THE CONTRIBUTIONS OF LANDSCAPE TO THE URBAN AND ENVIRONMENTAL PLANNING PROCESS AND TO THE INTEGRATED MANAGEMENT OF THE HYDROGRAPHIC BASIN

AS CONTRIBUIÇÕES DA PAISAGEM NO PROCESSO DE PLANEJAMENTO URBANO E AMBIENTAL E NA GESTÃO INTEGRADA DA BACIA HIDROGRÁFICA

LAS CONTRIBUCIONES DEL PAISAJE AL PROCESO DE PLANIFICACIÓN URBANA Y AMBIENTAL Y A LA GESTIÓN INTEGRADA DE LA CUENCA HIDROGRÁFICA

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ABSTRACT

In the current scenario of environmental manipulation and landscape interventions, the adoption of a new paradigm for urban and environmental planning becomes urgent, raising the question of how landscape planning, design, and architecture can contribute to the urban and environmental planning of the watershed. The objectives consist of investigating the theoretical and methodological concepts applied in landscape planning, design, and architecture; contributing to urban and environmental planning, using the watershed as the basis of this process; identifying proposals, experiences, and projects carried out on this theme; and contributing to broadening conceptual reflection and deepening the debate on integrated landscape management. The methodology was exploratory, involving the collection and compilation of documents and texts; reading, studying, and analyzing the selected material; and textual organization. It was concluded that landscape planning, design, and architecture contribute to the urban and environmental planning of the hydrographic basin through the application of environmental solutions such as connectivity, biodiversity, water governance, strengthening urban resilience, and the interaction of nature with people, as living, adaptive, and sustainable solutions to the urban and environmental challenges of contemporary cities.

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Keywords: Landscape Architecture. Urban Drainage. Landscape Ecology. Green Infrastructure. Nature-Based Solutions.

RESUMO
No cenário atual da degradação ambiental e das intervenções na paisagem, torna-se urgente a adoção de um novo paradigma para o planejamento urbano e ambiental, suscitando o questionamento de como o planejamento, o projeto e a arquitetura da paisagem podem contribuir para o planejamento urbano e ambiental da bacia hidrográfica. Os objetivos consistem em investigar os conceitos teóricos e metodológicos aplicados no planejamento, no projeto e na arquitetura da paisagem; contribuir para o planejamento urbano e ambiental, tendo a bacia hidrográfica como base desse processo; identificar propostas, experiências e projetos realizados com essa temática; e, contribuir para ampliar a reflexão conceitual e o aprofundamento do debate sobre a gestão integrada da paisagem. A metodologia foi exploratória, com o levantamento e compilação de documentos e textos; na leitura, estudos e análise do material selecionado; e, na organização textual. Concluiu-se que o planejamento, projeto e arquitetura da paisagem contribuem para o planejamento urbano e ambiental da bacia hidrográfica, através da aplicação de soluções ambientais, como a conectividade, a biodiversidade, a governança das águas, o fortalecimento da resiliência urbana e a interação da natureza com as pessoas, como soluções vivas, adaptativas e sustentáveis, para os desafios urbanos e ambientais das cidades contemporâneas.

Palavras-chave: Arquitetura da Paisagem. Drenagem Urbana. Ecologia da Paisagem. Infraestrutura Verde. Soluções Baseadas na Natureza.

RESUMEN
En el contexto actual de degradación ambiental e intervenciones paisajísticas, la adopción de un nuevo paradigma para la planificación urbana y ambiental se vuelve urgente, lo que plantea la cuestión de cómo la planificación, el diseño y la arquitectura del paisaje pueden contribuir a la planificación urbana y ambiental de la cuenca hidrográfica. Los objetivos consisten en investigar los conceptos teóricos y metodológicos aplicados en la planificación, el diseño y la arquitectura del paisaje; contribuir a la planificación urbana y ambiental, utilizando la cuenca hidrográfica como base de este proceso; identificar propuestas, experiencias y proyectos realizados sobre este tema; y contribuir a ampliar la reflexión conceptual y profundizar el debate sobre la gestión integrada del paisaje. La metodología empleada fue exploratoria e incluyó la recopilación y compilación de documentos y textos; la lectura, el estudio y el análisis del material seleccionado; y la organización textual. Se concluyó que la planificación, el diseño y la arquitectura del paisaje contribuyen a la planificación urbana y ambiental de la cuenca hidrográfica mediante la aplicación de soluciones ambientales como la conectividad, la biodiversidad, la gobernanza del agua, el fortalecimiento de la resiliencia urbana y la interacción de la naturaleza con las personas, como soluciones vivas, adaptativas y sostenibles a los desafíos urbanos y ambientales de las ciudades contemporáneas.

Palabras clave: Arquitectura Paisajística. Drenaje Urbano. Ecología Del Paisaje. Infraestructura Verde. Soluciones Basadas en la Naturaleza.

1 INTRODUCTION

In the current scenario, in the Anthropocene era, anthropogenic actions are increasingly intense and accelerated (Magalhães, 2023), resulting in profound transformations in the landscape and the environment. These transformations lead to the loss of biodiversity, environmental degradation, destruction of ecosystems, fragmentation of the landscape, interruption of ecological flows and climate change (Olivo; Meneguetti, 2023). As a consequence, there is also an increase in the impermeabilization of urban soil, water pollution and extreme weather events.

