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Reinvigorating A City Through Water Conservation: Review of Literature

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ABSTRACT

This paper investigates the pivotal role of water conservation in revitalizing urban landscapes and enhancing community well-being. The lack of appreciation and awareness of water conservation in accessible urban blue spaces, like rivers or parks, hampers well-being and limits opportunities. This paper addresses the historical trajectory of water-centric infrastructure, the integration of water elements into architectural designs, and water accessibility in improving urban life quality and driving economic progress. It employs a systematic review that draws upon a broad array of peer-reviewed sources from urban planning, architecture, environmental science, and sociology using the Scopus online database, curated on July 10th, 2023. The culmination of this exploration yields invaluable insights and actionable recommendations, offering a nuanced understanding of the intricate interplay between water conservation and the urban community fabric. These findings are poised to significantly influence urban planning and policy decisions, fostering a vision for harmonious, sustainable, and thriving cities equipped to navigate future challenges with resilience and foresight.

1. Introduction

Urbanization globally increases urban populations and quality of life in growing cities concerns urban planners, architects, and designers. Integrating water into urban spaces transforms them into dynamic, soothing domains stated by Kurochkina *et al.,* [16] and Langie *et al.,* [17]. Water's allure in urban design is ancient, seen in Persia's reflective pools and Renaissance Europe's ornate fountains mentioned Filson [11]. Water's aesthetic, cultural, and spiritual significance endures in modern urban challenges, water elements offer solutions beyond aesthetics, aiding human well-being.

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Amidst urban stress, pollution, and green space loss, water's presence soothes and enhances well-being stated by McDougall *et al.,* [23] and M. P. White *et al.,* [39]. Understanding water's role in urban well-being is crucial in today's urbanizing world. This review delves into water's multifaceted contributions to urban well-being, historically, psychologically, and architecturally. Empirical research and case studies inform future urban planning and architecture, prioritizing inhabitants' well-being amidst urbanization.

1.1 Research Background

Urbanization has led to over half of the global population residing in cities stated by Elmqvist *et al.,* [9]. While it brings economic and cultural opportunities, it also poses significant challenges to urban dwellers' well-being. The fast-paced, densely populated urban environments often result in physical and mental health issues, such as stress, anxiety, and reduced well-being. These challenges affect not only the poor but also other city residents, with the spillover effect increasing as urbanization continues globally stated by Kuddus *et al.,* [15]. To address these challenges, urban planners and architects are exploring innovative approaches to improve the urban experience, including integrating water elements said Nowacka-Rejzner [26]. Water has diverse effects on human well-being and offers potential solutions to mitigate the adverse impacts of urban living Langie *et al.,* [18].

This research aims to investigate the influence of water on well-being in urban contexts, encompassing both indoor and outdoor spaces. Despite existing literature on the subject, there is a need for comprehensive research exploring how water impacts well-being and its practical implications for urban design and architecture. This research is significant as it can provide insights into designing urban environments that prioritize dwellers well-being as cities continue to grow and evolve. Furthermore, this research contributes to the discourse on sustainable and human-centric urban development. By examining water's potential to enhance well-being, it aligns with the goal of creating resilient, livable, and healthy cities for current and future generations.

1.2 Research Objective

The research comprises three primary objectives aimed at the historical trajectory of water-centric infrastructure, tracing its evolution from ancient civilizations to modern urban environments. This objective involves a comprehensive analysis of historical records, archaeological findings, and scholarly literature to understand the development of water-centric systems across different cultures and time periods.

Secondly, the integration of water elements into architectural designs, focusing on the evolution of techniques, technologies, and design philosophies. This objective entails a review of architectural literature, and design methodologies to elucidate the diverse ways in which water has been incorporated into built environments and its impact on architectural aesthetics and functionality.

Finally, evaluate the role of water accessibility in improving urban life quality and driving economic progress in contemporary contexts. This objective involves empirical research, including data analysis, surveys, and case studies, to assess the effects of water-centric infrastructure on factors such as public health, social well-being, economic productivity, and environmental sustainability. By quantifying the benefits and challenges associated with water accessibility in urban settings, this objective aims to provide evidence-based insights for policymakers, urban planners, and stakeholders.

2. Literature Review

2.1 The Role of Water in Urban Design

Water has been a fundamental and enduring element in the design of urban spaces throughout history. From ancient civilizations to modern metropolises, the presence of water has played a pivotal role in shaping the character and functionality of cities. Its multifaceted contributions to urban design extend beyond mere aesthetics, encompassing ecological, cultural, social, and well-being dimensions explained Donofrio *et al.,* [8] Langie *et al.,* [17]. Ancient civilizations, like Mesopotamia, utilized water for sustenance and sanitation, showcasing early engineering feats stated Le Doaré *et al.,* [19]. Water is vital for ecological sustainability in modern urban design. Urban ponds enhance biodiversity and combat the urban heat island effect, while green infrastructure techniques like permeable pavements mitigate stormwater runoff stated Oertli *et al.,* [27]. Water features, from grand structures like Singapore's Marina Bay Sands Skypark to public fountains in Paris, shape a city's cultural identity, attracting tourists and fostering community pride explained Langie *et al.* [18]. Water promotes social interaction in cities, with public fountains and waterfront parks serving as gathering places for relaxation and outdoor activities stated Pitt [29]. Revitalizing waterfronts has boosted tourism and strengthened community bonds mentioned Kostopoulou [14]. Water has profound effects on human well-being in urban areas. "Blue space" induces calmness, while visually engaging water features improve aesthetics and air quality, providing physical comfort amidst rising temperatures explained Zhang *et al.,* [42]. Recognizing water's potential is crucial for enhancing urban residents' health and quality of life.

2.2 Historical Perspective on Water in Architecture

Water has long been a central element in the evolution of architectural design, transcending centuries and civilizations. From the ancient irrigation systems of Mesopotamia stated Le Doaré *et al.,* [19] to the opulent fountains of the Renaissance, the integration of water in architecture has continuously reshaped not only the physical environment said Deming [6] but also the human experience within it.

During the Renaissance, a revived interest in classical aesthetics and the human-nature connection influenced architectural design, with fountains and water features becoming prominent again said Este et al., [10]. The Villa d'Este in Tivoli, Italy, exemplifies this fascination with water through its Renaissance gardens, featuring terraces, cascades, and the captivating Water Organ Fountain, combining music and water for a multisensory experience. Similarly, the gardens of Versailles, designed by André Le Nôtre in the 17th century, epitomize French formal garden design, with water as a central element mentioned Julie Crew [13]. Grand fountains, reflecting pools, and intricate canal networks, including the Water Parterres with classical sculptures, served as symbols of royal power and opulence.

In Islamic architecture, gardens and courtyards were designed around water features, embodying the concept of the "paradise garden" stated Mohammad Abuaemar [24]. These gardens utilized intricate channels and fountains to create coolness and serenity in arid regions, serving as places for reflection and social gatherings. The Alhambra in Granada, Spain, is a prime example, with its Generalife Gardens showcasing water's interplay with architecture through cascading fountains and reflecting pools, creating a sensory experience beyond the physical environment.

In the 20th century, modernist architects departed from ornate water features, embracing simplicity and functionality in their designs. Water integration became subtle, focusing on light, reflection, and sound. