The urban water cycle from the environmental, social and health point of view: convergent urban proposals

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Over the last century and a half, urban water management has been a crucial topic in urban planning, with various theories and solutions featuring recurring design parameters. This paper explores the planning criteria for the urban water cycle in Western urban planning, considered from the perspective of health, environmental impacts, and social inclusion, throughout five historical stages. It presents a narrative review of the literature, comparing discourses and proposals with similar theoretical foundations. The analysis identifies three recurring planning and design parameters: safety, integration, and access. Strategies to achieve these include proposals such as: gray infrastructure for water supply and sanitation, regulation of urban waterways, restoration of waterfronts and riverbanks, integrated water cycle management, and ecological restoration of urban aquatic habitats. The results provide a broad overview of the validity or failure of certain urban strategies used during the analyzed time period, which can facilitate informed decision-making for the future.

Keywords: urban water management; urban health; sustainability; urban water history; social inclusion

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The authors report there are no competing interests to declare

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Introduction: The Meaning of Water in the City over Five Periods since the 19th Century

Throughout history, urban water management has evolved significantly, influenced by the needs and technological advances of each era. From the hygienist concerns of the 19th century to the post-Covid sustainability strategies, the relationship between cities and water has undergone multiple transformations. In this sense, 19th-century industrialization marked a radical shift in this relationship, as it transitioned from a circular, natural management of river resources to a linear approach, with full control of the water cycle through advanced infrastructure systems (Crosas and Martí 2020).

This study proposes a historical review of this relationship, starting from the aforementioned paradigm shift and proposing a division into five temporal periods (hygienism, functionalism, postmodernism, environmentalism, and post-Covid). These stages are characterized by the use of various arguments for the transformation of the urban water cycle (health promotion, social access to water, and environmental improvement), but which, nevertheless, led to recurring urban planning parameters implemented through disparate strategies.
Below is a brief characterization of the five established time periods.

Hygienism

The 19th century marked a significant change in the perception of water and its

relationship with health. The cholera epidemic of the 1830s established hygiene as a scientific discipline closely linked to urban water treatment. The discoveries of Louis Pasteur and Robert Koch identifying certain microbes as the causes of infectious diseases, revolutionized water management, displacing the previous 'miasma theory' that attributed the origin of these diseases to effluvia in the air.

The ensuing hygienic practices promoted from the mid-19th century resulted in the renewal of pavements and sewers, and a progressive burial of surface watercourses. Additionally, the densification of cities and the consequent contamination of aquifers from cesspool infiltration led to the adoption of unified underground sanitation systems.

By the late 19th century, besides hygiene and health, the formation of the industrial city also induced new dynamics of relationship between natural watercourses and the citizenry. Thus, the gradual occupation of riverbanks by industrial activities distanced recreational areas from riverbanks, causing the relationship with their margins to lose naturalness and intimacy (Del Caz 2001).

Modern Movement

With the turn of the century, users' relationship with water changed. Mass production of sanitary equipment after World War I reduced costs and extended its use to all social spheres, universalizing direct contact with water from homes and generating new standards of consumption and demand. Urban planning during this first half of the century focused on achieving sufficient clean water flow, resulting in significant hydraulic infrastructure development that, in some cases, extended beyond urban limits.

In the public space, water adopted new functionalities related to the popularization of sports and outdoor gymnastic practices (Prost and Vicent 1989). The notion of physical exercise was included in the realm of leisure, combining effort, play, and bodily pleasure in aquatic activities. Facilities such as lakes, pools, and urban spas

for leisure, swimming and nautical exercises emerged, reflecting a utilitarian conception associated with mass urban culture (De Cárdenas 2020).

Postmodernism/development policy

After World War II, urbanization accelerated, colonizing new lands and exerting great pressure on the natural environment, specially water bodies. Cities turned their backs on river courses and waterfronts, degrading them to critical extremes (Pellicer 2001). Increased consumption combined with the impermeabilization of large land areas and excessive asphalt use to accommodate the growing demands of automobiles led to the saturation of sanitation systems, causing frequent floods in historical centers where existing infrastructure was old and often obsolete.

The response to these situations, dramatic for the population, was the anthropization of natural systems, facilitating rapid water evacuation through the channeling of river courses and constructing concrete and other artificial infrastructures. Some watercourses were buried and used as urban sewage collectors or even expelled from the city. During these years, many other river courses were transformed into monofunctional canals, compressed between buildings and road and rail infrastructures that exploited their linear layout to structure opportunistic networks unrelated to the environmental, social, and landscape values of urban waterfronts (Monclús 2016).

In parallel, environmentalist warnings emerged about the implications of urbanization for natural water cycles. Authors such as Ian McHarg and Michael Hough highlighted the importance of ecological values in urban planning, while Kevin Lynch and Jane Jacobs also criticized its negative effects on urban life.

Environmentalism/Sustainability

As mentioned, there was already growing concern in the 1960s about the

environmental impacts of urban development on the natural cycles of the territory[1], which, however, did not translate into an immediate change in urban policies. A series of reports and international commitments around which the paradigm of sustainable development led to the approval of several policies that sought to protect and sustainably manage water resources. The reductionist approach that had dominated water management, based on the belief in total control of the water cycle through sophisticated infrastructure, began to be questioned.

A new mindset in urban water planning emerged, focused on responsible and sustainable management. Strategies such as Water Sensitive Urban Design (WSUD) in Australia, Low Impact Development (LID) in Canada and the United States, and Sustainable Urban Drainage Systems (SUDS) in the United Kingdom proposed managing small-scale runoff by replicating the natural hydrological regime through infiltration, filtration, and storage systems (Molina and Villegas 2015; Perales and Doménech 2008).

Following this objective, the landscape urbanism of the sustainable stage began to work on integrating urban and peri-urban waterfronts as public spaces of great interest for environmental, social, and cultural improvement of the urban environment (Monclús 2016, MA 2005).

Post-COVID

The Covid-19 pandemic reinforced the importance of aquatic spaces in human

[1] In 1965 was published the Abel Wolman's article on the metabolism of cities. In it, he highlighted the problems of scarcity and pollution of urban waters due to the loss of the natural metabolic cycle of water by human action (Wolman 1965).

health and well-being. It is known that the presence of water bodies in urban spaces influences a wide range of issues related to citizen health, from those related to the consequences of climate change to those due to environmental degradation and urban lifestyle. The sustainable management of water and its integration into urban public spaces, specifically in the form of green-blue infrastructure, are presented today as essential strategies to promote public health and adapt to new climatic scenarios (Guerrero 2022; Wutich, Brewis and Tsai 2020).

Materials and methods

The article uses a classic discursive analysis methodology based on a narrative review of historical literature, supported by three parts: a documentary section, an analytical section, and a final summary of the two. This review results in the proposal of three [2]water management parameters in cities that have been used recurrently from the mid-19th century to the present day.

The review process begins with the definition of a theoretical and conceptual framework capable of defining the concepts that will be the subject of subsequent analysis. This is followed by a selection of theoretical proposals and practical projects that, in addition to having been significant in the formation of the general urban planning discipline, are representative of the dominant discourse regarding the

[2]For the purposes of this study, the term "parameters" is intended to encompass a series of notions (criteria, standards, indicators, recommendations, etc.) that define design and planning guidelines for urban greenery, urban mobility and the urban water cycle, both quantitative and qualitative, and that have been emerging and consolidating in urban planning practice through guides, manuals, monographs, academic texts, theoretical proposals, practical projects, urban policies, etc.

justification of urban planning practices during each defined historical period. Once these have been selected, a dual qualitative analysis is carried out: argumentative and conceptual, both of the justifications put forward by their authors and of the criteria established as appropriate in urban planning and design to achieve the objectives pursued. Subsequently, the different criteria, guidelines, standards, etc. identified are grouped into synthetic parameters capable of explaining the different cases from a single unifying concept.

Thus, one of the methodological foundations of the research, in tracing the temporal evolution of urban planning thought and practices over the last century and a half, will be historiography. The aim is to construct a synthetic narrative discourse capable of organizing facts and ideas within the urban planning discipline based on the research hypothesis. Cases and references proposed during the selected period (from the Industrial Revolution to the present) are identified, in which emphasis is placed on one of the three study themes: health promotion, social access to water, and environmental improvement.

The comparative analysis is carried out synchronously and diachronically, with the aim of establishing analogies between temporally close events and of these with others of a similar structure in distant periods of time, since, following Landa (2020), this is the way to build one's own conceptualization of urban processes.

