife movement corridors.
- Improving the health of the ecosystem by preserving the natural water cycle resources and protecting the quality of surface and ground water and the existing topography.
- Reducing capital and maintenance costs of water resource infrastructure through Low Impact Development (LID) design.
- Exchanging interdisciplinary knowledge and community involvement in water management to improve economic growth and employment.
- Reconnecting waterways with green networks and enhancing people's connections.
- Reducing the carbon and energy associated with water management, as well as reducing the urban heat island effect.

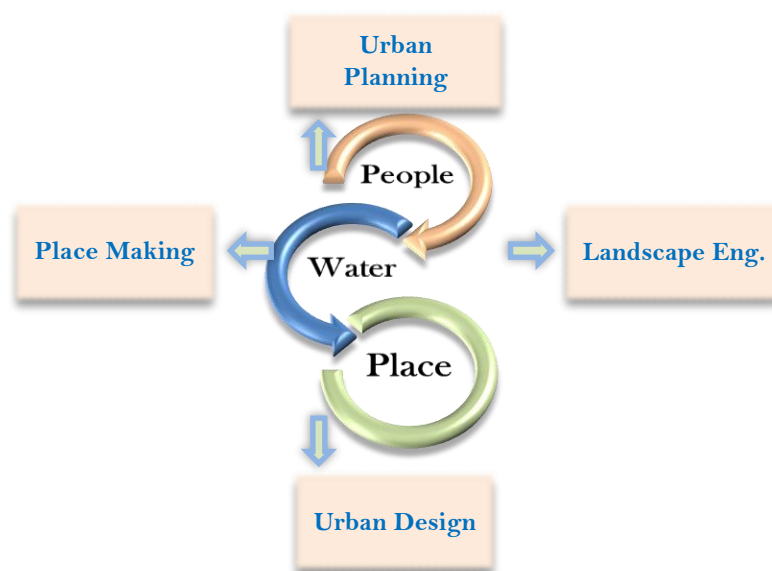


Fig. 4: Aspects associated with water-sensitive urban design

Source: Author based on Morgan et.al. (2013)

According to Hoyer et al. (2011), it is found that the main objective of water-sensitive urban design is to protect water resources and reintegrate them with the built environment through the integration of urban planning and design with sustainable management for water resources. Thus, Wong et.al. (2009) point out that the most important principles of this approach can be organized into five topics:

Water Sensitivity

- Protect natural systems by strengthening natural water systems (streams, rivers and wetlands) within the urban fabric.
- Restore the urban water balance by raising awareness of the importance of reusing rainwater, gray water and recycled water.

Usability

- Protect water quality by improving the quality of water drained by urban developments from streams, rivers, and bay environments.
- Minimize potable-water demand where water resources are preserved through the efficiency of the system, which depends on the rationalization of water consumption and reuse.

Functionality

- Reduce hydromodification and reuse of treated wastewater. Reduce wastewater production, and reduce peak flows and runoff volumes from urban developments while providing for seepage and groundwater recharge.
- Integrate stormwater treatment into the landscape to support multiple uses such as water quality treatment, wildlife habitat, public open space and recreation.

Aesthetics

- Create landscape amenities: Increasing social amenities in urban areas through multi-purpose green spaces, landscaping and incorporating water into the landscape to enhance visual, social, cultural and environmental values.

Public perception and acceptance

- Minimize costs while adding value. To ensure widespread application of WSUD principles they must be economical and easy to implement.
- Consider the demands of all stakeholders and involve them in the designing process.

According to the foregoing, the principles of water sensitive urban design are applied to achieve its objectives within four aspects: planning, urban design, place making, and landscape architecture to achieve urban integration between the trilogy of water, place, and people according to three spatial levels (the city level, the district level, and the project level). As Wong et.al. (2009) explain:

- 1. City and regional-wide level:** Using appropriate urban planning strategies, methods and tools to integrate water-sensitive urban design solutions and concepts in the city through comprehensive spatial planning for water management within the city plans.
- 2. District level:** Enabling the interaction between the water management system and the urban structure of the provinces and regions to achieve the concepts of sustainability with environmental, economic, social and cultural requirements.
- 3. Project level:** Documenting and analyzing innovative, small-scale solutions for water sensitive urban design and its activation to manage urban areas, landscapes and water, so that it focuses on individual water-related measures and elements and their integration in the urban context.

