SVU-International Journal of Engineering Sciences and Applications (2022) 3(2): 106-115
Print ISSN 2785-9967| Online ISSN 2735-4571
DOI 10.21608/SVUIJESA.2022.152330.1060

# Proposed sustainable infrastructure criteria for achieving sustainable development in Egyptian cities: Using integrated gray, green, blue infrastructure approaches

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**Abstract** The approaches to the sustainable infrastructure are one of the tools to achieve the sustainability of the infrastructure, which aims to achieve sustainable development in urban communities. This research aims to determine the most appropriate sustainable infrastructure approaches for Egyptian cities, while defining the planning criteria for these approaches, through which it is possible to assess the sustainability of the infrastructure sector in Egyptian cities. The research found that the approach of integration between the approaches to the sustainable infrastructure (gray - green - blue) is the most suitable approach to the sustainable infrastructure for the Egyptian case. It is commensurate with the specificity of the Egyptian case, through a set of research steps, which will be dealt with in detail within this research.

**Keywords:** (Sustainable Infrastructure; Sustainable development; Green, Gray and blue Infrastructure, Sustainable Infrastructure approaches, criteria of GGBI).

## 1 Introduction

Urban growth necessitates extensive infrastructural demands. Sustainable infrastructure is essential to achieving the Sustainable Development Goals (SDGs) and the climate objectives of the Paris Agreement, given that current infrastructure systems are responsible for more than 60% of global GHG emissions. This is because urban development requirements must be met while also achieving the SDGs. Infrastructure is implied in the other socioeconomic SDGs even though it is only specified specifically in SDG 9. By assisting nations to integrate social and environmental advantages into infrastructure development, SDG 3 clean transportation systems, SDG 7 energy access, SDG 9 sustainable industrialization, and SDG 3 responsible production and consumption will all have positive effects on health and air quality (SDG 12). Sustainable infrastructure may also help to safeguard.

To achieve this environmental balance, lessen the consequences of climate change, and respond to them, it was important to rely on non-traditional (grey) infrastructure options. Traditional infrastructure systems (grey) lack the resilience to adapt to any variables that may arise at any moment and are now unable to handle environmental threats, natural disasters, and climate change occurring throughout the world. Decision-makers are starting to go beyond the obvious and test out less conventional approaches to infrastructure. The Blue-Green-Gray Infrastructure (GGBI) is a practical, affordable, and valuable option for urban regions facing challenging climate change conditions. The demand for climate-resilient 21st century solutions may be met through the integration of green, blue, and grey infrastructure. Combining outdated

Received: 25 July 2022/ Accepted: 16 August 2022
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and inexperienced infrastructure.

Biotechnologies or hybrid methods, such as the GGBI paradigm, are particularly well adapted to the urban setting, where relying purely on green infrastructures seldom fulfils risk reduction goals, but where city planners have historically relied entirely on constructed structures. These projects seek to reduce the metropolitan system's reliance on grey infrastructure, as well as the challenges that this involves, and to improve municipal sustainability.

Gray infrastructure for disaster risk reduction has significant limits under most circumstances, although it is straightforward to adapt to urban situations. Green infrastructure, on the other hand, is a flexible, no-regrets strategy that provides several advantages and co-benefits that go beyond conventional protection or buffering functions. However, in cities, this is frequently impossible to do. Hybrid systems are ideally adapted to the intrinsically mixed character of cities while delivering powerful solutions that encompass many, if not all, of the co-benefits of more classic green or blue approaches. As a result, integrated methods are recommended at the local level as avenues for disaster risk reduction and climate change adaptation solutions throughout the CCA region's cities and regions. urbanized zone [7]. The Global Green Building Index (GGBI) is crucial in making cities more livable, sustainable, and resilient. [6]

The research carried out a set of methodological steps as shown in fig. (1), which are represented firstly: a study of the temporal development of the approaches to sustainable infrastructure planning by presenting the concepts of each approach - the criteria for each approach - the main issues that each approach affects - the environmental sectors that each approach affects ... and through Theoretical framework The research combined the most important criteria related to sustainable infrastructure planning approaches (gray - green - blue) and came up with combined criteria. In the next step, the research was concerned with studying a group of the most important global experiences for sustainable infrastructure planning approaches, and the research extracted a set of criteria related to integrating sustainable infrastructure planning approaches (gray - green - blue). The research extracted a set of criteria for planning sustainable infrastructure by integrating the gray-green-blue approach after studying (theoretical framework - global experiences). To study the suitability of these criteria for Egyptian cities, the research conducted a questionnaire for a group of the most important experts in the field of sustainable infrastructure planning in several sectors concerned with environmental planning and sustainable development and asked them about the suitability of these criteria for Egyptian cities. Planning sustainable infrastructure using the gray-green-blue approach to Egyptian cities.