From the second half of the twentieth century, with the advance of industrialization and urbanization, technical and technological development intensified interventions on the landscape. Such interventions, called gray infrastructure, consist of engineering works, which, through artificially constructed structures, control natural processes through technique, conducting urban waters through impermeable pipes and galleries, making the systems of nature invisible in the daily life of the contemporary city (Lima; Ragonha; Schenk, 2023). As a result, the impacts resulting from this process cause the rupture, reduction and alteration of natural processes, in addition to the loss of the role of water in the urban landscape (Baptista; Cardoso, 2013).

In Brazil, the practice of gray infrastructure was adopted from 1889 (Silveira, 1998), and has continued to the present day. Despite scientific and technological advances, as well as the creation of instruments for territorial planning of environmental policy, it is observed that a technocratic vision of the city persists, conceived as a technical object aimed at urban regulation. This model of urban planning, based on principles and methods aimed mainly at regulatory efficiency, privileges socioeconomic processes (Brasil, 2002a) to the detriment of the integration of the landscape system with the environmental planning of Brazilian cities.

Thus, therefore, urbanization has generated a series of impacts on water bodies, causing the loss of their potential and multiple uses, the reduction of the quality and quantity of available water, in addition to the increase in organic load and pollutants. It is noteworthy that the channeling of urban rivers did not solve problems such as floods, pollution and contamination; on the contrary, it has aggravated the degradation of ecosystem functions, biodiversity and the landscape. In this context, the intensification of urbanization has increased concerns and stimulated the search for sustainable solutions aimed at the well-being of the population, the improvement of water quality, the increase of urban and climate resilience, urban drainage, the valorization of the natural environment and the river landscape (Silveira; Rodrigues; Dornelles, 2025).

Therefore, it is urgent to adopt a new paradigm for urban and environmental planning, related to the insertion of multidisciplinarity in the complexity of the landscape. In this scenario, the river basin takes the lead in the process of planning, territorial planning, and integrated landscape management, incorporating both water management and its governance (Sant'Anna, 2020). Hydrographic basins contain environmental structures of extreme relevance in the cultural landscape of Brazilian cities, being considered as the synthesis of the territories interconnected to them (Lourenço *et al*., 2015).

After World War II, regional planning proposals based on the urban landscape emerged, which began to guide territorial planning, with the watershed as a priority in this process (Sant'Anna, 2020). However, this perspective requires the integration of environmental agendas into political, social, economic and scientific discussions and decisions, with a view to formulating public policies for sustainable urban development.

In view of the above, the problem that this study proposes to investigate raises the following question: "How can landscape planning, design and architecture contribute to urban and environmental planning, with the watershed as the basis of the planning process, territorial planning and integrated landscape management?". Thus, this work aims to: investigate the theoretical and methodological concepts applied in landscape planning, design and architecture; contribute to urban and environmental planning, with the hydrographic basin as the basis of this process; identify proposals, experiences and projects carried out with this theme; and, to contribute to broaden the conceptual reflection and the deepening of the debate on integrated landscape management.

2 THEORETICAL FOUNDATION

2.1 ENVIRONMENTAL PLANNING IN BRAZILIAN LEGISLATION

In Brazil, from the middle of the twentieth century, the intense process of urbanization generated numerous socio-environmental impacts. In 1960, the urbanization rate was 45.52%; however, in 2022, the Brazilian population living in urban areas jumped to 87.40% (IBGE, 2022). This unbridled urbanization has caused numerous impacts in cities, such as socioeconomic inequality (Brasil, 2002a), environmental racism and social and climate injustice.

Between 1980 and 2000, Law No. 6,938/1981 was enacted, creating the National Environmental Policy (PNMA) (Brasil, 1981); and, in 1988, the Federal Constitution (FC) (Brasil, 1988), contemplating the fundamental principles of environmental legislation. In the context of the hydrographic basin, Law No. 9,433/1997 created the National Water Resources Policy (PNRH) (Brasil, 1997), which in addition to directing the management of this national

heritage, also influenced urban and regional management, since the hydrographic basins encompass the territories: national, state and municipal (Ferrão, 2018). In this way, the hydrographic basins are considered as the unit of integrated landscape management, as they integrate in their territories, the waters, the soil, the flora, the fauna, the natural resources, the cultural heritage, the people and the anthropic actions on these landscapes.

It is in this scenario that the City Statute was born, as a way of responding in a purposeful way to the challenges of reconstructing urban, redistributive and inclusive planning, under new principles, methods, conceptions and tools. Thus, the City Statute created by Law No. 10,257/2001, regulated articles 182 and 183 of the 1988 Federal Constitution, and established the general guidelines of urban policy, aiming at the full development of the city's social functions, the guarantee of the right to a sustainable city and the democratization of urban management (Brasil, 2002a). According to the City Statute, the municipality is responsible for urban policy, which has the Master Plan (PD) as its basic instrument.