Results: Parameters for Managing the Water Cycle with Environmental Sustainability, Citizen Health, and Social Inclusion Criteria

The relationship established between the water and cities over the century and a half studied in this research work shows repetitive trends in the parameters or criteria that have guided the planning and design of these urban spaces.

An analysis of what has happened from the perspective of the three study perspectives (social, environmental, and health) shows that the dual role that the water cycle plays in urban societies—as a resource or consumer good and as a generator of spaces with significant natural and cultural values—has influenced the strategies followed by theorists and planners when addressing planning. The three main parameters identified in this study for urban water cycle planning are: safety, related both to how the problems generated by the presence of this natural phenomenon in urban environments are addressed and how the necessary quality and quantity of water are guaranteed; the coexistence of this natural element and its associated public spaces within the urban fabric; and citizen access to both the consumer good and the spaces and facilities associated with water. The following sections will explain how they have done this through the analysis of significant proposals and projects in each historical stage considered.

Safety

Safety in the management of urban water and its control through drainage systems has been, as Burian and Edwards (2002) point out, a central concern for urban planners throughout history.

Since the second half of the 19th century, concern for the issues that water generated regarding habitability and safety in industrial cities has led to significant urban interventions. The Sanitary Movement emerged as the main force behind these urban transformations. Edwin Chadwick, in his influential Sanitary Report of 1842, argued that unsanitary conditions in British industrial cities were caused by the decomposition of organic matter in the streets, such as garbage and stagnant water, which emitted harmful health effects (Chadwick 1842).

The Public Health Act of 1847, based on Chadwick's recommendations, was a key piece of legislation in promoting sewerage and water supply systems in Great Britain. This law required the creation of sewerage system maps, the construction of sewers in new housing developments, and the maintenance of a supply of clean and healthy water (Benevolo 1992). Its principles influenced urban reforms carried out in other European cities during the 19th century (from Paris to Florence, passing through Hamburg, Vienna, Brussels, Liverpool, and Barcelona). Some of the most significant examples are outlined below:

One of the most emblematic urban reforms in this regard was the Parisian Renovation (1852-1870) led by engineer Eugène Belgrand. This project revolutionized urban water management by incorporating a comprehensive water supply and sewerage system (tout-à-l'égout), that included the construction of large interceptor sewers and a network of service galleries for infrastructure maintenance protecting the Seine River as a source of drinking water (Cano and Cantó 1998; Douet 2021).

In Barcelona, Ildefonso Cerdà's Eixample project also reflected hygienist principles in urban planning, particularly in the development of the "subterranean works" (Cerdà [1859] 1991, 386). Cerdà, unlike his Anglo-Saxon contemporaries, based his proposals on a detailed social analysis of living conditions in the medieval city and advocated for a sewer system and street paving that would not only evacuate wastewater but also prevent "miasma emissions" (Cerdà [1859] 1991).

In London, was the Great Stink of 1858 that led to significant advances in urban planning (Figure 1). Public outrage over the unsanitary conditions of the Thames River prompted the design of a new metropolitan sewer system by the engineer Joseph Bazalgette. His project included a network of main interceptors and pumping stations to redirect wastewater to the east of river (Douet 2021). This innovative solution

significantly improved London's sanitary conditions, although water treatment was not addressed until decades later.

Figure 1. "Faraday Giving His Card to Father Thames; And we hope the Dirty Fellow will consult the learned Professor" published during the Great Sink (1855). Source: John Leech Cartoons from Punch magazine.

In the United States, although there was initially a slow adoption of municipal sewer networks, as scientific evidence on disease transmission advanced in the 19th century, American cities began to build sewer systems inspired by European practices (Burian 2001). The first cities for which a comprehensive sewer system was planned included Brooklyn and Chicago in the late 1850s (Burian 2001)[3].

[3] Apart from those projects, a notable figure in the development of sanitation solutions was Frederick Law Olmsted, who, with his landscape design approach, proposed the Bay Back Fens project in Boston to manage flooding and restore the Muddy River's waters. Olmsted designed a wetland landscape that not only stored water during floods but also included salt-tolerant plants to improve water quality (Olmsted [1879] 2001).

Moving beyond the hygienist era, functionalism in early 20th-century urbanism focused on expanding water supply and sanitation networks to a greater number of urban settlements. This period was marked by an intensification of sanitary engineering to meet a growing demand for water, both for domestic and industrial use, and to meet new service quality standards (Matés-Barco 2009). This dynamic aligned with the social outlook of this period which, through rational and technical urbanism, sought to extend living conditions and empowerment to the most disadvantaged social classes. So much so that social housing programs like the *siedlungen* (Germany) proposed pioneering housing typologies incorporating wet rooms and community heating and laundry systems. Additionally, an important design criterion was the quality of public community spaces, considering the presence of water and its natural dynamics.

In this context, functionalist urbanism also drove technical advancements in water supply, including the construction of large dams, long conduits, and the use of new machines and materials to improve system resilience and efficiency (Matés-Barco 2009).

The phase focused on development policies, which followed functionalism, brought a series of urban transformations aimed at modernization and economic growth. During this period, automobile use was promoted, and suburban expansion intensified urban water supply and drainage problems. The construction of extensive asphalt surfaces and impermeable pavements for roads, parking lots, and large facilities (such as shopping centers and stadiums) contributed to increased surface runoff and drainage system saturation (Figure 2) (Herce 2013).

Figure 2. Valencia flooded by the 1957 flood. Source: Federación Valenciana de Municipios y Provincias

In addition, during this period the construction of large infrastructure projects like urban highways and ring roads often took place over or adjacent to river courses, creating physical barriers that isolated rivers from the urban fabric and promoted the artificialization of riverbeds for flood control (Pellicer 2001). Furthermore, the intensification of soil sealing and the expansion of secondary networks to serve new urban areas contributed to worsening water management issues and the creation of new environmental crises (Pellicer 2001).

As urban modernization progressed, the impact of these strategies became more evident, revealing the need for a new perspective in urban planning that integrated environmental considerations with development demands. Thus, while functionalist and developmentalist urbanism sought technical and economic answers to urban challenges, the lessons learned during these stages laid the groundwork for a critical reflection on the future of hydraulic engineering and urbanism.

In 1965, Abel Wolman addressed for the first time in "The Metabolism of Cities" the pollution of resources as a consequence of the imbalance between materials and energy within and outside the city (Wolman 1965). Parallelly, Ian McHarg, in

“Design with Nature” (1969), proposed urban development that respects natural hydrological cycles by studying the landscape and determining the suitability of land for certain uses.

These works laid the foundations for urban ecology, a field of study that considers the city as an ecosystem with its own metabolism and seeks to understand the consequences of urban expansion on natural ecosystems and the effects of these on urban life. Although these ideas took time to influence public debate and policy decisions, they eventually led to a new sustainability paradigm in urban planning and water cycle management.

During the 1980s and 1990s, various seminal texts began to explore the negative effects of urbanization on the hydrological cycle and urban aquatic ecosystems. Notable among these texts are "Nature in Cities" by Sukopp and Werner (1982), "The Granite Garden" by Anne W. Spirn (1984), and "Nature and the City" by Michael Hough (1998). These authors documented how urban planning practices alter natural water cycles and proposed alternatives for more ecological management. Their conclusions are grouped into several key issues (Hough 1998; Spirn 1984; Sukopp and Werner 1991): alteration of the natural hydrological cycle; flooding and erosion; water quality degradation or water scarcity, among others.

To counter these issues, the mentioned authors proposed several strategies based on ecological principles (Hough 1998; Spirn 1984): balancing the hydrological cycle advocating for understanding and restoring natural water cycle characteristics; rainwater harvesting, recommending the storage of rainwater through retention ponds or increasing permeable surfaces and restoration and conservation of natural waters with the use of treatment lagoons and phytoremediation.

This period reveals a time lag between academic (environmentalist) discourse

and urban planning (developmentalist) practice. Thus, during the 1980s and 1990s, a series of urban-landscape strategies were implemented to open cities to their waterfronts. Over time, however, the urban-landscape strategies that were implemented to open cities to their waterfronts during the 1980s and 1990s to achieve global positioning in the consumer society (Harvey 1989; Biere and Beraldinelli 2010), began to incorporate sustainable management principles, influenced by a growing "environmental vision" in urban planning (Bruhn 2015; Santasusagna and Tort 2019).