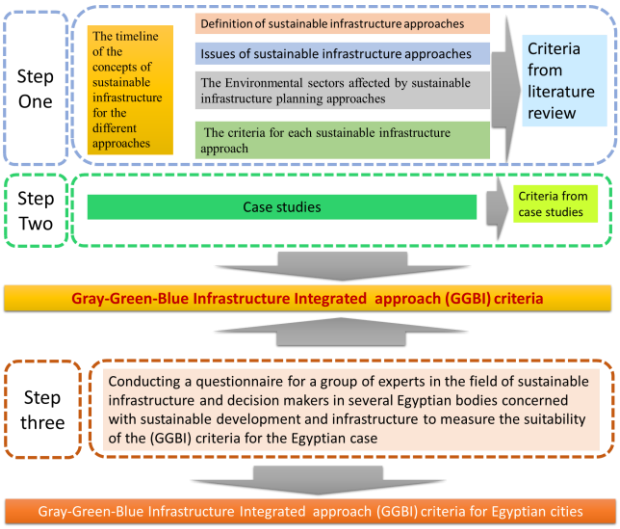


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**Fig. 1 The Research methodology**

## 2 Evolution of sustainable infrastructure approaches

### 2.1 Definitions of sustainable infrastructure approaches

**Table 1 The Definitions of sustainable infrastructure approaches**

| Approach of IS | Definitions |
|---|---|
| **Gray Infrastructure** | Dams, seawalls, highways, pipelines, and water treatment facilities are examples of structures. These constructed solutions are integrated inside watersheds or coastal ecosystems, whose hydrological and environmental characteristics have a significant impact on the functioning of grey infrastructure [1],[2]. |
| **Green Infrastructure** | (GI) refers to natural and man-made components that perform ecological and hydrological activities and processes while also providing a variety of co-benefits. Natural heritage elements and systems, parklands, stormwater management systems, street trees, urban forests, natural waterways, permeable surfaces, and green roofs are examples of green infrastructure components. [1] [6] |
| **Blue Infrastructure** | Refers to hydrological infrastructure, such as rainfall and urban storm water systems, as well as surface water and groundwater aquifers. Blue infrastructure resilient provision for water supply and water security in urban design [6] [3] [4] |

Source: authors

Several planning approaches have appeared to achieve infrastructure sustainability. The Previous table (1) presents the most important definitions of sustainable

infrastructure planning approaches.

### 2.2 Environmental issues and sectors dealing with infrastructure approaches

#### 2.2.1 Issues related to achieving infrastructure sustainability

Each approach of sustainable infrastructure planning faces a set of issues, as shown in the following fig. (2)

- Administrative issue: the importance of local government in the planning and design process and stakeholder participation.

- Economic (financial) issue: the cost of green infrastructure is higher, which should be considered in the construction costs

- Environmental Issue: reduce air, water, and soil pollution. Connected green infrastructures can create corridors for wildlife to allow for the movement of species and more resilient biodiversity in the face of climate change.

- Social Issues: creates green spaces that can be a focal point for community participation by engaging the public in the design, provision, and management of new resources and by providing education, training and volunteer opportunities.

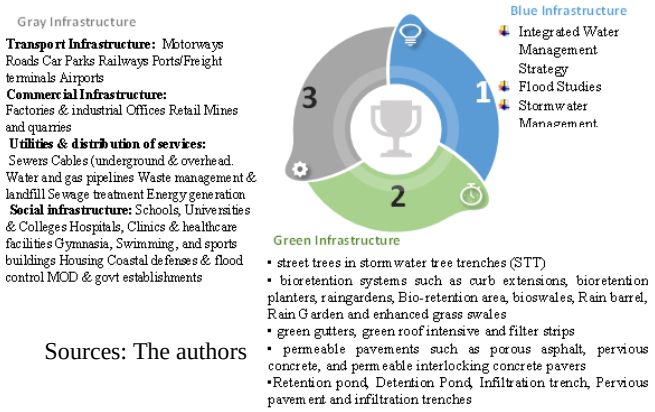
- Technical Issues: Would green infrastructure reduce the cost, enhance the quality, or boost the service's resilience? [4]

  - Planning: Conduct planning-level studies utilising generic assessment techniques to identify the basic scope, function, and cost of the "Infrastructure Master Plan."

- Policy Enabling: What can the service provider do to strengthen the enabling environment for green infrastructure [4]?

  - Proactive government engagement: Work with governments at all levels, from political leaders to government departments, to help with policies, legislation, regulations, research, and community outreach.