Federal Decree No. 4,297/2002, through ecological-economic zoning, established the parameters of municipal environmental zoning (ZA), as a beacon of urban, rural and environmental territorial planning, and should consider the proposals of civil society and public agents, programs and projects that use natural resources, seeking the full maintenance of ecosystem services and ecological conservation, making use, protection and control compatible, as a way to achieve sustainable development (Brasil, 2002b).

The Brazilian Forest Code, updated by Law No. 12,651/2012 (Brasil, 2012), regulated by CONAMA Resolution No. 369/2006 (CONAMA, 2006), established the parameters for intervention and suppression of vegetation in the immediate surroundings of rivers, called Permanent Preservation Areas (APPs), constituting an important instrument of territorial planning of Brazilian environmental policy (Souza; 2015).

Consequently, municipal environmental planning and management are of fundamental importance in the contemporary context, considering popular participation, the promotion of the sense of belonging, of experience, of the identity of people and communities in relation to the place (Piroli, 2024), incorporating the multidisciplinarity of landscape complexity in the process of planning, territorial planning and sustainable management of the city.

2.2 INTEGRATED LANDSCAPE MANAGEMENT IN THE ENVIRONMENTAL PLANNING PROCESS

In the environmental planning process, landscape systems must be contemplated (Sant'Anna, 2020). In this context, the hydrographic basin is considered the territorial unit of

planning and integrated management. Water governance and integrated landscape management should be part of public policies, with a view to sustainable urban development.

The articulation of water governance is a key element for the implementation of sustainable, participatory and integrated management of water resources. Of particular note is the guarantee of access to quality water for all, the promotion of sustainable use of water, the mitigation of the impacts of climate change, the guarantee of water security, social justice, transparency and citizen participation in decision-making processes in Brazilian municipalities (Empinotti; Jacobi; Fracalanza, 2016; Nicollier; Kiperstok; Bernardes, 2023).

Water governance has become relevant to the Brazilian public administration due to the frequent and intense water crises in the country (ANA, 2019; OECD, 2015). These facts show that water crises are the result of poor public management of water resources and areas that impact water; such as, land use and occupation, environment and basic sanitation (GWP, 2000; Tundisi, 2013; Pahl-Wostl, 2017).

One of the biggest challenges in water governance is the more effective participation of municipalities in the implementation of water resources management policy (OECD, 2015). For Nicollier, Kiperstok and Bernardes (2023), one of the possible factors is the lack of control of the municipal administration over water, and the municipalities have their participation in the National Water Resources Management System, indirectly, through the River Basin Committees. Thus, the importance of expanding spaces for social and political participation in the management of water resources in Brazil is emphasized.

Another relevant aspect is the complex relationship that the landscape and water governance establish between themselves, as these involve multiple actors, interests and scales of intervention (Ribeiro *et al*., 2013).

Integrated landscape management includes the river basin, through various approaches, such as: land use, basic sanitation, environmental health, biodiversity, culture and sustainable urban development (Cerezini; Hanai, 2017; Xavier, 2025).

3 METHODOLOGY

From the point of view of the objectives, the research is characterized as exploratory. According to Prodanov and Freitas (2017), exploratory research allows the study of the theme from different angles and aspects, first involving the survey and compilation of documents and bibliography; then, the reading, studies and analysis of the selected material; and, finally, the textual organization compatible with the objectives of the research. From the point of view of technical procedures, the research is bibliographical. For Gil (2022), bibliographic research is based on material already published, including printed material, such as books, magazines,

newspapers, theses, dissertations and annals of scientific events, as well as material made available on the Internet.

4 RESULTS

Hydrographic basins comprise environmental structures of extreme relevance in the cultural landscape of Brazilian cities. These structures are shaped through natural processes throughout the planet's evolution (Piroli, 2024); Thus, the hydrographic basins are part of the set of natural and anthropic environmental factors; and, they are related to geomorphological aspects, which influence the way waters move and are distributed in the river basin (Sant'Anna, 2020).

Consequently, designing the urban landscape from its waters constitutes a challenge and an opportunity to reincorporate its social, environmental, cultural, economic and political value. The mutant and intertwined landscapes constitute the synthesis of the territories interconnected to them (Lourenço *et al*., 2015).

The integrated planning, management and management of the watershed require the adoption of sustainable socio-environmental practices, and public policies aimed at expanding water availability, reducing conflicts and critical hydrological events, promoting water conservation as a socio-environmental value, as well as the protection and recovery of ecosystems, aiming at maintaining adequate environments for all (Piroli, 2024).

In the case of water governance, the landscape must be in the context of the interaction between the use of water resources, preservation and environmental conservation. In this way, integrated landscape management, including quality of life, well-being of people and ecosystems, is connected to water governance (Fernandes *et al*., 2015).

