Blue Infrastructure Affect Residential Areas' Attractiveness Rating

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Blue Infrastructure (BI) is a system of water-based ecological and engineering interactions that provides multiple social and ecosystem benefits in an urbanized environment.

housing estates residential neighborhood water bodies water reservoirs

1. Introduction

Blue Infrastructure (BI) is a complex concept. It refers to a system of water-based ecological and engineering interactions that provides various social and ecosystem benefits in an urban environment. The development of BI in cities is currently a significant research topic for scholars and urban planners, focused on sustainable urban development. Given that water is a scarce and essential resource for life, such research aligns with multiple Sustainable Development Goals (SDGs) [1]. A predominant focus is on devising concepts for sustainable water management under SDG 6 (Ensure availability and sustainable management of water and sanitation for all) [2]. Issues concerning Sustainable Drainage Systems, which involve infiltration, drainage, and water storage to provide benefits like improved water quality, wildlife habitats, and societal amenities, are actively explored [3][4].

From a climate change perspective (SDG 13—Take urgent action to combat climate change and its impacts), particularly recent global warming trends, studies have emerged to determine the impact of BI on reducing the urban heat island effect, common in urban areas [5]. It has been proven that green spaces, surface waters, and other elements of BI can help lower temperatures and create a more pleasant thermal environment in cities [6][7]. Other studies in this field focus on assessing the influence of BI on the air quality in urban areas. Green areas and water features reduce air pollution by capturing dust, and absorbing carbon dioxide and other harmful substances [8][9].

However, the topic of BI encompasses more than research related to systems, ecosystem services, and sustainable water management solutions aimed at managing stormwater, minimizing flooding [10][11][12], and improving surface water quality. It also includes studies on the evaluation of urban landscapes and their esthetic and functional value arising from the presence or absence of BI, as well as public awareness regarding water use and participation in development projects. Consequently, under SDG 3 (Ensure healthy lives and promote well-being for all at all ages), research examines the impact of green areas, parks, ponds, and other BI elements on the mental health and well-being of urban residents. Numerous studies have shown that access to nature, in the form of green spaces and water elements, contributes to stress reduction, improved well-being, and overall quality of life

[13][14]. This was particularly evident from research conducted during the COVID-19 lockdowns [15][16]. Furthermore, with regard to SDG 4 (Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all), the level of residents' awareness and knowledge regarding BI and its benefits has been assessed. This includes analyzing the effectiveness of information and educational campaigns on blue solutions and their impact on acceptance and community engagement [17][18].

Under SDG 11 (Make cities and human settlements inclusive, safe, resilient, and sustainable), emphasis is placed on scientific research regarding residents' access to BI in cities. These studies aim to identify inequalities due to cultural preferences, mobility needs [19][20], or exclusions based on race [21] and develop strategies that ensure equitable access to blue solutions' benefits for all city residents [22]. Finally, concerning SDG 17 (Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development), research focuses on community participation in planning, designing, and implementing BI projects. Local community involvement, knowledge, and engagement are crucial for the success of BI projects [23]. However, despite a number of studies considering the accessibility of BI in cities and their importance for the well-being of residents, there are no studies in the available literature that examine what type of BI functionality is most desired by residents and thus influences the attractiveness of housing neighborhoods. Six primary functions of water bodies are distinguished: ecological, recreational [24], educational, social, economic, and esthetic [25]. The topology of this classification can be applied to both natural and anthropogenic water bodies.

2. Diagnosis of Urban Design and Water Management

Previous evaluations of entire cities or specific districts included an indicator of the average share of green spaces within estates [24] or accessibility/distance to recreational areas with constructed water bodies, regardless of their size or functionality [25]. Diagnostics and evaluations of water reservoirs in cities are carried out using various methodological approaches, including taking into account the elements of ecosystem services [26][27] or laboratory criteria for water purity [28][29]. There are also methods that determine various approaches, such as esthetics and landscape shaping, recreation and tourism, biodiversity, climate use, water retention, and flood management. However, some authors omit several functions of water bodies in their methodologies. Li et al. [30] conducted a study on the ecological health and inhabitants of river corridors in Zhengzhou, China, using 26 indicators (mainly ecological, economic, and geographical) assessed through a five-point Likert scale in expert surveys. The indicators included charge cards, width of the border, water transparency, and eutrophication status. However, they used an expert interview without taking into account the actual needs and preferences of the residents. Kimic and Ostrysz [31] analyzed various green and BI solutions in terms of their value in shaping the public space of urban transport, identifying 19 different Blue-Green Infrastructure services based on territorial, functional, service, and social aspects. Langie et al. [32] identified data on the availability of water facilities in the public space of large cities, considering factors such as communication, composition, infrastructure, use, and esthetics. Bacchin et al. [33] focused on BI responsible for spatial and performance modeling of stormwater systems, integrating catastrophic and blue performance. Their research in the city of Porto Alegre utilized water, ArcGIS, and EPA SWMM platforms to analyze the spatial environment, identify flood-prone areas, and model the performance of

stormwater drainage infrastructure at various spatial scales—macro, meso, and micro. This method integrates the theory of landscape ecology with practical applications for stormwater management.

Over the past five years, ISO 37,120 norms [34] have also been employed for assessing the urban quality of life, where supporting indicators take into account the aspect of accessibility to BI and include: 13.1 square meters of public indoor recreation space per capita and 13.2 square meters of public outdoor recreation space per capita (supporting indicator). The primary indicators in this norm are: 21.1% of the city population with potable water supply service, 21.2% of the city population with sustainable access to an improved water source, 21.3% of the population with access to improved sanitation, and 21.4 total domestic water consumption per capita (liters/day). However, there is a lack of an approach to evaluating the attractiveness of residential neighborhoods that considers the accessibility indicator for BI, marked by various distinct functions that such water bodies can serve despite the increase in popularity of BI plans and investments in recent years [35]. There is growing evidence of potential environmental, social, and health benefits [36]. Blue and green infrastructure elements combine and have a multifunctional impact on urban space [37]. This definition covers a wide range of issues and solutions. Moreover, green infrastructure and BI cannot be assigned to one profession [38]. Views on the topic also change depending on the discipline [37]. Authors often point out that blue (water) and green (nature, squares, and parks) infrastructure serve to protect against floods, droughts, and other effects of climate change and undoubtedly contribute to maintaining environmental balance and security in the city [39]. Therefore, BI functionalities are manifold. It is important to determine which of them are the most important and have the strongest impact on the assessment of the attractiveness of the public open space residential areas, taking into account the needs and preferences of the residents, which is part of a resident-friendly approach to spatial management. In this light, the following research hypothesis was verified: the recreational and esthetic function of a water body and the accompanying amenities are the most attractive features, which hold significant importance in evaluating residential neighborhoods.

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