Although a prior tradition existed in the United States with projects started as early as the 1980s—such as the Sacramento, Colorado, Kissimmee, Elwha, Green Rivers, or urban stretches of the Charles River in Denver and the Don River in Toronto—Europe was slower to adopt these practices. Much of this progress was driven by EU legislation[4] that, since the late 20th century, provided a legislative framework linking water quality improvements with ecosystem protection, climate change adaptation and recent urban development.

In parallel, the 1990s saw the consolidation of integrated water management strategies driven by the concept of *urban stream syndrome*, which describes the degradation of urban streams due to pollutant transport (Walsh et al. 2005). These strategies aimed to adapt cities to increasing water demands and extreme weather events, promoting concepts such as Water Sensitive Urban Design (WSUD), Low Impact Development (LID), and Sustainable Urban Drainage Systems (SUDS)

[4] Some of these key directives include: The *Urban Waste Water Treatment Directive* (UWWTD, 1991); the Water Framework Directive (WFD, 2000); the Floods Directive (2007); the Birds and Habitats Directive (2009) or the Climate Change Adaptation Strategy (2017).

(Donofrio et al. 2009).

The implementation of these design strategies involves a variety of measures, classified into two types (Badia et al. 2020; Perales and Doménech 2008):

- Non-structural measures: Include urban planning to reduce impervious surfaces, cleaning hard surfaces, controlling chemical use in green areas, collecting and reusing rainwater, and educating society on responsible water use.

- Structural measures: Include devices for capturing, filtering, infiltrating, and treating stormwater. Examples are detention basins, filter strips, infiltration wells, and artificial wetlands, which aim to restore the natural hydrological cycle and improve water quality (Figure 3).

Figure 3. Bioswale in a street of Washingtong DC. Source: Erica Fischer - https://www.flickr.com/photos/walkingsf/40369762221/

These practices have been applied in a variety of urban contexts, from new developments to the revitalization of established spaces, and the implementation of concepts like "sponge cities" that combine natural solutions for managing extreme rainfall and improving public space quality (UN-Habitat 2018).

In the most recent phase, within the context of the COVID-19 pandemic, integrated urban water management has gained relevance as a tool for creating healthier environments. Concepts such as renaturalization, green-blue infrastructure, and climate change adaptation have been reinforced to improve air and water quality and enhance urban resilience against extreme weather events (Guerrero 2022; Mishra et al. 2021; Zapata 2023). These water-sensitive design systems are being applied also with concepts like ecological restoration or nature-based solutions aiming to improve factors crucial for public health[5]. Strategies that also aim to create urban microclimates through evapotranspiration to alleviate extreme temperatures and improve public space comfort, maximizing the benefits of ecosystem services related to aquatic spaces to advance towards more preventive and effective health measures.

Integration

During the study period, one of the main criteria in urban projects has been the treatment and improvement of surface water bodies in cities, such as seas, lakes, rivers, streams, and canals, and their integration into urban public spaces. These bodies of water have been nuclei of attraction for urban development for centuries, playing essential roles such as providing access to drinking water or supporting industrial, commercial, and defensive activities. Over time, their relationship with the urban environment has constantly evolved, shaping spaces for social gatherings, recreation, and work, but sometimes being restricted or instrumentalized.

[5] These include increasing biodiversity, reducing zoonotic disease risks associated with animal-to-human infections –which have been considered a cause of the COVID-19 pandemic (Valladares 2022)–.

In the 19th century, water bodies in cities had a notable presence and a variety of uses. Natural channels were visible elements in the urban fabric, essential for daily activities such as water collection for consumption and laundry, as well as for leisure in the surrounding promenades and meadows. This period also saw the beginning of urban transformations that beautified the riverbanks and coastal areas. Cities like Paris, Bordeaux, London, and Vienna developed large urban façades along their rivers between the 18th and 19th centuries, creating river walks and buildings that defined the city's identity (Monclús 2016). In parallel, coastal areas were transformed into centers of recreation and health, encouraged by the medical discourse of the time that promoted the benefits of sunbathing, breathing sea air, and taking invigorating cold baths (Del Caz 2001).

However, as the 19th century progressed, industrialization led to intensive exploitation of water bodies, radically altering their role in urban spaces. The development of industry turned rivers and ports into production hubs, resulting in water pollution and the restriction of recreational uses. Increasing pollution and the emerging hygienist movement spurred the adoption of sanitary engineering to clean and drain stagnant water bodies, dismantling many traditional water-related activities.

Despite these challenges, some 19th-century urban planners recognized the aesthetic and cultural potential of water bodies. For example, Frederick Law Olmsted, in his Emerald Necklace project in Boston, transformed the Back Bay Fens marshes into a park system that not only improved the quality of stagnant water but also promoted a harmonious connection between water and urban public space (Beveridge and Rocheleau 1995). This project, with its paths, bridges, and green areas, offered a natural refuge in the city, integrating the Muddy River into the urban fabric in a lasting and effective way (Spirn 1984).

In Europe, urban planners like Camillo Sitte and later Josef Stübben promoted a landscape beautification approach through the regulation and ordering of river spaces. Sitte, in his book "The Art of Building Cities" (1889), advocated for creating accessible and visible spaces around water bodies, proposing that these spaces serve as promenades and gardens that should be free of industrial constructions, except those necessary for port operations (Sitte 1926).

Similarly, architect Josef Stübben, in his work "Der Städtebau" (1890), advocated for the preservation of maritime and riverfronts as areas for recreation and contemplation, recommending that these spaces be publicly managed and that industrial transit be kept separate from ordinary recreational use (Stübben 2014).

These examples are representative of the main use of water in public spaces in the second half of the 19th century. An element used to shape the design of new urban parks and green spaces that hygienism advocated as beneficial for air cleaning and population recreation.

The late 19th and early 20th centuries saw the emergence of the City Beautiful movement in the United States, an urban planning approach that sought to improve urban quality of life through architectural and landscape beauty. Inspired by Olmsted's work in Boston, the movement promoted the creation of public spaces that fostered citizens' happiness and social virtue through aesthetically pleasing where water bodies played a crucial role[6].

[6] Significant examples are the National Mall in Washington D.C. (J. McMillan, 1901) which incorporated water elements to enhance the city's monumental character or the Plan of Chicago (D. Burnham, 1909) aimed to integrate existing parks with Lake Michigan to maximize their recreational and contemplative use (Blasco 2012, González 2022).

All these interventions, which aim to beautify the city and thereby improve social conditions, anticipate the arguments surrounding the treatment of urban waters in the functional city. At the beginning of the 20th century, the principles of the Modern Movement continued this tradition, although with a less detailed focus on specific water bodies and more on creating large continuous green spaces for collective leisure.

During the post-war period, functionalist principles led to a general loss of quality in urban public spaces, including water bodies. The postmodern urbanism saw an intensification of the appropriation of port areas and the construction of large highways that often acted as barriers between cities and their rivers, as in the case of the M-30 in Madrid. These urban transformations, influenced by American urban renewal, turned riverbanks into marginal areas and ignored their landscape and social potential, as documented by Pellicer (2001).

A notable example of this dynamic is Valencia after the 1957 floods. The decision to divert the Turia River out of the urban center reflected an engineering vision that prioritized flood control over preserving the city's historical connection with water (Figure 4). However, citizen opposition to converting the riverbed into an urban highway led to the transformation of the old riverbed into a linear park, a green space that offered a landscape presence of water in the city (Blasco 2016).

Figure 4. Turia River (Valencia) aspect of the proposed road layout build on the bed of the old river and image of the current green corridor occupying the old river bed. Source: https://elblogdefarina.blogspot.com/2022/12/el-jardin-del-turia.html

During the 1960s and 1970s, significant criticism emerged towards postmodernist and developmentalist urban processes that had created an increasing separation between natural water bodies –rivers and seas– and urban fabrics. Urban analysts like Jane Jacobs and Kevin Lynch questioned the transformation of these spaces into "urban edges": marginal zones with little urban life, becoming inhospitable and unsafe places. Jacobs, in her 1961 work, argued that this dynamic displaced the void "inland" (Jacobs 1961, 281), highlighting how these underutilized spaces could be reimagined as "seams" within urban fabrics, a potential claimed by the emerging environmental and socio-cultural culture that desired better open spaces to promote urban life.

This criticism opened the door to new urban and landscape strategies that, since the 1980s, sought to recover and revitalize the bordering areas between cities and their water bodies. This trend was driven by two main factors: the recognition of the potential

of "waterfronts" as urban regeneration projects, and technological changes in maritime transport and global trade (Grindlay 2008).

