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Harnessing the Potential of Blue Infrastructure in Urban Riverbanks for Sustainable Development

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Abstract— This research paper explores the potential benefits of integrating green-blue infrastructure on urban riverbanks. The study addresses this gap by exploring the key benefits of utilizing green and blue infrastructure to improve urban environments and enhance sustainable practices, by leveraging water features, access points, and public spaces. The study aims to create lively and attractive urban settings that meet the needs of diverse stakeholders, by emphasizing harmony between urban development and nature.The study examines green-blue infrastructure initiatives aimed at enhancing environmental function, managing stormwater, improving water quality, and promoting ecological connectivity in urban river settings. It highlights the importance of human interaction with the environment and physical activity in shaping dynamic and sustainable urban landscapes through the implementation of strategies related to green-blue infrastructure. The findings emphasize the importance of leveraging green-blue infrastructure to develop vibrant and resilient urban environments that foster a healthy and active lifestyle while contributing to environmental preservation and community well-being. Activating green-blue infrastructure can significantly contribute to urban sustainability and the ability to cope with hydrological events caused by climate change.

Keywords— Blue-Green Infrastructure, Urban River Revitalization, Environmental Sustainability, Sustainable Urban Design.

1. Introduction

Rivers have played a crucial role in shaping the locations and development of traditional cities, providing valuable ecosystem services through rich and attractive ecosystems. Riverfront infrastructure offers unique opportunities to develop a new mix of uses with strong identities that respond to sustainable living agendas [34]. Therefore, it is appropriate to explore ideas of good practices related to planning and designing built forms along riverbanks . Urban river corridors have significant potential to be a key part of green infrastructure. There are deficiencies in urban infrastructure, urban space, and its socio-economic structure [29] currently, public access to river corridors is considered an indicator of successful riverfront development. By implementing urban green infrastructure projects, large and multifunctional open spaces can be found near rivers worldwide [40], which in turn has had an impact on social and economic development [2].

Rivers serve as urban blue infrastructure and play a vital role in shaping the complex cultural landscapes of cities. Sustainable and enjoyable urban planning of riverbanks can facilitate dynamic urban areas by enhancing the river's importance to people and the region [22].

The environmental and design characteristics of these spaces, along with their integration with the river, determine the types of public recreational activities. Additionally, they impact the ecological condition of the river system, influence urban flood resilience, and contribute to city sustainability [15]. As global environmental problems such as climate change and the energy crisis increase, along with the shortage of material resources, stricter environmental guidelines and regulatory measures will be imposed [6]. To achieve the research objective, a review of literature related to blue-green infrastructure and riverbanks was conducted to extract a descriptive and analytical approach and to deduce the most important effective vocabulary and indicators for achieving

blue-green infrastructure designs along urban riverbanks. These studies provide useful information for improving urban planning of riverbanks and designing blue-green spaces more effectively.

2. Blue Green Infrastructure

Blue-Green Infrastructure (BGI) is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to provide a wide range of environmental services, including microclimate regulation and enhancing human thermal comfort [12].Solutions based on green and blue infrastructures are fundamental to the concept of BGI. In this context, BGI includes several natural elements (such as rivers, ponds, and wetlands) and designed organized elements (such as rain gardens, permeable pavements, and subsurface systems), which provide environmental, economic, social, and ecological benefits [36].

Blue-Green Infrastructure (BGI and GI) are two similar approaches that offer more natural environments for addressing environmental issues. Each focuses on reducing impervious surfaces and increasing natural environments to enhance infiltration processes into the soil and plants [19]. The green approach focuses on plants and natural areas to address stormwater issues, while the blue approach employs similar principles but also includes a separate water body such as rivers, channels, reservoirs, etc. [32].

Blue-Green Infrastructure is an integrated approach to urban and environmental planning that combines "blue" and "green" elements to manage water resources, enhance ecosystem services, and promote sustainability in urban areas. This approach becomes increasingly important in the face of climate change and urbanization trends, helping cities adapt to environmental conditions while enhancing sustainability and quality of life for their residents.

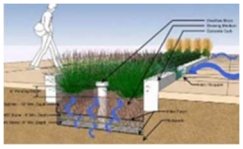
2.1 *Problems and Techniques of Blue-Green Infrastructure*

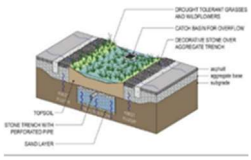
The problems related to blue-green infrastructure designs are specifically defined in terms of public open spaces [10]. The issues associated with the dual use of public open spaces for recreation negatively impact the quality of retail points regarding distribution, diversity, ease of use, and flexibility within the open space system. Introducing dual-use open spaces may entail several emerging problems, including:

- Open space lacking diversity tends to be monotonous and simple.
- Inappropriate distribution of open spaces concentrated along drainage channels.
- Lack of consistency by local authorities in implementing dual-use policies.
- Decreased usability and flexibility of open spaces.
- Increased maintenance costs.