4.1 THE COMPLEXITY OF THE RIVER BASIN AND THE ROLE OF THE LANDSCAPE IN PLANNING, TERRITORIAL PLANNING AND INTEGRATED MANAGEMENT

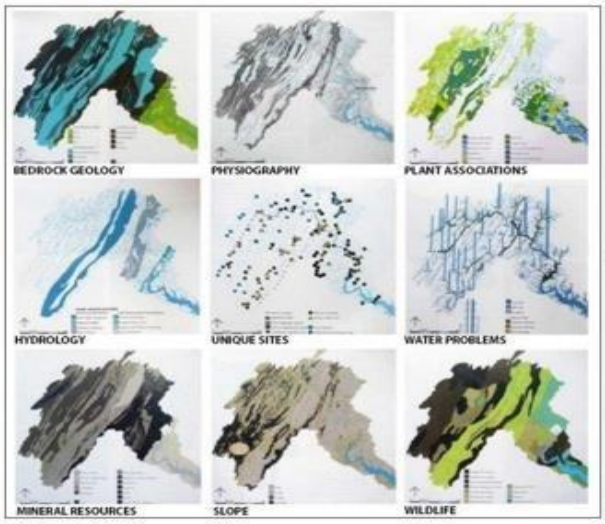
In the twenty-first century, environmental planning, by incorporating the complexity of increasingly urbanized territories, is associated with other areas of knowledge, which study and intervene in the territory. In this sense, considering the hydrographic basin as the basis of landscape planning, in a regional cut, it includes relief and geography. In turn, the river corridors drain the surface waters of the hydrographic basin, through the relief and vegetation that accompanies the banks of the rivers (riparian forests), where it is possible to identify and describe the natural resources contained in this territory in an integrated way (Sant'Anna, 2020).

From this point of view, the planning, design and architecture of the landscape must incorporate its physiographic regions, composed of natural elements, relief, geomorphology, soil types, water resources, vegetation, etc., in their different scales in studies, analyses, discussions and propositions in the context of the hydrographic basin, (McHarg, 2000).

McHarg (2000) in studies carried out in the Potomac watershed, in Canada, sought to enhance the relationships between uses and preservation. In this way, he defined the climate as a fundamental factor in the relationship with the physiography of the territory; and, the study and analysis of geomorphology to define the physiographic regions. These physiographic regions were analyzed and organized on thematic maps, based on hydrological conditions, soil, vegetation, fauna, mineral resources, landscape landmarks (natural sites and cultural manifestations) and slope (Figure 1); also, the aptitudes for agriculture, forestry, urbanization, leisure and recreation (Figure 2). Then, these maps were superimposed, generating a synthesis of guiding trends for the different types of land uses, the natural determinants, the analysis of the impacts of the occupation of unsuitable areas, the scale of compatibility with the type of land use and occupation, and the potential of the areas of the watershed (Figure 3).

Figure 1

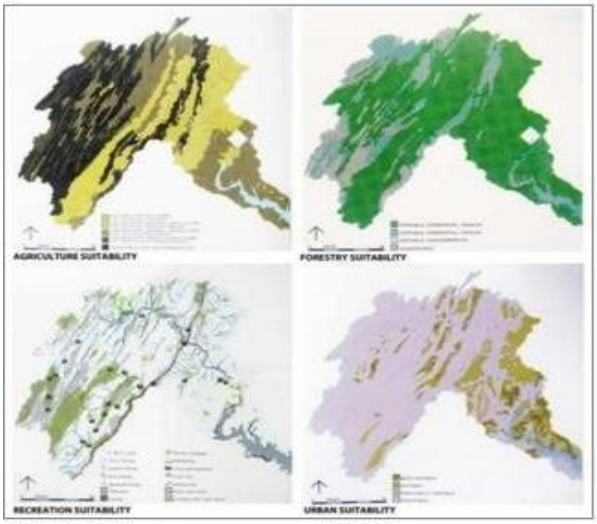
Studies for the Potomac River basin, through maps related to geology, physiography, landscape landmarks, hydrology, vegetation, water problems, mineral resources, slope and fauna



Source: McHarg (1997, p.140-145).

Figure 2

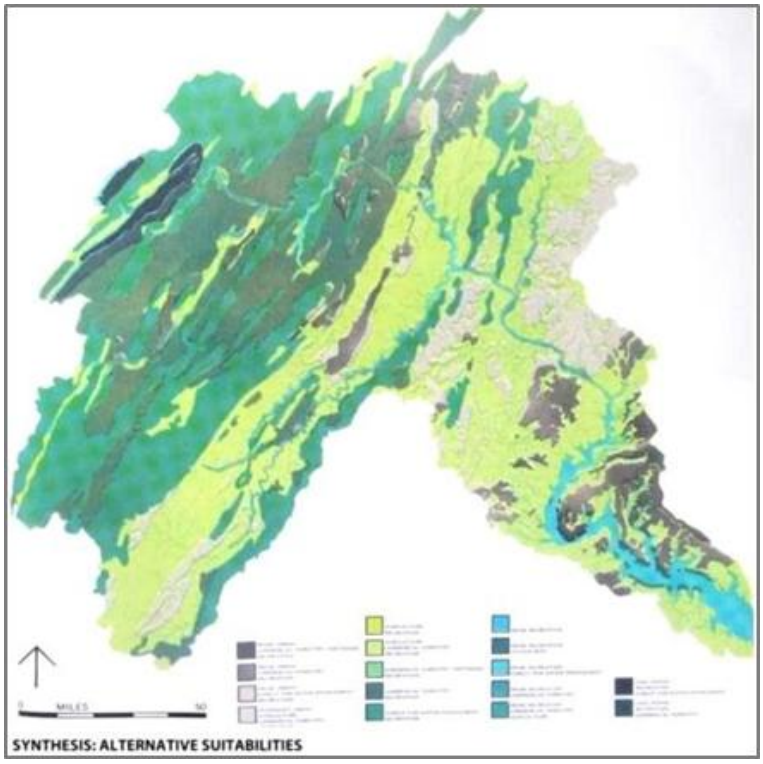
Studies for the Potomac River basin, through overlapping maps of the surveys carried out, indicating the suitability of the territory for agriculture, forestry, recreation and urban use



Source: McHarg (1997, p.140-145).