  - Development partners: Where possible, collaborate with development partners and specialist civil society groups to create and fund green infrastructure.

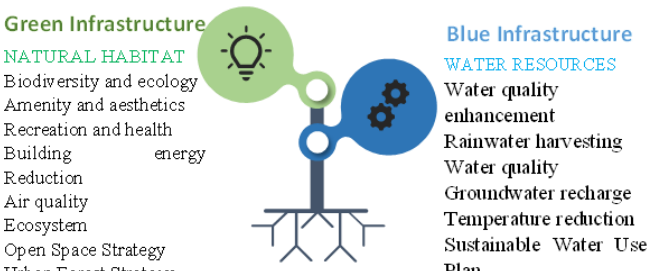



Sources: The authors

**Fig. 2 The Environmental sectors affected by sustainable infrastructure planning approaches**

#### 2.2.2 The Environmental sectors affected by sustainable infrastructure planning approaches

The effect of the green infrastructure approach and the blue infrastructure approach on several environmental sectors as shown in the following Fig. (3), while the gray infrastructure approach did not have a clear impact on the environmental sectors, as it is an approach concerned with the physical aspect and facilities supply.




Sources: authors

**Fig. 3 Issues of sustainable infrastructure approaches**

### 2.3 criteria of sustainable infrastructure approaches

Each of the approaches to the sustainable infrastructure includes a set of criteria to achieve the sustainability of the infrastructure in urban communities, and the following table (2) includes the criteria for the approaches to the sustainable infrastructure

### 2.4 Case studies related with sustainable infrastructure approaches

**Table 2 criteria of sustainable infrastructure approaches**

| | Criteria |
|---|---|
| **Gray Infrastructure** | • Conveyance (sewers, manholes and pumps)<br>• Sewer separation<br>• Storage tank<br>• Storage tunnel<br>• Retention–treatment basin<br>• High-rate clarification<br>[16] [23] |
| **Green Infrastructure** | • Ensure adequate room for the installation of the GI system while preserving safety and efficiency.<br>• Soil composition<br>• Topography: Different GI systems operate at different grade levels.<br>• Groundwater to prevent local groundwater impacts<br>• Utilities and subterranean features:<br>• Geotechnical Evaluation<br>• Hydrologic Evaluation<br>• Microclimatic Evaluation<br>• The kind of sewage system available; storm or combined<br>• Heavy industrial land usage [17] [16][25][15][22][23] |
| **Blue Infrastructure** | • Real-time control (RTC)<br>• Flow and level sensors<br>• Inflatable dams<br>• Automated sluice gates<br>• safeguarding and improving local rivers and aquatic habitats<br>• Water Sensitive Urban Design<br>• Slow and minimize urban stormwater<br>• Naturalize waterway corridors<br>• Reconnect floodplains to waterways and promote subsurface flow<br>• Use other water sources<br>• Promote the use of green spaces and trees.<br>• Use vegetated systems (such as wetlands or biofilters) to minimize storm water runoff volumes.<br>• Increase permeability of urban areas by increasing percentage of green space and unpaved areas.<br>• Incorporate ‘sunken' places and overland paths into green spaces.[11][14][15][26] |

Source: authors

In this part we study, analysis case studies related with sustainable infrastructure approaches to determine criteria to ensure sustain in cities as shown in table (3)

India has As governments around the world begin to implement economic recovery strategies in the aftermath of the COVID-19 epidemic, the need for a sustainable revival focused on adjusting to and mitigating climate change, climate-proofing the economy, and developing resilient development sectors is widely acknowledged. To decide on blue-green infrastructure as a strategy for creating resilience to climate change and health and wellness phenomena, India needs a policy and investment response that addresses the three interconnected dimensions of sustainable development: economic, social, and environmental. [1]

A quality infrastructure system, according to UNIDO, is a collection of projects, institutions, organizations, activities, and people necessary to ensure the efficacy and security of commodities produced and supplied to customers. A regulatory framework, quality service providers (such as Conformity assessment), businesses, customers, and consumers (who include citizens as "consumers" of government services) are all part of the QIS. It also includes a national quality policy and institutions to implement it, including standardization, metrology, and accreditation. This index developed within the framework of the Global Quality and Standards Program (GQSP), which funded by the Swiss State Secretariat for Economic Affairs (SECO), in collaboration with partners from the International Network on Quality Infrastructure (INetQI) [2].