Research Methodology

Based on the theoretical basis presented, the most important indicators of water urbanism are summarized in the principles of water sensitive urban design as shown in the Table 1. They are to be tested on two international projects that have implemented responses to the issue of introducing water components into the urban environment and have achieved some principles of water urbanization and water sensitive urban design. Each of the international projects are analysed describing the objectives, the methodology followed and the most important strategies used in the implementation of the projects. These projects are tested on the basis of indicators derived in the theoretical basis. Each project is evaluated using the indicators as shown in the Table 1 to ascertain the effective indicators that have been implemented in the projects. Subsequently, they are applied as work strategies to a local case study at the historical center of the city of Baghdad, with the aim of applying the principles of urban design that are sensitive to water.

Findings:

Precedent Studies

Project 01 Riverfront Design in Topeka, Kansas, USA.

Project Description: As a result of changes in technology and transportation, rivers and water sources in America were neglected, which have led to the loss of urban cohesion, as well as the history and culture rooted in its rivers due to the construction of streets, railways, dams and flood protection walls. According to Johnson (2019), this project seeks to create a transitional area on the riverfront of the Kansas River in Topeka that constitutes a strong link between the downtown and the North of Topeka. This link was expected to create the needed connectivity through placement creation that unifies the divided urban center, create an identity for residents, reconnect the city to the river, and make the Kansas River part of a unified urban core for Topeka (Fig. 5).



Fig. 5: (a) City center & river, (b) overall analysis plan
Source: Johnson (2019)

Project Goal: The project's main goal is to reunite the urban center with the river by improving connectivity between North Topeka and downtown by achieving several goals. According to Johnson (2019), they are:

- Creating urban assets and features for Topeka that attract people,
- Connecting and strengthening a divided urban core through water-sensitive urban design, changing negative perceptions of rivers due to neglect,
- Renewing and solidifying Topeka's identity in its history, culture, and relevance to the Kansas River and the regional context. recognizing the principles of riverine development to connect and revitalize downtown and understand the principles that lead to successful place creation design.

Project Methodology: The project methodology included previous studies of the study area, archival research, site inventory and analysis of the collected data. Through previous studies, information about the final design of similar sites was identified. It studied the conditions and the design factors, to understand these projects which helped direct the design of the project. Thus, the most important factors extracted from the previous studies were :the context of the site, the client and the designer, the longevity of the project, the design objectives, amenities, activities, uses of the surrounding land, accessibility, social and economic aspects and impacts, site definition and flood control.

According to Johnson (2019), as for the archival research, it delved into the historical, city and county documents in Topeka, Kansas, these documents included comprehensive plans, neighborhood plans, land use plans, pedestrian and road plans, revitalization plans, city zoning maps and others, which helps in understanding the identity and importance of water sources in design, relationships between people, and history of Topeka. As he says, while the site analysis included collecting and examining local factors for consideration that would help in designing the project, the main features of the site were inventoried and the obstacles and dilemmas presented in it were analyzed to integrate the design of the city center with the water source

represented by the river front to create special strategies for designing this site. (Plans analysis is not mentioned in detail in this paper)

Design Strategies used in the Project: (Fig. 6)

Johnson (2019) indicates the strategies used.

- Creating a green network linking the Riverfront to the City and giving priority to the pedestrians at bridge crossings.
- Converting streets into green streets.
- Prioritizing the pedestrians & cyclists on the Kansas Avenue Bridge.
- Using fill to create a gradual slope up to the top of the dam. This creates a sloping garden area.
- Establishing the key viewpoints along the Levees.
- Providing access to floodplain & water interaction.
- Raising the Levee height to improve flood protection.
- Connecting the green streets to the Levees through the Plaza spaces which provide a gathering place for site visitors and are multifunctional in nature.
- Creating attractions at the end of Street Networks.