Figure 3

Studies for the Potomac River basin, presenting the synthesis of alternatives and trends



Source: McHarg (1997, p.321-333).

Thus, Ian McHarg developed a process of planning, design, and landscape architecture, encompassing the complexity of the territory and the role of the cultural landscape in territorial planning, thus contributing to the design of studies that enable decision-making based on modeling for future scenarios, as well as for proposals for the

formulation of legislation, regulation and public policies, aiming at current contemporary urgencies (Sant'Anna, 2020). The foundation of resilience as an environmental paradigm is close to ecological planning, as prescribed by McHarg (Olivo; Meneguetti, 2023).

Therefore, the application of the general principles of ecology such as connectivity, resilience and biodiversity, in the territorial coverage of the hydrographic basin, can be used as tools for the planning, design and architecture of the landscape (Olivo; Meneguetti, 2023; Pellegrino *et al*., 2006).

4.2 LANDSCAPE PLANNING, DESIGN, AND ARCHITECTURE

After the Second World War, proposals for regional planning began to emerge from the landscape of the cities, guiding territorial planning; and, having the hydrographic basin as a priority in this process (Sant'Anna, 2020).

McHarg (2000), in his book *Design with Nature*, released in 1969, defined the landscape as a means and method, incorporating the principles of ecology in landscape planning (Lima; Ragonha; Schenk, 2023; Meneguetti, 2009), the multi-scalarity of planning as the basis of the work, as well as proposing adaptive strategies for low-impact urban development (Sant'Anna, 2020). Thus, the methodology proposed by McHarg (2000) was based on the superimposition of thematic maps, allowing the crossing of data from the natural support (geological, geomorphological, hydrological, vegetation, etc.), from existing ecological processes (ecosystems, land use, and urban and regional development) (Souza, 2015), as well as historical, cultural, and aesthetic factors, introducing subjectivity into the experiential perspective experienced in the territory (Lima; Ragonha; Schenk, 2023), in order to contribute to decision-making in urban and regional planning.

In this regard, the Mchargian methodology allowed the application in different contexts and scales, such as watershed planning, incorporating the broader systems of the territories; and, in the project, through local scales related to environmental experience and perception (Ragonha, 2019), recognizing the place as the product of natural and social systems and values (Lima; Ragonha; Schenk, 2023). Thus, the work of McHarg (2000) constitutes an important legacy for the planning, design and architecture of the landscape, as well as a fundamental instrument for the development of sustainable environmental and urban solutions for the contemporary city (Hough, 1988; Lima; Ragonha; Schenk, 2023; Olivo, Meneguetti, 2023; Pellegrino *et al*., 2006; Sant'Anna, 2020; Souza, 2015; Spirn, 1995; Weiss, 2024).

Therefore, for the planning, design, and architecture of the landscape, an integrated and interdependent understanding is necessary (Weiss, 2024), as well as its practices require

a strategy of territorial multiscaling, in order to identify the diversity of the cultural and/or natural landscape (Schenk, 2008). Thus, in urban and regional planning, the landscape corresponds to the broad territories, such as the hydrographic basin, which is the unit of territorial planning and management; in the landscape project, the scale is local, linked to the functioning of the system, but not subordinated to it; and, in landscape architecture, the scale of planning is articulated with the design of the local scale, considering the experiential perspective of the people of the place, so that planning and design decisions are always connected to the context and to the various existing perceptions (Lima; Ragonha; Schenk, 2023; Weiss, 2008).

In this way, reflections on the relationship between man and nature and the multi-scalarity of the landscape are intertwined by objectivities and subjectivities. Thus, the objectivities of the landscape occur through the physiognomy and natural dynamics, such as, for example, the hydrological cycle, geomorphology, the tidal cycle (in coastal cities), winds, relief and vegetation; and the subjectivities, present in the places (historical, paleontological and archaeological sites), in the cultural manifestations and their meanings, and in the appropriations and perceptions. From this understanding, nature becomes an integral and guiding element of the process of planning, design, and landscape architecture, bringing human processes closer to natural processes (Olivo; Meneguetti, 2023), incorporating adaptive strategies committed to the characteristics of the place (Sant'Anna, 2020).

In view of this, landscape architecture and ecology come together, providing the promotion of diverse territories and new meanings (Olivo, Meneguetti, 2023). Thus, McHarg (2000), based on landscape ecology, elaborated the theoretical and practical foundations of landscape planning, design and architecture, influenced by anthropology, archaeology, biology, geology and ecology, based on the premise of nature as a fundamental element in the experience of the place, in physical and biological evolution, in adaptation and adjustment, also contributing to biodiversity, geography and territorial management (Spirn, 1995).

For Forma (1995), the landscape corresponds to a set of ecosystems, which interact and repeat themselves in space, distributing themselves spatially, in a heterogeneous way. Meneguetti (2007) emphasizes that landscape ecology represents a new look at landscape planning, through a more ecological approach and spatial solutions, as a way to balance anthropic interventions with biophysical support and its possibility of absorbing impacts. In this way, Forman and Gordon (1986) approach landscape ecology as a theoretical-methodological framework related to structure, function, and dynamics/change.

In this context, the landscape can be understood as a mosaic of matrices, spots or fragments and corridors, and must be analyzed from its structure, through the arrangement in spatial patterns of its elements, acting on the functioning and changes of the landscape. It is from this perspective that landscape ecology unites ecology and landscape architecture, as a methodological approach (Gobster; Xiang, 2012), recognizing the interdependence of design, ecology and society (Grose, 2014), using the general principles of ecology, such as connectivity, green corridors, resilience and biodiversity, as tools for landscape planning, design and architecture (Pellegrino *et al*.; 2006). Thus, "[...] the spatial component is the key to Landscape Ecology" (Souza, 2015, p.56).

Therefore, while landscape represents the connection between human and natural processes, landscape ecology represents the central point of the dialogue between the two processes, applying, for example, to the environmental planning of watersheds (Darmstadt; Olson; Forman, 1996; Forman, 1995; 2004; 2008; Meneguetti, 2009; Pellegrino *et al.,* 2006; Tardin, 2018; Weiss, 2024). From this perspective, two contemporary instruments stand out: nature-based solutions (NbS) and green infrastructure (McHarg, 2000).

4.3 NATURE-BASED SOLUTIONS AND ECOSYSTEM SERVICES OF RIVER BASINS

Urbanization impacts the surface climate of urban areas, alters the land surface, and contributes to climate change, becoming sources of greenhouse gas (GHG) emissions. Mosisa *et al*. (2025) highlight that, in 2015, urban areas accounted for 61.8% of GHG emissions; and, by 2100, this number should exceed 80%. The authors also warn that in Brazil there has been a 62% reduction in ecosystem services.

From this perspective, NBS emerge as important mitigators of these effects, because by recognizing nature in their processes, as fundamental elements in the construction of cities (Devecchi *et al.,* 2021), they become essential for the creation of resilient and sustainable urban ecosystems (Mosisa *et al*., 2025).

In the process of regional, urban and environmental planning, NBS propose integration and take into account the complexity of river basins and urban ecosystems. In this sense, NBS, with a focus on landscapes, are aligned with the 2030 SDGs, as they constitute living and adaptive solutions, inspired and supported by nature and with the involvement of people, (Evers *et al*., 2022; Olivo; Meneguetti, 2023; Puskas; Abunnasr; Naalbandian, 2021; Spirn, 1998; McHarg, 2000; Mosisa *et al*., 2025).

Olivo and Meneguetti (2023) point out that in the context of watershed ecosystem services, NBS seek to accelerate multiple services and benefits, valuing perception and experimentation, promoting a more holistic culture, as well as the incorporation and

understanding of nature with people. For Evers *et al.* (2022), ecosystem services (Chart 1) are the central element of NBS, promoting a series of positive impacts for climate adaptation and resilience.

Table 1

Contributions of ecosystem services in river basins

Services Provision	Food	Managed agrosystems, marine and freshwater systems, forests, and urban horticultures that provide food.
	Raw material	Woods, biofuels and vegetable oils, derived from native and cultivated plant species.
	Water	Vegetation and forests control the flow, store and purify the water. They influence the amount of water available locally.
Services Regulation	Local climate and Air Quality	Trees and green spaces reduce the temperature in cities. Forests influence the hydrological cycle, stimulating rainfall and removing pollutants from the atmosphere.
	Kidnapping of Carbon	Trees and plants remove carbon dioxide from the atmosphere, acting as carbon stores.
	Moderation of Extreme events	Ecosystems can act in the prevention of natural disasters. Plants stabilize slopes and mangroves filter river waters.
Cultural services	Recreation and health	Green spaces contribute to the socialization and welcoming of people. Also for physical and mental health.
	Tourism	Ecosystems and biodiversity are sources of socio-environmental benefits and income generation.
	Experience spiritual and sensory	Nature and biodiversity are common to the main cultures and traditional knowledge, giving a sense of belonging.
Services Support	Habitats for Species	Ecosystems provide essential habitats for the life cycle of many terrestrial and aquatic species.
	Maintenance of the Diversity Genetics	Genetic diversity provides the basis for well-adapted locally adapted crops and a gene *pool* for the development of agroecology, especially in food and animal production.

Source: Adapted from WRI Brasil (2022).

However, whether the contributions of watershed ecosystem services can actually maximize benefits as an adaptation strategy will depend on the approach and scale of the landscape. The protection, restoration and management of urban ecosystems are considered to ensure the integrity and connectivity of these ecosystems, which undoubtedly constitute the key to the maintenance of biodiversity and the resilience of the solutions themselves. This will minimize climate impacts, such as floods, droughts, and fires (Evers *et al.*,2022; Mosisa *et al*., 2025). The authors emphasize that the solutions can be implemented at different scales, and compose a network of NbS combined with gray infrastructures. To this end, NBS planning must count on the participation of local populations, as well as traditional communities, in order to identify priority areas, obstacles and facilitators for their implementation.