Massive urbanization in Russia causes a range of environmental, economic, and social challenges and concerns (Kotter et al. 2009). Green infrastructure, as opposed to grey infrastructure, is acknowledged as an alternative nature-based and cost-effective strategy for improving the sustainability of urban growth as a response to some of these negative impacts of urbanization (Ahern 2013; Alberti 2008). At the same time, GI is multidimensional and provides residents with a variety of user-centered ecosystem services (Gill et al. 2007; Hansen et al. 2014). All indicators in this case were divided into three groups: those that 1) characterise general green infrastructure availability; 2) support a comfortable urban environment; and 3) form a stable integrated system of green infrastructure [3], on the Dutch side of Sint Maarten Island, one of the most vulnerable areas to flooding. [4] The case study was based on cost/benefit analysis; in the United Kingdom, it is based on the Framework for delivering excellent green infrastructure. [5] Which takes into account the Core, nature conservation, health, and water management. [6]

**Table (3) criteria of sustainable infrastructure approaches**

| Case studies | Sectors of Criteria | Sustainable infrastructure approaches |
|---|---|---|
| **India** ORF | health and wellness<br>climate change | Green & blue infrastructure |
| SECO& INetQI UNIDO | A quality infrastructure<br>quality service | Green & gray infrastructure |
| Russian | describe the broad availability of green infrastructure<br>encourage a pleasant urban environment<br>A reliable, integrated green infrastructure system. | Green infrastructure |
| Dutch side of Sint Maarten Island | Cost / co-benefit solution | green-blue-grey infrastructure |
| UK | Core principles<br>HEALTH AND WELLBEING<br>SUSTAINABLE WATER MANAGEMENT<br>NATURE CONSERVATION | green infrastructure |
| **IHE Delft** IHE DELFT | FLOOD REDUCTION<br>ecosystem services<br>human wellbeing<br>and co-benefits | green-blue-grey infrastructure |
| Koshigaya Lake Town | ecological functions<br>environmental functions, both physical and natural<br>social and economic functions | Green Infrastructure |
| GreIn | urban ecosystems<br>quality of urban<br>urban climate control<br>water management<br>green networks | GREEN INFRASTRUCTURE |
| U.S. Environmental Protection Agency EPA | Improved water quality<br>Increased resilience to climate change<br>Reduced air pollution improves public health<br>more physical exercise<br>Cost saving | GREEN INFRASTRUCTURE |
| TO2 federatie | Financial benefits<br>Human health benefits<br>Environmental benefits<br>Climate Mitigation<br>Circular economy | green and blue infrastructure |

Source: Authors

To realize ecosystems and environmental wellbeing, and herald sustainable future communities in Koshigaya Lake Town, green infrastructure is an approach to achieving these goals, so that this case is dependent on ecological functions, physical and natural environmental functions, and socio-economic functions [7]. Green infrastructure is a Green approach for dealing with rising urbanization. Urban green spaces serve an important role in urban ecosystems, increasing city quality in a variety of ways such as water management, climate control, and support for substantial green networks. As a result, they improve the quality of life for city dwellers [8].

The United States Environmental Protection Agency emphasized better water quality, enhanced resilience to climate change, improved public health due to lower air pollution and more physical activity, and cost savings [9],]. Financial advantages, human health benefits, environmental benefits, climate mitigation, and circular economy were highlighted by the Commissioner for Human Rights. [10]

From these cases, we can identify the almost issues and main sectors of criteria that related with criteria of sustainable infrastructure approaches as shown as fig. (4)

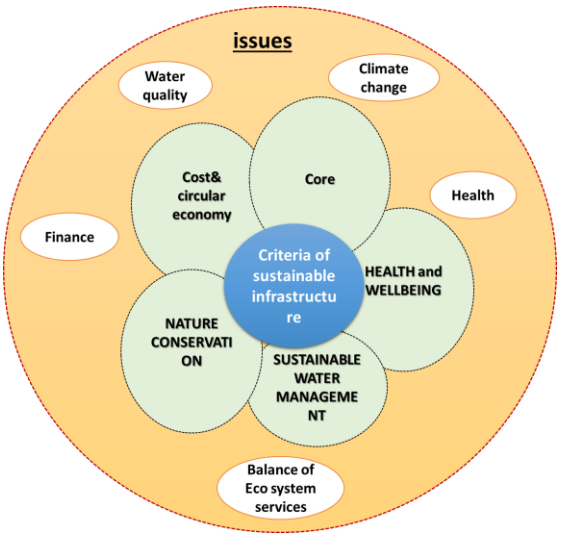



**Fig. 4 criteria and issues that related with sustainable infrastructure from case studies**

Source: authors

Through the previous theoretical lecture review, the research concluded that the approach to the integration between the approaches (Gray- Green – Blue) to the sustainable infrastructure is the most appropriate approach to achieve sustainable development. In the next part, the research will present the concept, benefits and importance of the gray-green-blue (GGBI) approach

and the most important environmental sectors it affects. The research will also define the planning criteria for the gray-green-blue (GGBI) approach.