Fig. 6: Implementation of project strategies

Source: Johnson (2019)

Project 02: Muscatine Riverfront Strategic Growth Plan, Muscatine, Iowa, USA

Project Description: This project was carried out by a group of graduate students during the year (2013-2014). According to Sarasmita et.al. (2014), this project was to create a strategic plan for growth on the river in Muscatine, to develop a plan to integrate current and future redevelopment projects and to connect the downtown commercial area to the riverfront physically and visually. It was intended to make use of water resources, and to provide recreational facilities best suited to the interests of the residents and potential visitors of Muscatine. Further, it was intended to ensure that the walkway facing the river is a functional and beautiful space in itself. They also emphasized its roles as a component of the city's garden system, an element of local character, and a gateway for regional recreation and tourism. The project area is centered on the main part of the riverfront park, located between Mississippi Road and the Mississippi River, and extends from Mad Creek River downstream after Ash Street directly to the city center (Fig. 7).



Fig. 7: Boundaries of the study area and the most important obstacles in the site

Source: Sarasmita et.al., 2014

Project Goal: According to Sarasmita et.al. (2014), the main goal was to connect the city center and Riverside Park with the aim of enhancing both the areas through a coordinated approach. This is to improve the flow of the water resources between the urban fabric represented by the facilities of Riverside Park and the city center to create a unified area based on natural resources. It was achieved by setting a comprehensive vision for integrating the riverfront with the city center, creating a visually unified scene between the river and the city center, recycling and optimizing the use of water resources, identifying potential uses for large open spaces at the lower end of the river, determining community preferences and developing a plan to expand service and recreational facilities and organizing parking spaces to preserve area aesthetic

Project Methodology: According to Sarasmita & et.al. (2014), a theoretical approach was selected and a comprehensive methodology was developed for its application, where the current conditions were monitored, reviewed how the other cities have dealt with such problems, and community preferences were assessed. The project methodology was divided into four phases, the first phase included collecting data through field observations and research, establishing the scope of the project, problem statement, methodology, and the proposed timetable, while a survey of best practices, data collection and analysis was carried out in the second phase. The third phase included the development of preliminary alternatives based on the results of the first and second phase research, to focus on the selected alternatives, evaluate the proposed alternatives, and recommend one or a group of alternatives in the fourth phase.

Design Strategies used in the Project: (Fig. 8) (Sarasmita & et.al, 2014)

- Enhancing the visual connection between the riverfront promenade and the central business district, ensuring cohesion throughout the area and smooth transition.
- Construction of the runway facing the river and providing solutions to issues related to maintenance, operation, post-flood clean-up and safety concerns.
- Green parking: the use of turf pavements for excess parking during periods of peak use as the green excess parking acts as a permeable surface for rainwater infiltration.
- Considering the Stormwater Wetland at Mad Creek as it is specifically designed to provide ecosystem services for human development rather than simulate natural conditions to support aquatic flora and fauna.
- Adding places for mobile food vendors, which encourages street vitality and neighborhood life, increases foot traffic, increases public awareness of safety, and creates a place for social interaction, taking into account reducing negative impacts such as excess litter through preventive measures such as ensuring the availability of benches and trash receptacles.
- Organizing an outdoor exhibition space and a native prairie walkway to serve as an outdoor extension of the Muscatine Center for History and Industry located downtown as well as adding an event tent facility, giving visitors the experience of viewing artistic representations of local history and culture while walking through landscapes that reflect the natural history of Iowa.
- Monitoring & Performance Measurement Counting the number of people using different facilities can yield quantitative data describing the overall project usage.