However, these interventions, although aligned with emerging environmental sustainability ideas, often reflected tensions between conflicting interests. Marshall (2001) described the waterfronts of the post-industrial global city as "frontier spaces" that illustrate how market forces and interest conflicts shape our cities. Often, projects prioritized economic profitability through high-end commercial and residential uses rather than focusing on the revitalization of natural public spaces. Despite these criticisms, these projects managed to integrate elements of public pedestrian accessibility and environmental sustainability (AIVP 2006, UN 2000).

In recent years, the focus on urban river spaces has evolved towards a more ecological vision, seeking not only the regeneration of marginal areas but also the development of "green-blue corridors" that offer environmental and quality of life benefits. The dissemination of environmental and cultural values from human ecology disciplines has encouraged strategies to recover and naturalize urban channels, addressing the development of public spaces with social and ecological values (Santasusagna and Tort 2019; Swyngedouw 1996). Prominent examples of these new interventions are: the renaturalization of the Isar River in Munich in 1995, the restoration of the Manzanares River banks in Madrid in 2005 (Figure 5) or the Besòs river park in Barcelona, which since 1995 has addressed the problem of pollution (Parrilla et al. 2021).

Figure 5. Burgos and Garrido Associate Architects, Madrid Río Project, Segovia Bridge area in 2005 and 2011. Source: Bertiz (2022)

Alongside these large-scale projects, since the 1970s, local sustainable stormwater management initiatives have also emerged, associated with the livability of residential areas. These initiatives integrate bodies of water into the urban fabric in both new construction areas and the rehabilitation of existing spaces. These approaches included the creation of streams, ponds, and fountains in streets and squares accessible to citizens. This coexistence between bodies of water and other uses of public space becomes “a natural component of the everyday ecology of a community” and “plays an important role in our psychology” (Alexander 1980, 300), but it is also capable of reflecting the city’s hydrological processes and restoring the identity of vital processes (Hough 1998).

Towards the end of the 20th century, during the sustainability period, the concept of the eco-neighborhood emerged as a spatial solution to integrate ecological principles into metropolitan urban design. This concept aims to fuse environmental and social sustainability through strategies such as green urban design, sustainable

transportation, and water cycle management (Rudin and Falk 1999). Regarding water treatment, these urban developments strive to integrate sustainable resource management elements with climatic comfort elements, enjoyment and educational aspects (Morán 2008).

Furthermore, during this period, smaller-scale projects in specific consolidated urban areas also developed, involving the regeneration or new design of public spaces where water plays a prominent role[7]. Examples of these interventions include water-squares (Figure 6), multifunctional public spaces (for social interaction, play, and rest) designed to act as catchment basins that progressively filter water into the subsoil during times of sewer network saturation and overflow (Mondelli and Rabazo 2019).

Figure 6. Water-square in Copenhague (Tåsinge Square). Source: the authors

[7] Cities like Copenhagen and Rotterdam have implemented these spaces as part of their climate change adaptation plans, complementing them with integral water management elements such as rain gardens, permeable soils, and multifunctional green spaces to improve urban resilience.

In the 21st century, especially after the COVID-19 pandemic, the focus on the benefits of green and aquatic spaces for citizens' physical and mental health has been reinforced. Ecological corridors and green-blue infrastructures not only improve water quality and biodiversity but also contribute to creating healthy microclimates and improving air quality (Guerrero 2022). The presence of the natural water cycle in public spaces, like vegetation, has biophilic values. These values can establish connections with the human mind that enhance knowledge, well-being, and overall human health (Santasusagna and Tort 2019).

Moreover, as already noted, landscapes associated with bodies of water have a broad socio-cultural component that interacts with natural surroundings (Ribas 2007). The possibility of daily access to them has been linked to mental health improvements such as stress reduction and mental fatigue restoration and even a greater sense of happiness and life satisfaction (Gascon et al. 2017; White et al. 2013).

Access

The history of water management in urban environments reflects a constant dialogue between historical models of water access and contemporary urban planning proposals, which have sought not only to distribute the resource but also to make public spaces related to water bodies accessible and enjoyable. This section explores this evolution.

In the nineteenth century, access to water in cities was marked by clear inequality. In major Western cities such as Paris, New York, and Madrid, water supply was a privilege of the affluent classes, who could afford services provided by small private companies. The rest of the population “depended on public water sources in squares and streets, animal troughs, and natural access points to rivers and minor watercourses” (Del Caz 2001, 48-49). Industrialization brought with it a greater demand

for water and increasing pollution of water sources, exacerbating issues of supply quality and quantity.

The growing demands for water drove the construction of extensive distribution and sanitation networks, although these networks faced physical and technical limitations. The need to bring water from distant sources and the difficulty of extending networks in expanding urban areas created zones excluded from service, a problem that became a matter of social and health justice (Herce 2013). The response to these challenges was the public distribution model of water, promoted at the end of the nineteenth century as an essential good that should be managed by the state to ensure universal access (Gandy 2002).

In this context, the municipalization of urban services became a solution to provide potable water and improve sanitation conditions. Cities began to build modern hydraulic infrastructures and regulate services through laws like the London Water Act of 1853, pioneering in quality regulation. This model spread globally, with England leading the way in creating supply and sanitation systems that were adopted in other Western cities (March 2017).

As the twentieth century progressed, hydraulic networks became more complex and efficient, but services also began to privatize, and access to water became individualized. The development of the bathroom in affluent homes reflected a shift towards the privatization of hygiene spaces, while public bath and laundry services experienced a continued decline, moving away from previous public spaces towards progressive privatization and confinement of these practices to the domestic sphere (Herce 2013).

During the first decades of the twentieth century, the expansion of running water services in cities became a priority to improve living conditions. This stage is marked

by the interest of Modern Movement representatives and social-democratic policies in providing more dignified housing for the working classes. Access to running water drove a series of innovations in housing design, including new elements like bathroom furniture, water heating systems, and better-equipped kitchens.

The twentieth century also brought a renewed focus on public health and hygiene, reflected in urban planning. The democratization of physical activity and leisure time for the working classes led to an expansion of sports facilities, including public swimming pools.

In Europe, Germany stood out in the construction of spas and aquatic complexes, such as the Wannsee spa by Wagner and the Dresden-Briesnitz complex (De Cárdenas 2020). Similarly, in the United States, public swimming pools became key community centers, especially in cities like New York. The growth of these spaces reflected a shift in the perception of water, from a hygienic necessity to a resource for leisure and well-being (Figure 7).

Figure 7. Stadtbad Mitte. Public swimming pool in Berlin, Germany, first opened in 1930. Source: Bundesarchiv, Bild 183-09989-0002 / Quaschinsky, Hans-Günter / CC-BY-SA 3.0

After World War II, a third stage in water management began, in which water became a strategic resource for national growth. The state took a leading role in water management, and hydraulic and chemical engineering developed to meet increasing demand, influenced by urban growth in the form of large suburban residential complexes (Barraqué 2003).

At the same time, the economic crisis of the 1970s marked a significant turning point in water access management, generating a dual dynamic that transformed both the perception and management of water. On one hand, the arrival of neoliberal governments promoted a vision of water as an economic good susceptible to privatization and exploitation for the expansion of private capital (March 2017).

On the other hand, in response to this neoliberal trend, a counter-trend emerged focused on an environmental vision and the recognition of water as a fundamental human right. This shift is reflected in the development of Ecological Economics, a discipline that, starting with the studies of the Meadows brothers in 1972, sought to establish a new relationship between the economy and the environment (Naredo 2006). Ecological Economics introduces key concepts such as Virtual Water and the Water Footprint, which allow for the analysis of the amount of water needed in the production of goods and services, as well as the total volume of water consumed by a population (Chapagain and Hoekstra 2004).

During the 21st century, the demand management approach[8], emerging as an

[8] This paradigm has promoted rainwater harvesting, the reuse of greywater, and the adoption of alternative technologies to reduce urban demand for freshwater with actions such as citizen education, administrative regulation, and the implementation of policies oriented towards sustainability (Brooks 2006).

alternative to the traditional hydraulic-consumer model, seeks to overcome the vision centered on unbridled economic growth and promote a more balanced and sustainable management of water. This approach was formalized in the European Union's Water Framework Directive (WFD) from the year 2000, which has guided water policies with the objective of recovering and conserving the good ecological status of water bodies (Arrojo 2008). The United Nations Sustainable Development Goals (SDGs), particularly SDG 6 "Clean Water and Sanitation," have also reinforced the vision of water as an essential human right for health and well-being.