## 3. Results and discussion

### 3.1 Green-Gray-Blue Infrastructure approach

#### 3.1.1 Operational Definition of GGBI (Green-Gray-Blue Infrastructure)

It is a strategy for adapting to the consequences of climate change and delivering diverse services, including environmental and cultural advantages. It involves policies or activities to minimize societal vulnerability and build resilience capability. GGBI incorporates hydrology (sustainable water and rainfall management) and ecological treatment (urban ecosystems) into projects, offering important and functional services to human civilizations and increasing quality of life by merging green and blue components harmoniously. By restoring natural processes into the constructed environment and depending on the peculiarities of the local urban setting, such as available space, topography, and climate, can be efficient at different sizes.

It is a strategy for adapting to the consequences of climate change and delivering diverse services, including environmental and cultural advantages. It involves policies or activities to minimize societal vulnerability and build resilience capability. Meanwhile, GGBI incorporates hydrology (sustainable water and rainfall management) and ecological treatment (urban ecosystems) into projects, offering important and functional services to human communities and increasing quality of life by merging green and blue components smoothly. By restoring natural processes into the constructed environment and depending on the peculiarities of the local urban setting, such as available space, topography, and climate, can be efficient at different sizes. Green and blue infrastructures are primarily built on healthy and functioning ecosystems, with little or no technology intervention.

#### 3.1.2 Benefits of GGBI in urban areas for making - decision:

GGBI promotes future adaptation and even transformation by addressing challenges such as climate change, food insecurity, and limited resources. It can also create logical interdependencies for water, food, transportation, energy, health, and social systems and provides a multifunctional solution approach aimed at increasing urban sustainability. The supply of social, economic, and environmental advantages through GGBI enhances acceptance and implementation of these solutions. Awareness of the GGBI's added value and its economic appraisal might be deadly in persuading.

Decision-makers must be convinced of the feasibility and importance of adopting the GGBI. Economic analysis of these co-benefits can have a substantial influence on decision-making by demonstrating the economic efficiency of investing in climate change adaptation through GGBI.

Furthermore, because it establishes fact-based judgments and shows their financial ramifications, the economics of adaption techniques are an important element of the decision-making process. However, there are certain unquantifiable advantages to using GBI. Because it is critical to assess the complete spectrum of advantages available, efforts should be made to incorporate non-monetary factors such as increased health, human well-being, enhanced quality of life, and protection of natural resources. [3]

Green roofs, bio-wells, purification biotopes/rain gardens, retention and retention ponds and lakes, infiltration systems, and other components that may be linked to other SCI elements in a watershed comprise a typical GGBI. Each piece not only fills and contributes to the treatment of rain and storm water, but it may also be viewed as an ecological steppingstone in its own right, enhancing the connectedness that is essential for floodplain ecological management and conservation. These interconnected modules are frequently referred to as "process trains." The combination of blue and green infrastructure services yields a multi-functional design with several socioeconomic and socioenvironmental benefits. [6]

- Providing / conserving Water as a resource: GGBI not only successfully manages the amount of precipitation, but it also enhances the quality of the water. Cities' desire for an effective approach to water management is growing by the day. Green infrastructure provides alternatives to establishing a water treatment facility, such as planting trees and restoring wetlands, or selecting water efficiency over building a dam. Instead than constructing dykes, water supply and floodplain restoration should be prioritized. [18]

- Improving Air Quality: Trees, plants, and grass absorb smoke, dust, and other pollutants in the air. Green absorbs pollutants in the air and traps particles. Green plants mitigate air pollution caused by power generation by lowering energy

usage. Plants reduce energy consumption, which improves air quality and reduces greenhouse gas emissions, lowering CO2 levels.

Save Energy: In general, green roofs - as a type of green infrastructure practice – offer savings of 15-25% on energy costs. [18]

- Mitigate urban heat island (UHI): Urban development creates urban heat islands. Urban areas are always warmer than rural areas. The use of green infrastructure applications can help reduce UHI by increasing vegetation cover, decreasing soil conductivity and reducing ground-level ozone formation.

- Adaptation to climate change and biodiversity: GGBI has immense potential to adjust urban climates by minimizing the influence of urban heat islands, flattening diurnal temperature changes, and increasing natural ventilation. Reducing the bioclimatic implications of land cover changes, such as urban soil drying and accompanying air pollution from wind and dust threats. BGI increases the flexibility and resilience of urban infrastructure by regulating and modifying hydroclimatic variability and weather extremes.