Therefore, we will explore some of the techniques associated with blue-green infrastructure designs used in various projects to address environmental and urban issues, whether in public urban spaces, residential areas, or commercial spaces, and summarize them as follows [31]:

Table 1: Green-Blue Infrastructure Techniques with Modified Definitions from the New Jersey Department of Environmental Protection, 2023.

BGI techniques/ Image of the Element	Definition of the Element
Green Roof 	A green roof, also known as a vegetated roof, is a surface covered with a layer of growth and plants... This type of surface works to intercept stormwater runoff.
Porous Pavemen 	A porous pavement is a stormwater management facility used to deal with the effects of land development... and allows stormwater runoff to move through it.
Sand Filter 	Sand filters are designed to maximize the removal of pollutants from stormwater runoff, using a layer of sand as a filter medium along with its core materials.
Wet Detention Pond 	Wet detention ponds are a type of stormwater management facility that includes an elevated outlet structure, creating a permanent pond where stormwater runoff is detained and attenuated.
Vegetative Filter Strip 	The vegetated filter strip is a stable and uniformly graded area that removes pollutants from stormwater runoff through filtration and absorption of biological elements, depending on the type of plants.

Swales 	Grassed swales are stable, arc-shaped or trapezoidal channels lined with vegetation.
Constructed Wetlands 	Constructed wetland ponds are standard open wetland systems where pollutants are removed through sedimentation and plant uptake/filtration.
Infiltration Trench/Basin 	They are stormwater management systems built using high-permeability components aimed at maximizing pollutant removal from stormwater runoff, enhancing groundwater recharge, and mitigating the impacts of land development.
Rain Garden 	A rain garden is an absorption device consisting of a small area excavated and filled with a layer of mulch, planted with a variety of woody and herbaceous plants.
DryDetention Pond 	A stormwater management system temporarily stores accumulated water and reduces stormwater runoff.
Riparian Buffer 	An area adjacent to a water pond, lake, or wetland containing a mix of trees, shrubs, and/or other perennial plants (U.S. Department of Agriculture, 2023).

2.2 *The functions of green-blue infrastructure*

The functions of green-blue infrastructure are multifaceted, offering economic, environmental, and social advantages. Economically, it stimulates investment, generates employment, enhances land value, and lowers water treatment expenses. Environmentally, it aids in flood risk reduction, stormwater management, and climate change mitigation [1]. Socially, it fosters improved physical activity, mental well-being, and social cohesion [9].

Several strategies are employed to achieve green-blue infrastructure objectives. Water regulation solutions, such as ponds and green spaces, mitigate surface water flood risks and delay rainwater runoff [33]. Green cover contributes to cooling effects by reducing urban temperatures through shading, evaporation, and water bodies, effectively addressing urban heat island effects [13]. Trees and green spaces play a crucial role in purifying air, reducing traffic-related pollutants, and enhancing overall air quality [18].

Furthermore, green spaces promote physical exercise, social interaction, and psychological well-being, contributing to improved public health [26]. Culturally, well-maintained green spaces encourage community belonging, while disorganized areas may elevate anxiety levels [23]. Additionally, green-blue infrastructure serves as a vital carbon sink, isolating and storing carbon to reduce urban carbon footprints [17]. Lastly, it supports biodiversity by providing habitats for plants and animals, enhancing biodiversity and climate change resilience [25].

3. The urban waterfront

Urban waterfronts are settlements, civilizations, or commercial developments that emerge along bodies of water (rivers, canals, coastal areas, or lakes) and serve as lifelines for urban development. Shaping the urban waterfront is considered a better business idea to transform underutilized space into a thriving center for tourism, culture, entertainment, and business [30]. Connecting traffic flow, establishing various functions, and interacting with the inner part of the city are the main challenges associated with urban waterfront development [14].

Throughout history, waterfronts have served various functions, including transportation, industry, livelihoods, and trade. Water enhances interaction between humans and the environment, making it more comfortable and convenient. Therefore, it positively affects individuals' productivity and their personal, professional, and social lives. Consequently, economic growth in waterfront cities also relies on industrial activities, manufacturing, agriculture, and trade [37].

Thus, the urban waterfront is an area where the city meets a body of water, characterized by the integration of urban development with the natural water feature. This makes it focal points for urban planning and development efforts,

providing opportunities for recreational, economic, cultural, and environmental activities.

3.1 *Urban River Indicators within Urban Landscapes*

The importance of urban rivers as essential elements in cityscapes is evident, as they reflect the essence of a place and contribute to comprehensive urban riverfront planning. Historically, city centers were typically located near rivers due to their role as economic and industrial hubs. However, modern advancements in transportation and urban development have led to the separation of urban areas from their rivers. To address this, sustainable riverfront design methods have been proposed, emphasizing themes that leverage water for cultural, commercial, and residential purposes. Additionally, preserving collective heritage and authenticity in redevelopment projects is crucial for sustainable urban development. Ensuring access and creating high-quality public spaces along riverbanks is essential for accommodating diverse community needs and promoting intensive use by residents and tourists [17] [20].

4. Indicators of blue-green infrastructure within urban riverbanks

Rivers are part of the natural geographic constraints of a place and form the fundamental infrastructure for urban developments. There is a continuous call to preserve a belt of common lands directly adjacent to the water [3]. A set of indicators has been identified to contribute to the implementation of blue-green infrastructure within urban riverbanks:

4.1 *The relationship between urban planning and rivers:*

The nature of a settlement is influenced by the formation of the river upon which it grew. There are types of relationships between urban planning and rivers:

1. "River cities" are urban settlements directly influenced by the river in their urban development, primarily planned along the riverbanks. They share similarities with linear cities, which develop along important water routes [34].
2. "Bridge cities" are settlements associated with significant crossing points, characterized by dominant street patterns perpendicular to the river. The first bridge serves as a focal point, shaping urban planning and future development. This model allows for diverse street network designs, including grid plans [5] [28].
3. Radial development occurs around a nucleus such as a bridge or an island, with planning evolving in a concentrated pattern linked to multiple intersecting pathways. This type exhibits mixed characteristics, combining radial and linear development [34].

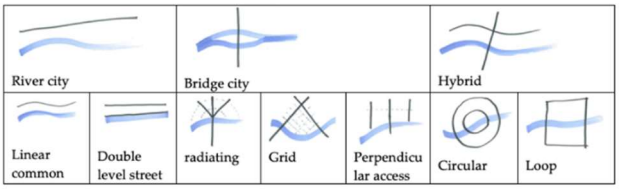


Figure 1: Various Traffic Flow Patterns Associated with Rivers [34].

4.2 *The relationship between urban planning and rivers:*

The importance of rivers as integral parts of urban public spaces network becomes evident. It is suggested to utilize low-lying areas and forgotten plains for creating green spaces and parks instead of buildings and hard surfaces. Riverbanks should be accessible either at water level or at higher elevations to provide attractive linear green spaces encouraging movement and recreational activities [34]. Establishing public parks along river corridors can address health concerns by providing fresh air and sunlight while simultaneously mitigating flood risks [11]. The "soft" and "hard" approaches are contrasting approaches to riverbank design, with the "soft" approach preferring to retain a strip of land along the water for water access, while the "hard" approach utilizes docks and embankments for movement and flood control [12].

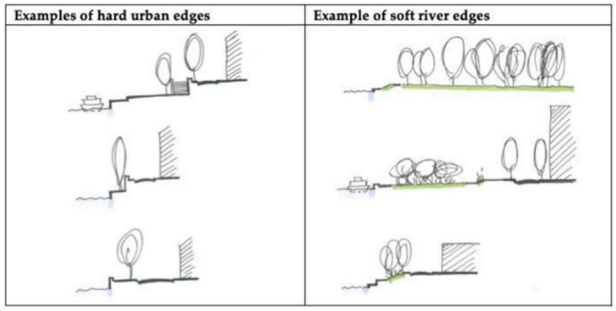


Figure 2: Illustrative diagram of riverbank types: Soft Edge and Hard Edge [34].

4.3 *Enhancing Access to Riverbanks*

Urban green infrastructure projects have led to the creation of large and multi-functional open spaces near rivers on a global scale [40]. The environmental and design characteristics of these spaces, along with their integration with the river, determine the type of public recreational activities available and impact the environmental condition of the river system. Accessibility to the water depends on factors such as the horizontal and vertical distance between the open space and the water's edge, as well as the presence of visual and physical barriers. Actual access to the river channel varies based on the type of recreational activities along the river corridor [15].

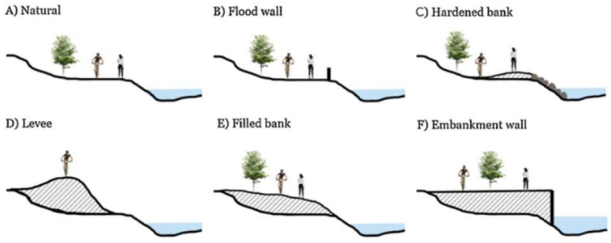


Figure 3: Natural Riverbank and Common Waterfront Barriers [15].

4.4 *Vegetation cover*

The aim of open space development measures in river corridor management plans and environmental programs is to establish connected parks along the river corridor to link neighboring communities while enhancing plant life, recreational and aesthetic opportunities, water quality, and overall quality of life. Four types of park development measures within the river corridor have been proposed: riverfront parks, linear parks, pocket parks, and recreation fields. Each type serves specific purposes within the river corridor to improve access, water filtration, and community engagement [27].

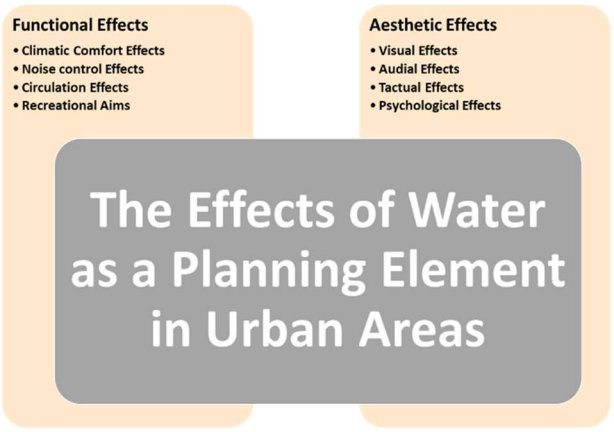


Figure 4: Effects of water as a planning element in urban areas [35].

5. Conclusions of the theoretical framework

The main conclusion of this research is that the development of urban waterfronts has great potential to enhance the urban environment, improve the quality of life for residents, and contribute to the sustainability and resilience of urban areas. It emphasizes the importance of integrating urban waterfronts into urban planning and design to create more livable and climate-resilient cities. Additionally, the research highlights various strategies and considerations related to urban rivers at the city level, emphasizing the need for a comprehensive and sustainable approach to the development of urban waterfronts. Based on this, we summarize in Table (2) below the important indicators regarding the application of blue and green infrastructure within urban riverbanks.

5.1 *The practical application will be implemented on the local case of Abu Nuwas Park.*

a) Background:

A street located on the eastern bank, towards Al-Rusafa, of the Tigris River, extending between the Republic Bridge (formerly known as the Al-Malika Al-Hiyaa Bridge) in the area of Al-Baab Al-Sharqi and the Suspension Bridge in the area of Al-Karrada Al-Sharqiya [4] .

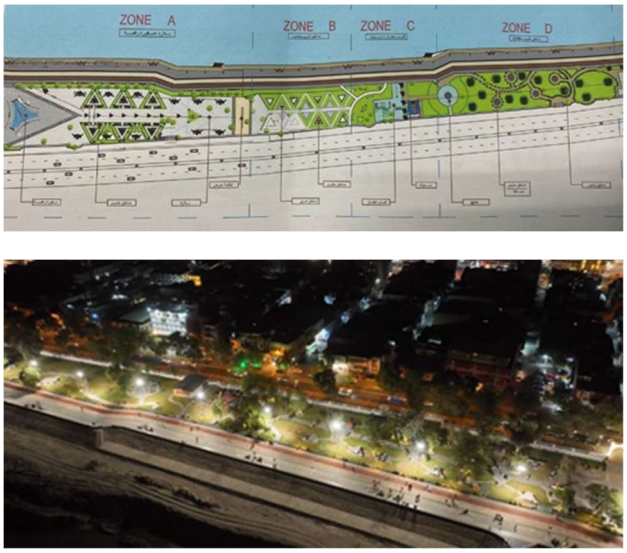


Figure 5: The New Development Process in Abu Nuwas Park .[8]

The history of Abu Nuwas Street in Baghdad dates back to the Ottoman era. The street was established in 1934, eighteen years after Al-Rashid Street, to serve as a continuous extension of it, running along the eastern bank of the Tigris River. It begins where Al-Rashid Street ends, specifically at the Republic Bridge, and extends to the Suspension Bridge[4] . The street was named "Abu Nuwas" in honor of the Abbasid poet, Abu Nuwas al-Hasan ibn Hani. [38].

b) General Description of the Project:

The Abu Nuwas area is one of the most important areas with economic, social, and recreational value in the city, given its central location, rich history, and view of the river. All of this makes it a site of great importance for the city [39].

The development project of Abu Nuwas Park is part of the "Baghdad Beautiful" campaign in response to the directives of Prime Minister Mohammed Shia al-Sudani. It includes the development and rehabilitation of the street, as well as the adjacent road along the Tigris River.

Table 2: Theoretical Framework Indicators.

Green-Blue Infrastructure Indicators		
Key Vocabulary	**The Possible Value**	**Secondary Vocabulary**
Water Management	To ensure the continuity of water resources within the urban fabric, it is essential to focus on water conservation and reuse.	Establishing wetland areas.
		Flood protection.
		Sustainable drainage systems.
Cooling Effect	Mitigation of the urban heat island effect, as vegetation and water bodies contribute to improving the local climate of a specific urban area.	Rain gardens
		Using green roofs
		Main greenery systems
		Cold pavement materials
Improving Air Quality	Sustainable urban development requires proactive measures to address environmental challenges and enhance the resilience of cities.	Climate change mitigation
		Pollutant removal
		Phytoremediation capacity
Open Spaces	Providing public spaces that connect urban areas by prioritizing pedestrians and fostering social interaction	Using green and blue networks
		Ease of access to green spaces
		Pedestrian paths and tree planting
		Multi-purpose green spaces
		Variety of outdoor activities
		Gradient in spaces and ease of movement
Cultural Value	Adding character and significance to the redevelopment of the riverfront while preserving the past and cultural heritage.	Utilizing heritage and religious landmarks.
		Preserving historical identity.
Carbon Sequestration	The potential for isolating and storing carbon in the form of biomass, where the soil of the vegetative cover reduces the carbon footprint of urban areas.	Urban green spaces
		Enhancing urban comfort
		Reducing the carbon footprint
Biodiversity	Developing green spaces is directly linked to the development of habitats that provide space for completing their initial growth stage, as well as comfort by absorbing urban noise.	Diversity in plant species.
		Providing habitats for animals.
Urban Rivers Indicators		
Key Vocabulary	**The Possible Value**	**Secondary Vocabulary**
The subject	The water links support physical and social connectivity, providing opportunities for interaction through the creation of green and blue corridors. These contribute to ease of movement and navigation throughout the area	Introducing the element of water into public space activities
		Determining the main entrances
		Visual and experimental diversity
		Public squares and clarification of their orientation towards the river
The image	Providing a state of physiological, psychological, and physical harmony between humans and the environment, achieving a balance between the content of urban space and its accessibility	Integration of design within the urban landscape
		The potential of urban furniture
Authenticity	Creating a vibrant and attractive public realm through innovative use of water in landscapes, adaptable to local conditions, with stakeholder engagement from both the public and private sectors	Facilitating its use for various demographics
		Providing water-related activities
		Engaging stakeholders in the design process
Employment	Creating unity and continuity among urban spaces by enhancing natural water systems (such as ponds, rivers, and wetlands) within urban fabrics	Multipurpose green spaces
		Enhancing the city's identity, culture, and history
		The integration between urban planning and the riverfront

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Green-Blue Infrastructure within Riverbanks Indicators		
KeyVocabulary	**The Possible Value**	**Secondary Vocabulary**
Urban planning	Rivers are considered the fundamental infrastructure for urban development, as the nature of the urban fabric is influenced by the formation of the river on which it has grown	River city planning
		Bridge city planning
		Circular development city planning
Vegetation cover	Increasing green spaces in urban areas helps enhance the visual, social, cultural, and environmental values with the purpose of gathering neighboring communities and surrounding each other across the river	Providing riverfront parks
		Providing linear parks
		Providing small parks
		Providing recreational fields
Riverbanks	The shape of the river edge is determined based on the adjacent function of the river edge to accommodate unexpected fluctuations in water level to mitigate potential flooding	Providing riverfront parks
		Presence of hard edges
	Providing attractive linear green spaces that are comfortable for movement and recreational activities while enhancing access to the river	The gradient of green spaces towards the river
		Providing water-level green areas
		Providing elevated green areas above the water level
		Providing green areas at both levels
The impact of the water element	The contribution of water as an element in urban planning is vital, as it plays a crucial role in a range of functional impacts that enhance the quality of life, promote sustainability, and improve the comfort of residents in urban areas	Climate comfort
		Circulation
		Recreation
		Noise control
Movement paths	Implementing measures for the safety and continuity of pedestrians and other users, including the addition of appropriate sidewalks and pedestrian standards, along with their aesthetic requirements such as trees and green plants	Providing bike lanes
		Park trails
		Pedestrian pathways
		Pedestrian bridges

The development project of Abu Nuwas Park is part of the "Baghdad Beautiful" campaign in response to the directives of Prime Minister Mohammed Shia al-Sudani. It includes the development and rehabilitation of the street, as well as the adjacent road along the Tigris River. Additionally, the development of the Kazimiyah and Atifiyah corniches is part of the projects directed by the Prime Minister to develop the banks of the Tigris River, under the continuous supervision and follow-up of the Mayor of Baghdad, Engineer Amar Musa Kazem [7]

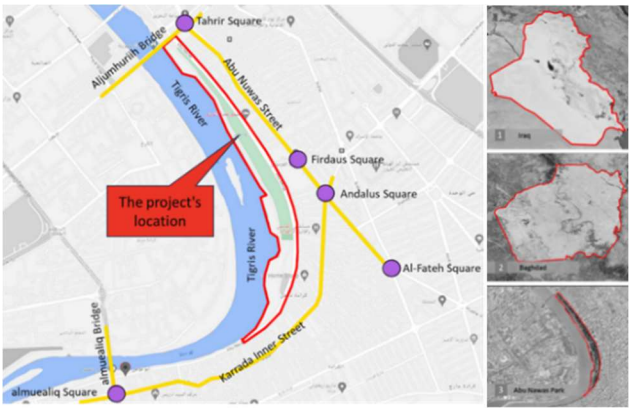

Figure 6: A map illustrating the boundaries of the main roads leading to Abu Nuwas Park.

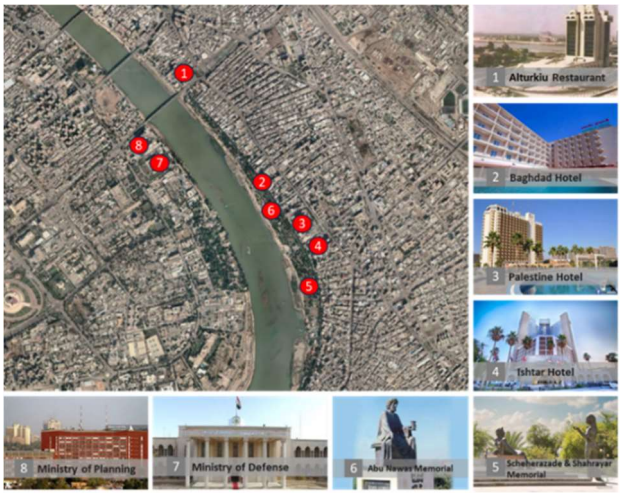

Figure 7: A map showing the main landmarks adjacent to Abu Nuwas Park.

c) Strategies for Blue-Green Infrastructure (BGI):

1) Providing Green Spaces:

The Abu Nuwas Corniche and Park include the plantation of 10 acres of green areas, diverse recreational zones, and a ground fountain. Abu Nuwas is the outcome of 1 km of corniche development works and 17 acres of green areas, with ongoing efforts to transform it into one of the largest recreational and touristic sites in Baghdad. [24] (Figure 8).

2) Social Interaction:

Several new activities are provided, including badminton and volleyball courts, a snake and ladder game area, along

with designated events for people with special needs and different social classes, including children and the elderly. Additionally, a parking lot for 100 cars and sanitary facilities for men and women have been established. Flower planting, seating terraces, water fountains, waste bins, and rest stations have also been installed for citizens. [7] (Figure8)

3) Cultural Value:

A "I Am Iraq" wall has been erected featuring pictures of celebrities and historical figures, and a clock area has been designated as a resting square for citizens. The Abu Nuwas Park aims to enhance the cultural value of the city by showcasing famous landmarks and historical figures. The park serves as a meeting place for citizens and provides a platform for cultural events and celebrations. It symbolizes Baghdad's rich heritage and honors the legacy of Abu Nuwas, the distinguished poet known for his wit, humor, and storytelling during the Abbasid era [24] (Figure 8)

4) Mobility Paths:

The site features pedestrian pathways that connect its various spaces, as well as the implementation of separate paths for walking and cycling [24] (Figure 8)

5) Community Participation:

The Prime Minister emphasized the importance of private sector involvement in the riverbank development project, with restaurants and casinos, to be built according to specific designs and specifications, characterized by beauty and simplicity [21] (Figure 8).

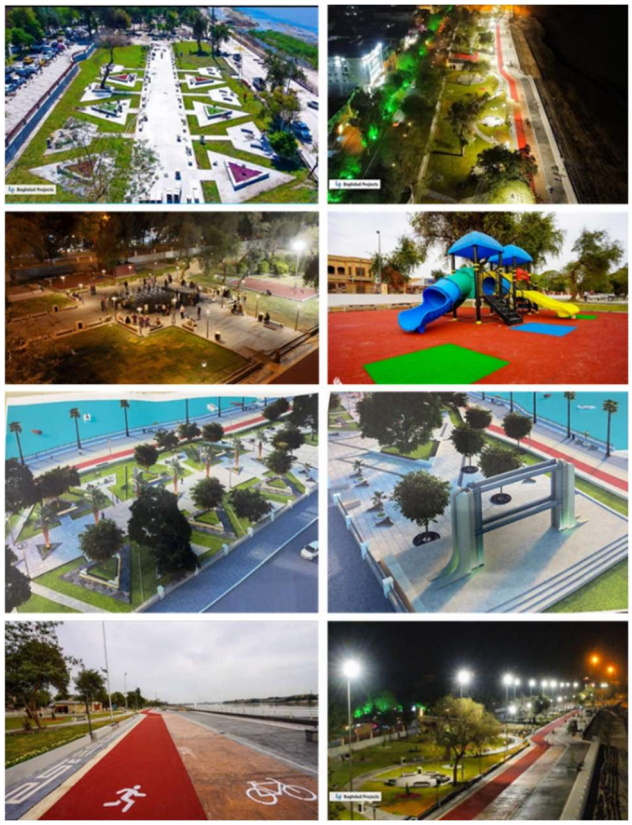

Figure 8: Illustrates the Implemented Infrastructure Strategies within Abu Nawas Park.

5.2 *Blue Infrastructure (GBI) Indicators on the Local Sample (Abu Nawas Park):*

Based on the analysis of the sample and understanding the methodology used in achieving the GBI indicators on riverbanks, the results indicate that 26% of these indicators have been achieved. It was observed that some criteria were not applied in the development process, such as the lack of consideration for cooling effects and the limited adoption of urban resilience criteria, reducing opportunities for adaptation to climate change.

Furthermore, there was weak performance in applying green-blue infrastructure techniques, although the development process contributed to accomplishing about 32% of urban river indicators. Although the design only focused on creating pathways along the watercourse without effectively interacting with the riverfront, there were some contributions that enhanced social interaction and achieved a modular unity between urban spaces. Moreover, the development process achieved Approximately 40% of the green-blue infrastructure indicators on urban riverbanks. Urban rivers are essential infrastructure for cities and play a vital role in shaping sophisticated cultural landscapes. Sustainable riverfront plans can create dynamic urban areas by enhancing the significance and value of rivers for people and the region.

Table 3: Application of Theoretical Framework Indicators on Local Case (Abu Nuwas Park Development Project

Green-Blue Infrastructure Indicators			
KeyVocabulary	**The Possible Value**	**Secondary Vocabulary**	**AbuNuwas**
Water Management	To ensure the continuity of water resources within the urban fabric, it is essential to focus on water conservation and reuse.	Establishing wetland areas.	🔴
		Flood protection.	⚪
		Sustainable drainage systems.	⚪
Cooling Effect	Mitigation of the urban heat island effect, as vegetation and water bodies contribute to improving the local climate of a specific urban area.	Rain gardens	⚪
		Using green roofs	⚪
		Main greenery systems	⚪
		Cold pavement materials	🔴
Improving Air Quality	Sustainable urban development requires proactive measures to address environmental challenges and enhance the resilience of cities.	Climate change mitigation	⚪
		Pollutant removal	🔴
		Phytoremediation capacity	⚪
Open Spaces	Providing public spaces that connect urban areas by prioritizing pedestrians and fostering social interaction	Using green and blue networks	🟡
		Ease of access to green spaces	🟡
		Pedestrian paths and tree planting	🟡
		Multi-purpose green spaces	🔴
		Variety of outdoor activities	🔴
		Gradient in spaces and ease of movement	🔴
Cultural Value	Adding character and significance to the redevelopment of the riverfront while preserving the past and cultural heritage.	Utilizing heritage and religious landmarks	🟢
		Preserving historical identity	🟢
Carbon Sequestration	The potential for isolating and storing carbon in the form of biomass, where the soil of the vegetative cover reduces the carbon footprint of urban areas.	Urban green spaces	🟡
		Enhancing urban comfort	🔴
		Reducing the carbon footprint	🔴
Biodiversity	Developing green spaces is directly linked to the development of habitats that provide space for completing their initial growth stage, as well as comfort by absorbing urban noise.	Diversity in plant species.	⚪
		Providing habitats for animals.	🔴
The total points achieved by the three experiments of green-blue infrastructure indicators			**6.25**
The percentage			**27%**
Urban Rivers Indicators			
KeyVocabulary	**The Possible Value**	**Secondary Vocabulary**	**Abu Nuwas**
The subject	The water links support physical and social connectivity, providing opportunities for interaction through the creation of green and blue corridors. These contribute to ease of movement and navigation throughout the area	Introducing the element of water into public space activities	🔴
		Determining the main entrances	⚪
		Visual and experimental diversity	🟡
		Public squares and clarification of their orientation towards the river	⚪
The image	Providing a state of physiological, psychological, and physical harmony between humans and the environment, achieving a balance between the content of urban space and its accessibility	Integration of design within the urban landscape	🟡
		The potential of urban furniture	🟡
Authenticity	Creating a vibrant and attractive public realm through innovative use of water in landscapes, adaptable to local conditions, with stakeholder engagement from both the public and private sectors	Facilitating its use for various demographics	🟡
		Providing water-related activities	🔴
		Engaging stakeholders in the design process	🔴
Employment	Creating unity and continuity among urban spaces by enhancing natural water systems (such as ponds, rivers, and wetlands) within urban fabrics	Multipurpose green spaces	🔴
		Enhancing the city's identity, culture, and history	⚪
		The integration between urban planning and the riverfront	⚪
The total points achieved by the three experiments of the blue-green infrastructure indicators			**3**
The percentage			**25%**