Fig. 8: Implementation of project strategies

Source: Sarasmita et.al.,2014

Table 1: Theoretical Basis Indicators
Source: Author

Main Vocab.	Sub Vocabulary	Indications	P1	P2
Water Sensitivity	Protect natural systems	Add waterways	✓	✓
		Easy access to river fronts	✓	✓
	Restore the urban water balance	Enhancing public spaces with the water element	✓	✓
Usability	Protect water quality	Add instructions to rationalize water consumption		✓
		Using modern means of awareness		
	Minimize potable-water demand	Improve the efficiency of the water distribution system	✓	✓
Functionality	Reduce hydromodification	Reuse of treated wastewater		✓
		Reducing wastewater production	✓	✓
		Reduce water flows while saving leakage	✓	✓
	Integrate stormwater treatment into the landscape	Providing free drinking water resources		
Ensure that it is evenly distributed		✓		
Aesthetics	Create landscape amenities	Multipurpose green spaces	✓	✓
		Water related activities	✓	
Public perception and acceptance	Minimize cost while adding value	To be economically easy to apply	✓	✓
		Use of local materials		✓
	Stakeholder participation	Involvement of various disciplines in the design process	✓	✓
		Stimulate local community participation	✓	✓
Percentage of each project for the indicators			67%	72%

Case Study

The Historical City Center of Baghdad

After getting acquainted with the global projects that have employed research concepts, the effective indicators were applied to the case study in Baghdad. Here, it is described together with the importance and most of the problems it suffers from identified.

The historical center of the city of Baghdad, located in Al-Rusafa, has been subjected to accumulations of deterioration and decay in all its urban, social, economic, environmental and urban joints. It represents a historical facade for the city of Baghdad, as it includes several heritage sites, including the Qishla building and clock, the Saray market and mosque, Al-Abbasi palace, the Baghdadi Museum and historical sites, in addition to its distinctive view of the Tigris River.

The study area is illustrated in the Fig. 9. It is represented in the area confined between the Bab Al-Moadam Bridge, the Al-Shuhada Bridge, and Al-Rasheed Street, overlooking the Tigris River. After the field study, it was found that the most important problems that appear in the site are:

- The urban fabric of the city center was ruptured and not integrated. It has lost its distinctive identity and urban effectiveness, and was completely isolated from the river front that extends along it.

- The heritage places in the region, such as the Saray Palace, the Qishla building, the Abbasid Palace, and others have been neglected without exploiting the open spaces for the activities that can revitalize the place.
- The pedestrian roads from the downtown street are receding. Their absence by the river, and the lack of recreational and cultural activities reflect negatively on the historical identity of the city.
- The implementation of the earthen barrier covered with stone along the river bank cut off the organic and visible axes and the drop in the river level. There is a difficulty of accessing the river bank, which has reached a depth of more than eight meters. This interruption has been doubled and the Tigris River has disappeared from the view.
- Modern technologies have not been used in the optimal use of water, recycling natural materials and taking into account the economic costs.

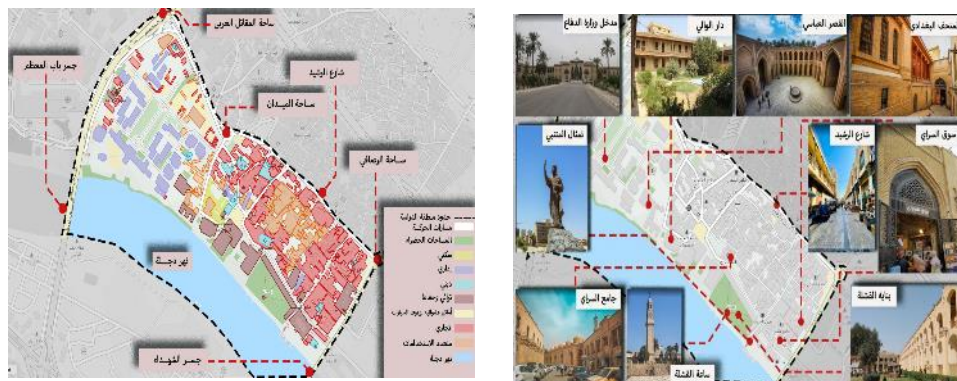


Fig. 9: Boundaries of the study area and the important heritage features at the site
Source: Author based on Google Earth and the field visit.