- Improve community livability: Increasing the usage of green infrastructure may improve the quality of life in the area in a variety of ways, including increased aesthetic value, noise pollution reduction, recreation, and community cohesiveness.

- Aesthetics: Green has a strong impact on the aesthetic value of urban areas. Several reviews have concluded that real estate values increase the greener a city neighborhood has.

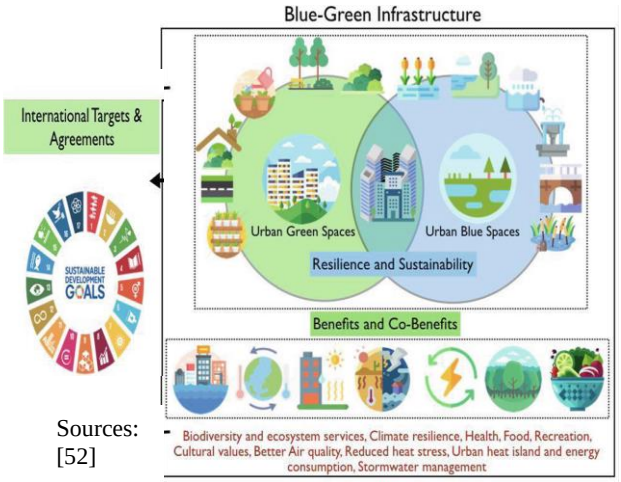
- Reduce noise pollution: another advantage of green infrastructure technologies is that they reduce noise pollution. There are several reassessments of noise pollution in urban environments. The noise level occasionally reaches the threshold at which it becomes a health danger.

- Recreation: Green infrastructure can increase recreational opportunities if there is greener within a community.

- Societal benefits and community cohesion: GGBI techniques can promote community livability through impacting community cohesiveness. BGI improves recreational, exercise, and social environments, hence improving human physical and mental health. These institutions save money on both public and individual health care.

- Food production: Cities today contribute around 15% of the world's food supply. GGBI can expand options for urban farming and foraging.

- Habitat enhancement: A number of green infrastructure greening measures can benefit a wide range of flora and wildlife. Environmental economics describe two habitat characteristics as necessary for the supply of a variety of ecosystem services. First, habitat includes both resident and migratory species. Second, habitat provides nurseries for animals that spend the majority of their adult lives elsewhere.




Sources: [52]

**Fig. 5 Benefits of GGBI in urban areas**

- Public Education: GGBI offers an honest likelihood to develop community awareness and information regarding the worth of property water re-sources management. Educating and informing the overall public about the economical use of water resources may be a useful service that may produce support for higher water management selections within the future. The Previous fig. shows the benefits of the GGBI.

GGBI ideas want to behave as a manual for strategic planners. Taken into consideration that strategic nearby ideas for Green infrastructure is being vital of the city increase framework, wherein it gives effective making plans tools & creates hyperlinks among scale, size, function, type & form. important ideas to the achievement of GGBI; A-Strategically designed, deliberate and handing over 'smart' conservation at one-of-a-kind scales, constructing connectivity in

ecological networks and selling inexperienced areas with inside the city environment. B- Delivering multifunctional benefits; designing and handling land as a multifunctional aid able to handing over a extensive variety of environmental and great of lifestyles benefits. C-Helping to supply place-making; spotting the person and uniqueness of various places and making sure that regulations and applications reply accordingly. D-Engaging key companions and concerning various stakeholders. [28]