NBS within the scope of the watershed can include, for example: urban afforestation; preservation, conservation, recovery of riparian forest and springs; water-linked green area

systems (Devecchi *et al*., 2021), restoration of native vegetation in PPAs, ecological corridors, green infrastructure, urban drainage and urban parks and linear parks on urban riverfronts (Evers *et al*., 2022).

4.4 GREEN INFRASTRUCTURE IN THE CONTEXT OF ENVIRONMENTAL PLANNING OF THE RIVER BASIN

Green infrastructure incorporates a series of connected green spaces, impacting different scales and in different modes, characterizing itself as an adaptive project (Olivo; Meneguetti, 2023). However, it is essential that green infrastructure incorporates people's perceptions and interactions with landscapes, in addition to physical-territorial aspects (Mell, 2010).

Thus, in the context of the environmental planning of the river basin, green infrastructure incorporates the principles related to multi-scalarity, connectivity, interdisciplinarity, multifunctionality, integration, and social participation (Sant'Anna, 2020).

According to the author, in the principle of multiscalarity and interdisciplinarity, when designing with nature, it becomes essential to analyze the spatial and temporal scale of the regional scale of the hydrographic basin, as the unit of planning, design and architecture of the landscape; Multifunctionality, related to adaptation and climate change, aims to articulate the different mosaics contained in the landscape, which from the integration of these processes and in the performance of their multiple functions, can guarantee resilience and ecological integrity from the performance of the ecosystem services of the hydrographic basin. In the principle of connectivity, the relationships between spatial structure, functions, interactions, activities and ecological processes of the landscape, make up a green system, interconnecting the ecosystems and the natural and anthropic landscapes of the watershed. The purpose of integration is to promote the relationship between green infrastructure and other urban infrastructures. Finally, the principle of social participation can be considered the core for the success and maintenance of the territory. The importance of the participation of different agents and social actors is highlighted, involving communities in the collaborative process of urban and environmental planning.

In this way, green infrastructure, from the perspective of the urban landscape, assumes the function of urban infrastructure, covering, in addition to environmental functions, leisure, culture, education, recreation equipment, among other essential uses of urban open spaces (Souza, 2015), which are part of the hydrographic basin. It is emphasized that green spaces, an integral part of urban infrastructure, are articulated with the urban fabric, the road system, buildings, and urban open spaces (Pellegrino *et al*., 2006). It is emphasized,

therefore, that in the process of planning, design, and landscape architecture, it is necessary to understand the relationship, the contribution of urban infrastructure in the design of the landscape, and the collaboration of green infrastructure within the context of the watershed.

Green infrastructure, when applied to urban drainage, acts to control land use and reserve (Souza, 2015), mitigating the impacts on river systems, whether in waste load and/or erosive processes, as well as ensuring the flow of runoff in river basins, soil permeability, and recharge of the water table and aquifers. Among the water management practices with low-impact interventions are: urban green corridors (*greenways*), constructed *wetlands*, reforestation of slopes and green streets (Sant'Anna, 2020; Pellegrino *et al*., 2006), and the protection and recovery of springs. Connected to other green spaces in the city, urban parks and linear parks play a fundamental role in people's well-being and quality of life, while preserving and connecting natural areas, with significant benefits to biodiversity (Benedict; McMahon, 2002).

It is noteworthy that green infrastructure can cost 50% less than equivalent grey infrastructure, providing an additional 28% value, benefiting pollution reduction, carbon capture, adaptation, and urban and climate resilience (Evers *et al*., 2022).

4.5 LANDSCAPE ARCHITECTURE: A NEW PARADIGM FOR ENVIRONMENTAL DESIGN

In the context of a new environmental paradigm, landscape architecture is one where the scale of planning is articulated with the design on the local scale and the experiential perspective of the people of the place. This concept has emerged recurrently in the literature, revealing transdisciplinarity based on the foundations of the plastic instance, theoretical training, practical experimentation and complex worldviews (Olivo; Meneguetti, 2023). Therefore, this new environmental paradigm is an evolving model, aimed at the conception of unprecedented solutions (Ndubisi, 2002), correlating with other paradigms such as resilience, connectivity, accessibility, cultural standards, appearance performance, multiscalarity, integration, biodiversity, multifunctionality, ecological aesthetics, redundancy and modularization, sustainability and complex thinking (Olivo; Meneguetti, 2023). Thus, it is important to emphasize that the understanding of the ecosystem processes of the landscape presupposes the proposition of a flexible and participatory social structure.

Several landscape architecture projects and proposals have been carried out around the world, considering urban rivers, aquatic ecosystems and watersheds as central elements of planning. These initiatives seek to integrate ecological, social, and cultural aspects, promoting the multifunctionality of free spaces and strengthening urban resilience. By addressing connectivity, biodiversity, water management and governance, and the

interaction of nature with people, these projects highlight the practical application of contemporary paradigms of landscape architecture, consolidating living, adaptive, and sustainable solutions to current urban and environmental challenges, contextualized in the spatial and temporal scale of the watershed.