Conclusion

This paper extracted the indicators through the theoretical framework, which included the principles of water-sensitive urban design shown in the Table 1. International projects were discussed that included the application of some research concepts through several indicators. They were evaluated based in terms of these indicators to find out the most important effective indicators that can be applied to a local study represented in the historical center of Baghdad. The effective indicators implemented by both the global projects were converted into work strategies. They were then applied to the local case study to ensure the implementation of the principles of water-sensitive urban design, which are as follows:

1. Water balance strategy between the city center and the river

- Improving the efficiency of the water distribution system by reducing the demand for drinking water, and adding guidelines to rationalize water consumption.
- Recycling water by raising awareness of the importance of reusing rainwater, groundwater and gray water.

2. A strategy that equalizes the distribution of natural resources within the urban fabric

- Providing free drinking water resources, ensuring its equal distribution among users, and ensuring its access to all segments of society.
- Establishing landscape facilities such as multi-purpose green spaces, water-related activities, increase urban social amenities and enhance visual, social, cultural and natural values.

3. Mixed use strategy and urban comfort

- Achieving the good form of the urban scene through deliberate formations in dividing the spaces and streets of the city, for example defining the paths of vehicles and pedestrians using specific materials and finishes characterized by color and texture to determine the use.

- Achieving comfort levels by adding facilities, services, and a blue-green network that supports survival and continuity of use between the urban fabric and the natural environment.

4. The strategy of using modern technology and reducing costs

- Encouraging sustainable design, systems to rationalize energy consumption, and benefiting from the water component in power generation, in addition to expanding green spaces.
- Reducing costs through easy and economical applications, allowing the use and recycling of the local materials, and the use of local manpower in the study area.

5. Combined use strategy and cooperation of different disciplines:

- Providing activities that serve different age groups, which enhances the permanent use of the area.
- Involving different disciplines in the urban design process to ensure comprehensive urban integration at various environmental, urban, construction and sustainable design levels.

Since water sensitive urban design is one of the links of water urbanism, by applying its strategies, the principles of water urbanization are achieved, represented by:

- **Networks and water links** that depended on the elements of the physical and visual links of the spatial structure, water flow, people and species in the urban fabric in order to achieve spatial values and included (connectivity, ease of access, flexibility, vitality, revitalization).
- **Integrated design**, which relied on achieving integration between water management, urban planning and urban design, and architecture of outdoor spaces, which provides the most satisfactory and potential solutions through (water sensitivity, aesthetics, ease of use, functionality, public perception and acceptance).

Thus, the research has achieved its goal in devising strategies based on the principles of water sensitive urban design, which could make the historic city center of Baghdad a water sensitive area that falls within the concept of water urbanism, through several recommendations that are taken into account:

- Focusing on the most important elements of the neglected natural environment such as water sources, riverfronts, and green spaces, and integrating the built context in city centers with the natural environment, especially with river paths as the historical basis on which cities were formed, through designing streets, neglected spaces, facilitating access to water sources, and removing obstacles.
- Enhancing the interrelationship between the context of Baghdad's historic city center and natural resources through the contribution of various disciplines (urban designers, architects and landscape architects, including the Baghdad Municipality). The groups present on the area (hobbyists, craftsmen, and local labor force) using local materials or that are of a heritage nature that enhances the history and identity of the area avoiding the high costs that may cause a long time in the implementation of the project.
- Providing free use or symbolic wages lies in encouraging the pioneering of recreational places that are linked to the river resource, which could enhance the visit of most segments of society, taking into account setting guidelines that ensure the optimal use of these facilities.
- Using modern technology in ways that do not affect the historical and cultural context of the city of Baghdad, such as treating some dilapidated structures, using smart lighting systems, flood protection systems, guiding heritage sites in the region and introducing through establishment of guiding tools that are friendly to the natural environment and suitable for the historical urban fabric of Baghdad city center.

Finally, it is possible to benefit from the mentioned theoretical basis indicators and the proposed strategies by developing a joint urban development plan for the Iraqi city centers overlooking the Tigris and Euphrates rivers, as they share most of the problems and obstacles, and give flexibility in this plan taking into account the differences between the locations.

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