### 3.2 Proposed sustainable infrastructure criteria of GGBI

**Table 4 Basic criteria of GGBI**

| CATEGORIES | CRITERIA | BENEFIT FOR SUSTAINABLE URBAN DEVELOPMENT |
|---|---|---|
| **CORE** | A multifunctional network is formed by green infrastructure. | Ensures that green infrastructure matches local objectives and requirements, as expressed in local policy or through collaboration with local stakeholders, ensures that proper provisions are made for how green infrastructure will be managed and maintained, as well as who will be responsible for these activities and how they will be funded. |
| | Green infrastructure reflects and promotes the local environment's character. | |
| | type, quality, and function of green infrastructure are all influenced by the surrounding environment. | |
| | Green infrastructure is climate change resistant and improves environmental quality. | |
| | Long-term management and maintenance of green infrastructure is planned. | |
| **COST& CIRCULAR ECONOMY** | expected annual damage | helpful decision-making tool, compare among optimal combinations of green, blue and gray measures, flood risk reduction |
| | minimum cost | |
| | maximum damage reduction | |
| | maximum total benefits | |
| | Longer life span infrastructure, water loop , energy loop | |
| **ENHANCE HEALTH AND WELLBEING** | Green infrastructure is easily accessible and conveniently located near people's homes. | Ensures that green infrastructure elements remain available and pleasant throughout the year, increasing the advantages of green infrastructure. Ensures that green infrastructure elements are accessible and enjoyed year-round, increasing the advantages of green infrastructure. |
| | Green infrastructure is intended to be used and enjoyed by everyone. | |
| | Green infrastructure is meant to be used throughout the year. | |
| | contingency | |
| | adaptive design | |
| | Participation of the community in the creation, administration, and utilization of green spaces | |
| **SUSTAINABLE WATER MANAGEMENT** | Green infrastructure is essential for long-term drainage. | Ensures that green infrastructure elements go above and beyond the statutory minimum to respond to local water management policy needs. The qualities of green infrastructure guarantee that, in addition to regulating water quantity and quality, people and nature benefit. |
| | improved drinking water | |
| | waste collection and disposal | |
| | improved sanitation facility | |
| | On-site water quality has been improved using green infrastructure. | |
| | Green infrastructure for water management also enhances and preserves the quality of life for both humans and environment. | |
| | Green infrastructure reacts creatively to local policy situations in terms of water management. | |
| **ENHANCE NATURE CONSERVATION** | Green infrastructure provides long-term environmental benefits in accordance with the local goals. | Ensures that habitats and habitat linkages are increased in order to restore ecosystem function, thereby aiding in the reversal of long-term biodiversity decline. Ensures that the site layout, as well as habitat creation and restoration, meet the needs of target species, while also improving connectivity between green infrastructure features. |
| | green infrastructure, essential species populations are more viable. | |
| | Green routes for people and wildlife | |
| | Green infrastructure helps to develop, maintain, and improve habitats and their interconnections | |

Source: Authors

All these factors and case studies determine basic standards we can rely on for achieving higher benefit for sustainable urban development, which are summarized in core, cost & circular economy, enhance health and wellbeing, sustainable water management, and enhance nature conservation as shown in table (4)

The criteria necessary to achieve sustainable urban development in urban communities in Egypt have been defined in light of the importance of setting green and blue infrastructure standards within development plans to avoid problems in cities and achieve sustainability:

Availability of data for the standard and its measurement indicators Data Availability of the body responsible for monitoring the indicator

Periodicity of the indicator Compatibility with environmental plans and strategies Questionnaire for a group of experts Criteria for achieving water sustainability in cities

The research adopted a questionnaire form for a set of questions for the criteria that were previously determined and expressing the goal of the research that pertains to the Egyptian situation for each of the dimensions with their different criteria, and an interview was conducted with 15 concerned parties related to the subject of the research from academics at Cairo University, members of the city neighborhood councils New, engineers and executives at the New Urban Communities Authority, engineers at the Urban Planning Authority, specialized in the Ministry of Environmental Affairs and the Ministry of Irrigation and Water Resources. The experts stressed the importance of all dimensions with their basic criteria as basic criteria to ensure the achievement of the GBBI approach as basic criteria that help decision-makers towards achieving the sustainability of societies in Egyptian cities.

## 5 Conclusion

- The evolution of the concept of green infrastructure to the blue infrastructure (GGBI) because of its general socio-economic benefits a, which have a more comprehensive developmental dimension than the single concept of green infrastructure so that the integration between this approach is very important for sustainable development

- The importance of the operational concept appeared towards its association with many environmental sectors and the attempt to achieve sustainability by dealing with various environmental issues, these approaches involves steps or actions to lessen society's vulnerability and boost its capacity for resilience in order to achieve adaptation to the consequences of climate change and to offer a variety of services that benefit the environment and culture. GGBI smoothly combines green and blue aspects while combining hydrology (sustainable water and rainfall management) and ecological treatment (urban ecosystems) into projects, enhancing the quality of life and offering useful and practical services to human civilizations. By restoring natural processes into the constructed environment and depending on the features of the local urban context, such as available space, topography, and climate, can be effective at various sizes.

- GGBI is a type of nature-based solution that is used to address urban and climatic challenges by relying on nature as much as possible.

- criteria of GGBI achieve the concept of flexibility of urban development in Egyptian cities and deal with all dimensions of sustainable development

- criteria of GGBI determine the basic development decisions that achieve sustainability in its various dimensions.

- During the research paper, it was noted the importance of studying the indicators with different criteria as future studies through which it is possible to define a ruler to assess the extent of achieving sustainable urban development desired from achieving the approach and thought of the GGBI

## References

[1] Y. D. a. T. McPhearson, “Integrating the Grey, Green, and Blue in Cities: Nature-Based Solutions for Climate Change Adaptation and Risk Reduction,” in *Nature-based Solutions to Climate Change Adaptation in Urban Areas*, New York, USA, Urban Ecology Lab, Environmental Studies Program, The New School, New York, USA, 2017, pp. 91-109.