The 2011 Habin Qunli Park project includes the green infrastructure for the management of urban waters in the Chinese city of Hardim and a walkable waterfront for the surrounding population. In this proposal, the concepts of connectivity and biodiversity are physically and functionally interconnected between different scales, relating them to integration, accessibility and multi-scalarity (Olivo; Meneguetti, 2023), characterizing itself as resilient, in the context of the contemporary sustainable city. Following the concept of Habin Qunli Park, Tanner Springs Park, in Portland, from 2010, works on the environmental process of the invisibility of urban waters, acting on a bioretention network as a complementary and ecological action in urban rainwater drainage, that is, a large rain garden (Cormier; Pellegrino, 2008).

In the case of Crissy Field Park, implemented in San Francisco (USA) in 2001, the concept of multifunctionality is combined with the biotic, abiotic, functional and cultural functions of urban open spaces (Hansen; Paulet, 2014), promoting social cohesion and the security of socio-ecological systems, with the reestablishment of tidal marsh and coastal dunes, and the juxtaposition and integration between people, wild fauna and flora. In this way, the park project works on the concept of diversity, recognizing the hybrid landscape in the human and ecosystem dimensions. Thus, biodiversity, the basis of the sustainability paradigm, considers both the diversity of biotic and abiotic factors and social, physical, and economic diversity, as an effective strategy for urban resilience (Olivo; Meneguetti, 2023). As for Daownsview Park, implemented in Toronto, Canada, in 1999, diversity is present in the concept of the project, through topography, considering the circulation of matter and energy (Corner, 2016) and the constitution of a mobility system.

The Pirapora River Park, in Maranguape, Ceará, Brazil was one of the projects selected by the call for proposals "NbS Accelerator in Cities" (WRI Brasil, 2022). Its proposal is based on the nature-based infrastructural system, based on the infrastructure of nature, infrastructure of care, infrastructure of local socio-biodiversity and the infrastructure of the immaterial, all with the purpose of generating better urban conditions, better housing conditions, reduction of pollution and environmental degradation, valorization of green areas, income generation and strengthening of community-based tourism, in order to contribute to the fight against climate change and the achievement of the 2030 SDGs (WRI Brasil, 2024). In this sense, the Pirapora River Park project represents the environmental paradigm of

landscape architecture, in which resilience incorporated into the other paradigms of environmental design, reads, interprets and incorporates the reality of the landscape, thus introducing the possibilities of change, as opportunities for living and adaptive solutions, supported and inspired by the focus of nature with people (Evers *et al*., 2022; Olivo; Meneguetti, 2023; Pellegrino et al., 2006; Puskas; Abunnasr; Naalbandian, 2021; Sant'Anna, 2020; Spirn, 1998; McHarg, 2000; Mosisa *et al*., 2025), presenting alternative scenarios and sustainable guiding trends for the watershed (McHarg, 1997; Olivo; Meneguetti, 2023).

5 CONCLUSIONS

Considering the national scenario of concerns with the various aspects of environmental degradation; and, the effort of the academic and scientific community, as well as the various sectors of civil society, new perspectives for urban and environmental planning emerge and, consequently, the formulation of public policies, from the complexity of the landscape to mitigate the effects of climate change and strengthen resilience.

Watersheds are understood as environmental structures of extreme relevance for landscape management and water governance, recognizing them as essential for the quality of life of people and ecosystems. The importance of understanding the ecosystem processes of the landscape is emphasized, through a flexible and participatory social structure.

It is identified in the principles and tools for planning, design and architecture of the landscape, connectivity, integration, interdisciplinarity, multidisciplinarity, multiscalarity, multifunctionality, adaptability, sustainability, water security, analysis of ecological processes, green corridors, resilience, accessibility, environmental conservation and biodiversity, preservation, recovery and ecological restoration, objectivities and subjectivities, manifestations cultural and their meanings, cultural patterns, social and climate justice, transparency, social participation and inclusion, landscape diversity and complexity; and, nature-based solutions and green infrastructure.

NBS aligned with the 2030 SDGs are living and adaptive solutions, which contribute to the multiple ecosystem services and benefits of the river basin; and, they promote climate adaptation and resilience. In turn, green infrastructure acts in the river basin, at different scales and in different ways, through the principles and tools already mentioned. The importance of popular participation in NBS is emphasized; and, of people's perceptions and interactions with landscapes and in green infrastructure proposals.

The practical application of the environmental paradigms of landscape architecture as central elements of planning, territorial planning and integrated management of the landscape of the river basins is highlighted. The integration of design, ecology and society

promotes the multifunctionality of open spaces, strengthens urban resilience, multi-scalarity, connectivity and biodiversity. Water governance and management must interact with nature and people, as living, adaptive, and sustainable solutions.

It is concluded that the objectives of the study were achieved. However, the subject is not exhausted, because, due to its breadth, it may be the object of multiple approaches. Therefore, it is recommended to continue the studies, with the deepening of the conceptual reflection and the debate on the integrated management of the landscape.

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