Regarding access to water in public spaces (for recreational, sports, contemplative functions, etc.), significant urban projects have been carried out to eliminate barriers and privatization of water fronts recovering recreational-sporting functions. A notable example of this approach is the transformation of the Seine promenade in Paris, which in the summer months becomes an urban beach with sand, cabins, and bathing areas, promoting contact with water and the enjoyment of recreational spaces, as well as fostering social cohesion and community well-being (Florian 2023).

In the post-COVID stage, the concept of water security has become a priority to ensure the reliable availability of quality water for health, well-being, and production (Grey and Sadoff 2007). This holistic approach is reflected in the recent third-cycle hydrological plans, which aim to improve sanitation, modernize irrigation, and digitize water management for more informed and efficient decision-making (MITECO 2021). The integration of digital technologies and the promotion of sustainable practices are key to facing the current challenges of water management in the context of climate change and urban growth. In addition, strategies for renaturalization, ecological conservation and recovery, as well as the implementation of Nature-Based Solutions,

are used to at maximizing the use of aquatic ecosystem services.

Regarding the built physical environment, improving access to potable water in urban public spaces involves increasing the provision of drinking fountains and public restrooms accessible to all people. As mentioned, these facilities have gradually disappeared from public spaces but are especially important for the comfort and use of physical space by social groups needing adapted equipment to maintain their autonomy (Fariña et al. 2022). Access to quality water for body hydration is fundamental for maintaining good health as it reduces the risk of heart problems or certain types of cancer such as colon or bladder cancer, regulates body temperature, hydrates the skin, aids digestion, and prevents headaches (Aranceta-Bartrina 2018; Fundación Aquae 2020). The psychological and social benefits of proximity to water bodies and vegetation from homes are also highly valued. Open-air swimming pools in the city are being promoted again to provide community environments that foster social cohesion and a sense of community while acting as social equalizers. An example of this is the action of the Belgian organization Pool is Cool, which in 2021 managed to build the first outdoor pool in Brussels after forty years (Figure 8).

Figure 8. Aquatic gymnastics class at the public pool on the river (Pool is Cool, Brussels, 2021). Source: https://www.pooliscool.org/

Discussions: synthetic matrix, conclusions and convergences

For discussion and conclusion, a synthetic matrix (Table 1) is presented, attempting to relate the selected proposals and projects for each identified parameter to the different established historical stages. The columns contain the five historical stages studied, and the rows contain the three planning parameters: security, integration, and access. Thus, the resulting cross-references include those criteria, standards, or guidelines identified as priorities in the disciplinary practice corresponding to the chronological period studied.

It should be noted that both the temporal delimitation of the stages and their classification according to design and planning criteria cannot be considered precise or fixed; rather, there are recurring overlaps, synergies, and coexistence of patterns and historical moments. However, in order to clarify the reading and understanding of the table, it has been decided to assign certain criteria to the historical stage where they are most strongly rooted or in tune with the general design perspective, despite their dates not being exactly consistent.

Table 1. Synthetic matrix of the evolution of parameters. Source: The authors.

		HISTORICAL STAGES				
		Hygienist current *9th and early 20th centuries* **Guiding idea:** to provide home water supply and the construction of an urban sewage network to eliminate putrid water. Progressive concealment of minor urban channels.	Functionalist urbanism *first half of the 20th century* **Guiding idea:** Extension of the supply and installation of toilets to humble homes with a unitary sanitation network. Aquatic recreational-sports equipment.	Postmodernist/Developmentalism stage *50-60-70 years of the 20th century* **Guiding idea: I**ntensification of industrial and road exploitation of the riverbanks, fights against oversaturation of networks with channeling and retaining walls.	Environmental awareness/Sustainable urbanism *from the 80s to the present* **Guiding idea:** Recovery of water fronts (waterfronts and riverfronts). Integrated water management through the introduction of NbS, reduction of consumption and reuse of gray water**.**	Post-Covid 19 stage *from 2020 to the present* **Guiding idea:** Recovery of outdoor water spaces and everyday equipment related to water.
DESIGN AND PLANNING PARAMETERS	SECURITY	· *Sanitary Report. N* (*Chadwick, 1842*). · Board of Health Prescriptions (*Public Health Act , 1847*). ·Paris Reform. Sanitation "tout à l'égout" (*Haussmann y Belgrand, 1852*). · Paving streets and sewer network (*Cerdá, 1859*). ·Brooklyn and Chicago sewer systems (*Sylverter Chesbrough, 1850*). · General sanitation collectors with pumping system to improve the healthiness of Thames waters(*Brazalgette, 1860*). · *Bay Back Fens* (*Olmsted, 1879*)	· Universalization of water supply associated with the inclusion of the toilet · Urban layout projects respecting the flood plains of the surrounding channels. (*Siedlungen Römmerstadt, 1920*). ·Introduction of large road networks on water fronts and riverside bands (*Urban renewal, 1930*)	· Engineering vision to cover the high demand of peripheral growth (*urban redevelopment and urban reconstructions after WW II)* · Waterproofing of soils and urbanized surfaces with oversizing of basins. · Promotion of hydraulic engineering to solve problems of saturation of sanitation networks: channeling and burying of water courses, dams and reservoirs for their containmentn. · "The Metabolism of Cities" (*Wolman, 1965*) · Respect for natural water systems when organizing the territory and urban settlements (*Ian McHarg, 1967*).	· Reporting problems regarding water quality, drought, soil erosion and the risk of flooding due to the breakdown of the natural water cycle by urbanization and intervantion proposals (*Sukkop y Werner,1982; Spirn, 1984; Hough, 1995*). · Renaturalization of urban channels in the USA (*Charles y Don, 1980*). · Definition and application of concepts WSUD, LID y SUDS Australia, EE. UU. y Europe (1990) · Examples of SUDS in eco-neighborhoods, public spaces, roads and industrial areas (*Europe 20100-2010*) · Promulgation of community regulations to protect natural water systems	· Integrated water management creates healthier environments by improving water and air quality and resilience to extreme weather events. ·Increase in biodiversity and reduction of risks from zoonoses (*Valladares, 2022*) · National Strategy for Green Infrastructure and Ecological Connectivity and Restoration (*MITECO, 2021*) ·Restoration of river ecosystems and flood risk reduction program in Spanish urban areas*(Fundación Biodiversidad, 2024)*
	INTEGRATION	· Natural access to the urban banks and their meadows for recreational use by the popular population (*s. XIX*) · Landscaping strategies on seafronts of seaside resort cities (*mid s. XIX*) · Industrial use of the banks and burying of channels *(second half of the 19th century)* · *Emerald Necklac,* Boston (*Olmsted, 1879*). · Beautification of the city through bodies of water in public space (*Stübben, 1890*) · Projects of City Beautiful movement in relation to bodies of water (*Chicago yandWashington, 1909*) ·Green space systems (*Forestier, first decade s. XX*).	·Urban parks with water areas designed for bathing and water sports (Volkspark and Boschpark, 1920). · Design of public spaces with water features in siedlungen (Britz, 1920). · Bodies of water in large peripheral free spaces to promote healthy activity *(Le Corbusier, 1941)* · Public facilities to promote water sports*(Le Corbusier, 1941).*	· Sensitivity towards natural water spaces in New Towns *(Milton Keynes, 1967)* ·Urban highways on river banks and water fronts (1960-70) · Privatization of industrial sectors on water fronts (1960-70) · City break with natural waterways. The disappearance of the Turia river (Valencia, 1960) · Margins of water fronts converted into urban edge spaces with negative consequences for urban vitality (*Jacobs y Lynch, 1960*). · Need for access to water in nearby public spaces for psychological and identity benefits(*Alexander, 1977*)	· First generation of waterfronts and riverfronts. Opening of cities to water fronts *(years 80 y 90).* · Second generation of waterfronts and riverfronts. With environmental and sustainable objectives (s. *XXI).* · Eco-neighborhoods with integrated water management in public community spaces *(2000-)* ·Landscape urban planning projects in European rivers: Madrid Río, Isar in Munich, Besós river park in Barcelona *(1995-)* · Strategies for integrating water processes in public spaces: water-squares, bioretainers, flood parks *(2010 -)*	· Ecological corridors and green-blue infrastructure with multiple advantages(MITECO, 2021). · Biophilic values to produce psychological well-being · Improves comfort in public spaces by reducing the heat island.
	ACCES	· Neighborhood public fountains and popular washing places on the banks of rivers and in free plots of the urban center *(s. XIX)* · Swimming pools in the river itself and public baths in wooden huts*(s. XIX)* · Water as a public good. Towards service change and quality minimums *(London Water Act, 1853)* · New homes served with bathroom, own sink and common laundry room and urinals.*(Cerdà, 1959)* · Privatization of laundry rooms and public bathrooms to neighborhood spaces *(late 19th century and early 20th century)*	· Dissemination of hygienic practices, schools and proliferation of public bathrooms *(firt half s. XX)* · Full bathroom as a single room inside the house *(irt half s. XX)* · Large swimming pool complexes by municipal initiative *(Germany, first decades of the 20th century)* · Supply and common services in new workers' homes *(Siedlungen and FgB Frankfurt)* · Municipalization of water management.	· Large supply infrastructures exceeding the limits of the bioregion for water collection. · Urban growth with oversized and centralized infrastructures without reflection on the urban model. ·Equitable and neighborhood access to public facilities for water sports *(Alexander, 1977).*	· Semi-public spaces with large water demands (water parks, soccer fields, golf courses) and road development fragmenting the territory. · Neoribellar dynamics towards privatization and sustainable counter-trend *(80s-90s)* . · Virtual Water and Water Footprint as indicators of water requirements *(1990s-2000s)* . · Shift towards demand management *(Water Framework Directive, 2000).* · SDG 6: Clean water and sanitation *(UN, 2015)* · Integrated water management to fight climate change and water stress *(1990s-2000s).* .	· Water security vital for human health. · Ecosystem services provided by water. · Access to fountains and public toilets in urban public spaces. · New outdoor pools as a meeting and socializing place *(2023).* · Digitization of the water cycle to ensure efficient and rational use *(2023).*