[2] B. W. PROF. HERBERT DREISEITL, “strengthening blue-green infrastructure in our cities,” 2020. [Online]. Available: www.ramboll.com/LCL.

[3] H. D. a. B. W. W. a. M. M. Peter Wouters, “blue-green infrastructures as tools for the management of urban development and the effects of climate change,” 2020. [Online]. Available: https://issuu.com/ramboll/docs/bluegreen.

[4] A. Alves, Combining green-blue-grey infrastructure for flood mitigation and enhancement of cobenefits, Delft, the Netherlands: Delft University of Technology, 2020.

[5] S. O. I. R. B. T. G. GREG BROWDER, “Integrating green,” world bank group, swedish, 2020.

[6] E. :. E. E. Agency, “Urban adaptation to climate change in Europe , Transforming cities in a changing climate,” EEA : European Environment Agency, Copenhagen, Denmark., 2012-2016.

[7] Z. A. Feisal, “Multifunction green infrastructure,” *Benha Faculty of Engineering, Benha University, Benha, Egypt,*, 2015.

[8] L. d. V. A. Z.-T. Y. S. A. H. &. G. B. Chad Staddon, “Contributions of Green Infrastructure to Enhancing Urban Resilience,” *The reselient shift*, 2017.

[9] Alida Alves , Zoran Vojinovic , Zoran Kapelan, Arlex Sanchez , Berry Gersonius, "Exploring trade-offs among the multiple benefits of green-blue-grey infrastructure for urban flood mitigation," *Science of the Total Environment*, 2020.

[10] Danielle Sinnetta, Sarah Burgess, Thomas Calvert, Roger Mortlock, "A framework for assessing the quality of green infrastructure in the built environment in the UK," *Urban Forestry & Urban Greening*, 2019.

[11] A. I. A. Beloqui, Combining green-blue-grey infrastructure for flood mitigation and enhancement of cobenefits, Institute for Water Education, 2019.

[12] lisa hair, and melissa kramer, "City green: innovative green infrastructure solutions for downtowns and infill locations," 2016.

[13] Laura Maxima, Joachim H. Spangenberg, Martin O'Connor, "An analysis of risks for biodiversity under the DPSIR framework," *Ecological Economics*, 2009.

[14] S. R. a. S. D. B. Dhanya, "Mainstreaming Blue-Green Infrastructure in Policy and Planning for Urban Resilience in the Global South: Promises and Pitfalls," *Blue-Green Infrastructure Across Asian Countries,Springer Nature Singapore*, p. 499, 2022.

[15] S. O. I. R. B. T. G. GREG BROWDER, "Integrating green and gray creating next generation Infrastructure," WORLDBANK, 2020.

[16] C. International, "Green-gray infrastructure," 2022. [Online]. Available: https://www.conservation.org/projects/green-gray-infrastructure.

[17] M. P. Niloufar Mohajerani, Design Criteria for Green Infrastructure in the Right-of-Way, City of Toronto: Engineering & Construction Services Design & Construction, Linear Underground, 2021.

[18] m. w. w. HYDROSPHERE (freshwater, "GEMET," Dec 2021. [Online]. Available: http://www.eionet.europa.eu/gemet/concept/15354.

[19] . U. Ltd, "GreenBlue Urban," 2021. [Online]. Available: https://greenblue.com/gb/about-us/why-green-and-blue/.

[20] SAYLI UDAS,MANKIKARBERJIS DRIVE, "Blue-Green Infrastructure: An Opportunity for Indian Cities," Observer Research Foundation, 2021.

[21] M. Nassar, "UNIDO to launch sustainable infrastructure index," UNIDO, 2022.

[22] Klimanova O.A., Illarionova O.I., "Green infrastructure indicators for urban planning: applying the integrated approach for Russian largest cities," *Geography, Environment, Sustainability.*, 2019.

[23] Wang QianNa, Isami Kinoshita, "Green Infrastructure Gauge: A tool for evaluating green infrastructure inclusion in existing and future urban areas," *Social and Behavioral Sciences*, 2012.

[24] Demet Demiroğlu,Aysen Coban, "Investigation of green infrastructure for sustainable cities: The Kilis case," *Journal of Environmental Protection and Ecology*, 2014.

[25] U. E. P. Agency, "City green: innovative green infrastructure solutions for downtowns and infill locations," 2016.

[26] Peter Bosch,Gertjan Willem Geerling.Martin Goossen,Gertjan Willem Geerling, "Designing green and blue infrastructure to support healthy urban living," 2016.