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Green-Blue Infrastructure within Riverbanks Indicators			
KeyVocabulary	**The Possible Value**	**Secondary Vocabulary**	**Abu Nuwas**
Urban planning	Rivers are considered the fundamental infrastructure for urban development, as the nature of the urban fabric is influenced by the formation of the river on which it has grown	River city planning	🟡
		Bridge city planning	🔴
		Circular development city planning	⚪
Vegetation cover	Increasing green spaces in urban areas helps enhance the visual, social, cultural, and environmental values with the purpose of gathering neighboring communities and surrounding each other across the river	Providing riverfront parks	⚪
		Providing linear parks	🟡
		Providing small parks	🟡
		Providing recreational fields	🟡
Riverbanks	The shape of the river edge is determined based on the adjacent function of the river edge to accommodate unexpected fluctuations in water level to mitigate potential flooding	Providing riverfront parks	⚪
		Presence of hard edges	🟢
	Providing attractive linear green spaces that are comfortable for movement and recreational activities while enhancing access to the river	The gradient of green spaces towards the river	⚪
		Providing water-level green areas	⚪
		Providing elevated green areas above the water level	⚪
		Providing green areas at both levels	⚪
The impact of the water element	The contribution of water as an element in urban planning is vital, as it plays a crucial role in a range of functional impacts that enhance the quality of life, promote sustainability, and improve the comfort of residents in urban areas	Climate comfort	🔴
		Circulation	🟡
		Recreation	🔴
		Noise control	🟢
Movement paths	Implementing measures for the safety and continuity of pedestrians and other users, including the addition of appropriate sidewalks and pedestrian standards, along with their aesthetic requirements such as trees and green plants	Providing bike lanes	🟡
		Park trails	🟢
		Pedestrian pathways	⚪
		Pedestrian bridges	⚪
The total points achieved by the three experiments of the blue-green infrastructure indicators			**7**
The percentage			**33%**
Note : 🟢 Good performance 🟡 Average to above average performance 🔴 Below average or unsatisfactory performance ⚪ The evaluation criteria do not apply			

6. Conclusions:

Based on the presented research, activating green-blue infrastructure on riverbanks plays a crucial role in enhancing urban life and harnessing the benefits of natural infrastructure. Integration between innovative water features, flexible access points, and vibrant public spaces

can create a lively and attractive urban environment. Furthermore, harmony between human physiology, the environment, and physical activity can achieve a balance Between urban development and nature. Strategies such as creating green pathways, pedestrian paths, and adaptive water resource utilization can benefit from urban experience and promote sustainable practices. Overall, the research emphasizes the importance of leveraging green-blue infrastructure to create lively and sustainable urban environments that meet the needs of various stakeholders and promote a healthy and active lifestyle.

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أستغلال إمكانيات البنية التحتية الزرقاء في ضفاف الأنهار الحضرية للتنمية المستدامة

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الخلاصة – تستكشف هذه الورقة البحثية الفوائد المحتملة لدمج البنية التحتية الخضراء-الزرقاء على ضفاف الأنهار الحضرية لتعزيز جودة البيئة وتعزيز التنمية الحضرية المستدامة. تتناول هذه الدراسة هذه الفجوة من خلال استكشاف الفوائد الرئيسية لاستغلال البنية التحتية الخضراء والزرقاء لتحسين البيئات الحضرية وتعزيز الممارسات المستدامة. من خلال استغلال ميزات المياه المبتكرة ونقاط الوصول المرنة والمساحات العامة الحيوية، تهدف الدراسة إلى خلق إعدادات حضرية حية وجذابة تلبي احتياجات الأطراف المتنوعة. من خلال التأكيد على التناغم بين التنمية الحضرية والطبيعة .تفحص الدراسة مبادرات البنية التحتية الخضراء-الزرقاء التي تهدف إلى تعزيز وظيفة البيئة، وإدارة مياه السيول، وتحسين جودة المياه، وتعزيز التواصل البيئي في إعدادات الأنهار الحضرية. تؤكد على أهمية تفاعل الإنسان مع البيئة والنشاط البدني في تشكيل مناظر حضرية ديناميكية ومستدامة. من خلال تنفيذ استراتيجيات تتعلق بالبنية التحتية الخضراء-الزرقاء. تؤكد النتائج على أهمية استغلال البنية التحتية الخضراء-الزرقاء لتطوير بيئات حضرية حية ومتينة تعزز نمط حياة صحي ونشط بينما تسهم في الحفاظ على البيئة ورفاهية المجتمع. وأن تفعيل البنية التحتية الخضراء والزرقاء يمكن أن يساهم بشكل كبير في استدامة المدن وقدرتها على مواجهة الأحداث الهيدرولوجية الناجمة عن تغير المناخ.

الكلمات المفتاحية – البنية التحتية الزرقاء - الخضراء ، إحياء الأنهار الحضرية، الاستدامة البيئية، التصميم الحضري المستدام.