Analyzing this matrix, we can draw two types of conclusions: On the one hand, those related to the variations in analytical perspectives according to the sociocultural contexts and schools of thought of each historical moment, which coincide with the proposed temporal periodization. Thus, for each of the historical stages, we can conclude that:

- **Hygienist Stage (Late 19th Century – Early 20th Century)**:

The primary drivers of the significant transformation in urban water management at the end of the 19th century were health and hygiene arguments. The miasmatic theory of infectious disease transmission, which identified putrefying water in public spaces as a source of illness, led to the development of sewerage and water supply infrastructure and the gradual disappearance of smaller urban watercourses (buried) and public drinking fountains and laundries. Bathing in river channels and recreational activities around rivers also diminished due to water pollution and the industrial use of riverbanks.

- **Functionalist Period (End of World War I – 1950s)**

The emphasis on social vision was reflected mainly in urban water management in two ways. On one hand, through the expansion of infrastructure networks to provide water supply to all citizens (a process that was slow and not completed until the mid-20th century) and the inclusion of laundry facilities and wet rooms in new working-class housing. On the other hand, by designing public facilities to promote water sports, both indoor (swimming pools) and outdoor (ponds and lakes in public parks).

- **Postmodern or "Developmentalist" Stage (1950s-70s)**:

This period definitively broke the connections between urban fabrics and their water fronts. In response to frequent and severe flooding of historic city centers due to expanded runoff areas and obsolete infrastructure, hydraulic engineering was employed

to resolve these issues. Rivers were channelized, buried, and diverted in many cities, and retention basins and upstream dams were created for flood control. The overgrowth of water supply networks, sometimes sourcing beyond the bioregion, was accompanied by increased soil impermeability due to urban sprawl and the creation of roads and parking spaces for cars. Despite this, scientific studies in the 1960s and 70s began to reveal the negative environmental consequences of this artificial water cycle.

- **Environmentalist or Sustainability Stage (1980s – Present):**

However, it was not until this stage that measures were taken to reverse this situation. Since then, ecosystem health and the preservation of natural and ecological cycles have become primary justifications for changes in urban water management towards a demand management approach. Urban planning models have been implemented that propose soft infrastructure for the collection and renewal of rainwater, enabling it to be absorbed by the ground, stored, filtered for aquifer recharge, and even purified through aeration and aquatic plants. Similarly, water consumption, which had surged in the Postmodern stage, is addressed through graywater recycling and reduced demand in parks, gardens, and water facilities. At the same time, previously degraded and privatized urban water fronts are being reopened to the public through urban transformation projects in obsolete port spaces, both maritime and riverine. Initially driven by commercial interests and urban image enhancement, these projects are now seen as great opportunities for improving urban natural processes through renaturalization, highlighting their cultural and social values.

- **Post-COVID Stage (year 2020 onwards)**:

Projects to open up water fronts undertaken during the Sustainability stage have gained special relevance from a health perspective, promoting ecological restoration of riverbanks and streams. Their accessibility is positively valued for both physical and

mental well-being benefits and for providing habitats conducive to species biodiversity enhancement. After the health pandemic, there has been a focus on the necessary care of ecosystem health to promote human health, making biodiversity improvement in natural habitats essential. For the urban water cycle, this goal is pursued through projects that incorporate ecological connectivity (green-blue infrastructure) and naturalized water cycle management. These strategies also aim to mitigate water stress (specially the Mediterranean cities) during droughts and enhance urban resilience to intense rainfall events due to climate change. Their integration into everyday public spaces, combined with vegetation, is also proposed as a resource to combat rising temperatures and the urban heat island effect in large cities.

Regarding the second type of conclusions, the identified design parameters are found to recur over time. This recurrence, however, highlights the different strategies used over time to resolve similar issues. For each parameter, the following can be summarized:

- **Safety against risks produced by urban water**:

Safety from the risks posed by urban waters has moved from channeling waterways and paving floors in the sanitary city of hygiene to achieving water control through the display of hydraulic engineering—the functional and productive city—and ultimately restoring the natural processes of the water cycle and enhancing its self-regulation—the sustainable and healthy city of the 21st century.

- **Integration of the urban water bodies in public spaces:**

This has also followed a discontinuous path. Although access to natural water was part of the everyday spaces and activities of the nineteenth-century city, sanitary regulations progressively removed water from urban spaces. Later, major waterways became definitively confined between industrial spaces and road infrastructure in the

modern city. Subsequently, the global city sought a new symbolism and image through its waterfronts, restoring accessibility to these spaces, which, subsequently influenced by an environmental perspective, have achieved a leading position as essential environments for the improvement of aquatic ecosystems and their biodiversity, as well as spaces with social and cultural values for citizen enjoyment. Thus, today, the concept of a healthy city promotes the ecological restoration of waterfronts and bodies of water at all levels and their integration into the network of urban public spaces.

- **Access to water resources for public and private use:**

Regulatory policies and technical advances have guided planning actions related to water resource access. During the hygienist era, access to water was largely public and collective. Over time, this characteristic shifted towards individualized supply and the privatization of public water-related facilities such as laundries and public baths. This trend intensified in the modern city with technological advancements and municipal management of water supply. In the first half of the 20th century, however, there was a push to build sports facilities in both private spaces and public parks related to water sports. Over time, these facilities also became increasingly privatized as natural water sources were exploited to meet rising water consumption demands. The new water culture associated with ecological and environmental values aimed to rationalize water use through demand management policies and to recover public accessibility through the design of public spaces for water sports, games, and the provision of public toilets and drinking fountains. This effort aligns with current programs for healthy cities.

Data availability statement

The data are available from the corresponding author on reasonable request.

References

Alexander, Christopher.1980. *Un lenguaje de patrones*. Barcelona: Gustavo Gili.

Aranceta-Bartrina, Javier. 2018. "Hidratación: importancia en algunas condiciones patológicas en adultos". *Med. interna Méx.* 34 (2): 214-43. https://doi.org/10.24245/mim.v34i2.1430.

Arrojo Agudo, Pedro. 2008. "La nueva cultura del agua del siglo XXI". Expoagua Zaragoza 2008. https://www.zaragoza.es/contenidos/medioambiente/cajaAzul/palabras/Arrojo_ES.pdf.

AIVP (International Association of Cities and Ports). 2006. "Carta para el desarrollo sostenible de las ciudades portuarias", 2006. https://www.oas.org/cip/docs/areas_tecnicas/8_rel_ciudad_puerto/4_aivp_charte_sydney.pdf.

Badia Casas, Eloi, Frederic Ximeno Roca, Cristina Vila Rutllant, and Francesc Jiménez Gusi. 2020. *Guia Tècnica per al disseny de sistemes de drenatge urbà sostenible. SUDS*. Barcelona: Ayuntamiento de Barcelona.

Barraqué, Bernard. 2003. "Las políticas del agua en Europa a partir de la directiva marco del agua". *Ingeniería del agua* 10 (3): 281. https://doi.org/10.4995/ia.2003.2586.

Benevolo, Leonardo. 1992. *Orígenes del Urbanismo Moderno*. Madrid: Fareso S.A.

Beveridge, Charles E., and Paul Rocheleau. 1995. *Frederick Law Olmsted: designing the American landscape*. Nueva York: Rizzoli.

Biere Arenas, Rolando, and Raphaella Beraldinelli Vieira. 2010. “Reflexiones acerca del paradigma de reconversion de los waterfront”. Barcelona: Universitat Politècnica de Catalunya. file:///C:/Users/USUARIO/Downloads/Reflexiones_acerca_del_paradigma_de_reco.pdf

Blasco, José Antonio. 2012. “Washington, del Plan L’Enfant al McMillan Plan y la City Beautiful”. *Urban Networks* (blog). 2012. https://urban-networks.blogspot.com/2012/04/washington-del-plan-lenfant-al-mcmillan.html.

Blasco, José Antonio. 2016a. “El río que se convirtió en parque: los Jardines del Turia en Valencia”. *Urban Networks* (blog). 2016. https://urban-networks.blogspot.com/2016/06/el-rio-que-se-convirtio-en-parque-los.html.

Brooks, David B. 2006. “An Operational Definition of Water Demand Management”. *International Journal of Water Resources Development* 22 (4): 521-28. https://doi.org/10.1080/07900620600779699.

Bruhn, A. 2015. “The “renaturation” of urban rivers: The case of the St Charles River in Quebec”. In *Understanding and managing urban water in transition*, edited by Q. Grafton, K.A. Daniell, C. Nauges, J.D. Rinaudo, y N.W.W. Chan, 527-48. Global Issues in Water Policy 15. Dordrecht: Springer. https://link.springer.com/chapter/10.1007/978-94-017-9801-3_24.

Burian, Steven J. 2001. “Developments in water supply and wastewater management in the United States during the nineteenth century”. *Water Resources IMPACT* 3 (5): 14-18.

Burian, Steven J., and Findlay G. Edwards. 2002. “Historical Perspectives of Urban Drainage”. In *Global Solutions for Urban Drainage*, edited by Eric W. Strecker y Wayne C. Huber. Oregon: American Society of Civil Engineers. 10.1061/40644(2002)284.

Cano, Juan Jaime, and Julián Cantó. 1998. “Evolución histórica de las galerías de servicio”. In *Actas del Segundo Congreso Nacional de Historia de la construcción*, 87-92. Universidade da Coruña. https://ruc.udc.es/dspace/bitstream/handle/2183/10556/HC%2012.pdf?isAllowed=y&sequence=1.

Cerdà, Ildefonso. (1859) 1991. *Teoría de la construcción de las ciudades. 1, Cerdá y Barcelona*. Original 1860. Madrid: Ministerio para las Administraciones Públicas.

Chadwick, Edwin. 1842. “Report on an inquiry into the sanitary condition of the labouring population of Great Britain”. Londres: W. Clowes and Sons.

Chapagain, A.K., and A.Y. Hoekstra. 2004. “Water footprints of nations”. Delft: Unesco-IHE Institute for Water Education. https://research.utwente.nl/en/publications/water-footprints-of-nations.

Crosas Armengol, Carles, and Joan Martí Elias. 2020. “Hidden Water Balances. Strategies for an Ecosystemic Urbanismin the Vall Baixa of the Llobregat River”. *ZARCH*, n.º 15, 80-95. https://doi.org/10.26754/ojs_zarch/zarch.2020154809.

De Cárdenas Maestre, Isabel. 2020. “Lo verde como sistema: espacios verdes y vida al aire libre en la Holanda de entreguerras a través de las páginas de la publicación neerlandesa de 8 en Opbouw”. *rita*, n.º 14, 86-94. https://doi.org/10.24192/2386-7027(2020)(v14)(03).

Del Caz Enjuto, M. Rosario. 2001. *El agua en el seno de las aguas: la ordenación del espacio balneario en el Cantábrico*.Valladolid: Universidad de Valladolid.

Donofrio, Julie, Yvana Kuhn, Kerry McWalter, and Winsor Mark. 2009. “Research Article: Water-Sensitive Urban Design: An Emerging Model in Sustainable

Design and Comprehensive Water-Cycle Management". *Environmental Practice* 11 (3): 179-89. https://doi.org/10.1017/S1466046609990263.

Douet, James. 2021. "The Steam Pumping Stations of the London Main Drainage, 1858–75". *Industrial Archaeology Review* 43 (2): 135-46. https://doi.org/10.1080/03090728.2021.1973226.

Fariña Tojo, José, Ester Higueras García, Emilia Román López, and Elisa Pozo Menéndez. 2022. *Guía para planificar ciudades saludables*. Madrid: Ministerio de Sanidad and Federación Española de Municipios y Provincias. https://www.sanidad.gob.es/areas/promocionPrevencion/entornosSaludables/local/estrategia/herramientas/docs/Guia_Planificar_Ciudades_Saludables.pdf.

Florian, María Cristina. 2023. "Piscinas públicas como espacios públicos: El papel de la natación y el baño en las ciudades". *ArchDaily* (blog). 2023. https://www.archdaily.cl/cl/1002509/piscinas-publicas-como-espacios-publicos-el-papel-de-la-natacion-y-el-bano-en-las-ciudades.

Fundación Aquae. 2022. "10 grandes beneficios de tomar agua para el cuerpo". 2022. https://www.fundacionaquae.org/wiki/10-grandes-beneficios-del-agua-para-nuestro-organismo/?_ga=2.142081073.2032785921.1712035813-1008587906.1712035813.

Gandy, Matthew. 2002. *Concrete and clay: reworking nature in New York City*. London: MIT Press. https://mitpress.mit.edu/9780262572163/concrete-and-clay/.

García Barba, Federico. 2013. "Siedlung Römerstadt". *Arquiscopio* (blog). 2013. https://arquiscopio.com/archivo/2013/10/12/siedlung-romerstadt/.

Gascon, Mireia, Wilma Zijlema, Cristina Vert, Mathew P. White, and Mark J. Nieuwenhuijsen. 2017. "Outdoor Blue Spaces, Human Health and Well-Being: A

Systematic Review of Quantitative Studies". *International Journal of Hygiene and Environmental Health* 220 (8): 1207-21. https://doi.org/10.1016/j.ijheh.2017.08.004.

Glick, Thomas F. 1987. "Las crisis del saneamiento en el Londres medieval y victoriano". *Ciudad y Teritorio*, marzo, 23-33.

González Roca, África. 2022. "Estrategias activas sobre el ciclo del agua en el proyecto de nuevos espacios libres en la metrópolis contemporánea". Barcelona: Universidad Politécnica de Cataluña. https://upcommons.upc.edu/handle/2117/374458.

Grey, David, and Claudia W. Sadoff. 2007. "Sink or Swim? Water security for growth and development". *Water Policy*, n.º 9, 545-71.

Grindlay Moreno, Alejandro Luis. 2008. "Ciudades y Puertos". *Ciudades*, n.º 11 (december), 53-80. https://doi.org/10.24197/ciudades.11.2008.53-80.

Guerrero, Irene. 2022. "Infraestructura verde y azul para la mejora de la calidad del aire en las ciudades". Universidad del Pais Vasco. http://hdl.handle.net/10810/57112.

Harvey, David. 1989. *The urban experience*. Oxford: Basil Blackwell Scientific Publications.

Herce, Manuel. 2013. *El negocio del territorio. Evolución y perspectivas de la ciudad moderna*. Madrid: Alianza Editorial.

Hough, Michael. 1998. *Naturaleza y ciudad: planificación urbana y procesos ecológicos*. Barcelona: Gustavo Gili.

INAP (Instituto Nacional de Administración Pública). 2016. "Renaturalización del río Manzanares en el tramo urbano de Madrid". Madrid: Ministerio de Política Territorial y Función Pública.

Jacobs, Jane. 1961. *The death and life of great American cities*. New York: Vintage Books.

March Corbella, Hug. 2017. “La gestión del agua urbana como ejemplo de los cambios en las tecnologías y modelos de gestión socioambiental urbana”. Barcelona: Universidad Oberta de Catalunya.

Marshall, Richard. 2001. *Waterfronts in Post-Industrial Cities*. Taylor & Francis. https://doi.org/10.4324/9780203166895.

Matés-Barco, Juan Manuel. 2009. “El desarrollo de las redes de agua potable: modernización y cambio en el abastecimiento urbano”. *Agenda Social* 3 (1): 25-58.

Maund, Phoebe, Katherine Irvine, Jonathan Reeves, Emily Strong, Ruth Cromie, Martin Dallimer, and Zoe Davies. 2019. “Wetlands for Wellbeing: Piloting a Nature-Based Health Intervention for the Management of Anxiety and Depression”. *International Journal of Environmental Research and Public Health* 16 (22): 4413-30. https://doi.org/10.3390/ijerph16224413.

McHarg, Ian. 2001. *Proyectar con la naturaleza*. Barcelona: Gustavo Gili

MA (Millennium Ecosystem Assessment Board Assessment). 2005. *Ecosystems and Human Well-Being: Synthesis*. Whasintong DC: Island Press. https://www.millenniumassessment.org/documents/document.356.aspx.pdf.

Mishra, Binaya, Pankaj Kumar, Chitresh Saraswat, Shamik Chakraborty, and Arjun Gautam. 2021. “Water Security in a Changing Environment: Concept, Challenges and Solutions”. *Water* 13 (4): 490. https://doi.org/10.3390/w13040490.

MITECO (Ministerio para la Transición Ecológica y el Reto Demográfico). 2021. “Síntesis de los borradores de planes hidrológicos de las demarcaciones hidrográficas intercomunitarias”. Madrid.

Molina Holgado, Pedro, Fernando Allende Álvarez, Nieves López Estébanez, and Lara Jendrzyczkowski Rieth. 2023. *Geografía: cambios, retos y adaptación*. Edited

by XXVIII Congreso Asociación Española de Geografía. 1.ª ed. ASOCIACIÓN ESPAÑOLA DE GEOGRAFÍA. https://doi.org/10.21138/CG/2023.lc.

Molina Prieto, Luis Fernando, and Ernesto Villegas Rodríguez. 2015. "Ciudades sensibles al agua: paradigma contemporáneo para gestionar aguas urbanas". *Revista de Tecnología* 14 (1): 53-64.

Monclús, Javier. 2016. "Waterfronts y Riverfronts. Recuperación de frentes de agua fluviales como proyectos urbanos estratégicos. El proyecto de riberas del Ebro". *Planur-e*, n.º 07, 1-19.

Mondelli, Francesca Paola, and Marta Rabazo Martin. 2019. "De la necesidad al proyecto: el diseño del espacio público para el control del agua y la mitigación del Cambio Climático". In *XIII CTV 2019 Proceedings: XIII International Conference on Virtual Cityand Territory: "Challenges and paradigms of the contemporary city": UPC, Barcelona, October 2-4, 2019*. Centre de Politica de Sol i Valoracions, CPSV / Universitat Politècnica de Catalunya, UPC. https://doi.org/10.5821/ctv.8634.

Morán Alonso, Nerea. 2008. "Ecobarrio". *Ciudades para un Futuro más Sostenible* (blog). 2008. http://habitat.aq.upm.es/temas/a-ecobarrio.html#fntext-1.

Naredo, José Manuel. 2006. *Raíces económicas del deterioro ecológico y social: más allá de los dogmas*. Madrid: Siglo XXI.

Olmsted, Frederick L. (1879) 2001. *The Emerald Necklace Parks. Master Plan*. Boston: Commonwealth of Massachusetts Executive Office of Environmental Affairs. https://ia802601.us.archive.org/3/items/emeraldnecklacep00walm/emeraldnecklacep00walm.pdf.

Oral, Hasan Volkan, Pedro Carvalho, Magdalena Gajewska, Nadia Ursino, Fabio Masi, Eric D. Van Hullebusch, Jan K. Kazak, et al. 2020. "A Review of Nature-Based Solutions for Urban Water Management in European Circular Cities: A Critical

Assessment Based on Case Studies and Literature". *Blue-Green Systems* 2 (1): 112-36. https://doi.org/10.2166/bgs.2020.932.

Parrilla, Orlando, Erika González, Raúl Urquiaga, and Santiago Martín. 2021. "Renaturalización de tramos urbanos de ríos". Área de Aguas de Ecologistas en Acción. https://www.ecologistasenaccion.org/wp-content/uploads/2021/05/Informe-rios-naturalizados.pdf.

Pellicer Corellano, Francisco. 2001. "Ordenación paisajística de espacios fluviales en las ciudades mediterráneas". En *Paisaje y ordenación del territorio*, de Florencia Zoido Naranjo y Carmen Venegas Moreno. Junta de Andalucía, Consejería de Obras Públicas y Transportes.

Perales, Sara, and Ignacio Doménech. 2008. "Los Sistemas Urbanos de Drenaje Sostenible: Una Alternativa a la Gestión del Agua de Lluvia". *Retema: Revista técnica de medio ambiente* 21 (124): 92-104.

Prost, Antonie, and Gérard Vicent. 1989. *Historia de la vida privada. 9, La vida privada en el siglo XX*. Editado por Philippe Ariès y Georges Duby. Madrid: Taurus.

Ribas Palom, Anna. 2007. "Los paisajes del agua como paisajes culturales: Conceptos, métodos y una experiencia práctica para su interpretación y valorización". *Associação de Professores de Geografia*. https://doi.org/oai:dugi-doc:10256/2049.

Rudin, David and Nicholas Falk. 1999. *Building the 21st century home. The Sustainable Urban Neighbourhood.* Architectural Press.

Santasusagna Riu, Albert, and Joan Tort Donada. 2019. "Agua y espacio urbano. Algunas consideraciones teóricas a propósito de la relación entre ciudad y río". *Documents d'Anàlisi Geogràfica* 65 (2): 371-97. https://doi.org/10.5565/rev/dag.513.

Sitte, Camillo. 1926. *Construcción de ciudades según principios artísticos*. Traducido por Emilio Canosa. Barcelona: Canosa. file:///C:/Users/USUARIO/Downloads/file_1.pdf.

Spirn, Anne W. 1984. *The granite garden. Urban nature and human design.* Nueva York: Basic Books.

Stübben, Joseph. 2014. *City Building. Joseph Stübben*. Tranlated by Julia Koschinsky y Emily Talen. Braunschweig: Vieweg. https://socialsciences.uchicago.edu/department/urbanism-lab/joseph-stubbens-city-building.

Sukopp, Hebert and Peter Werner. 1991. *Naturaleza en las ciudades*. Original 1982. Secretaría General Técnica. Centro de Publicaciones. Ministerio de Obras Públicas y Transportes.

Swyngedouw, Erik. 1996. "The city as a hybrid: On nature, society and cyborg urbanization". *Capitalism Nature Socialism*, n.º 7, 65-80. http://dx.doi.org/10.1080/10455759609358679.

UN-Habitat. 2018. "La Ciudad Esponja". *UN-Habitat* (blog). 2018. https://onuhabitat.org.mx/index.php/la-ciudad-esponja.

UN (United Nations). Global Conference on the Urban Future (URBAN 21). 2000. "10 Principles for a Sustainable Development of Urban Waterfront Areas". Berlín: United Nations. http://vana.chaplin.ee/english/ware/images/stories/resources/10-principles.pdf.

Valladares, Fernando. 2022. "Más biodiversidad para mejorar la salud. Los beneficios de favorecer ecosistemas funcionales y diversos en el bienestar humano". *Metode Science Studies Journal*, n.º 114, 59-65. https://doi.org/10.7203/metode.13.24072.

Walsh, Christopher, Allison Roy, Peter Cottingham, Peter Groffman, and Raymond Morgan. 2005. «The urban stream syndrome: current knowledge and the search for a cure». *J. N. Am. Benthol. Soc* 24 (3): 706-23. https://doi.org/10.1899/04-028.1.

Monclús. London: Routledge. https://doi.org/10.4324/9781315575520.

White, Matthew, Sabine Pahl, Katherine Ashbullby, Stephen Hebert, y Michael Depledge. 2013. "Feelings of restoration from recent nature visits". *Journal of Environmental Psychology*, n.º 35, 40-51. https://doi.org/doi:10.1016/j.jenvp.2013.04.002.

Wolman, Abel. 1965. "The Metabolism of Cities". *Scientific American*, 156-74.

Wutich, Amber, Alexandra Brewis, and Alexander Tsai. 2020. "Water and mental health". *WIREs Wate* 7 (5): 1-16. https://doi.org/10.1002/wat2.1461.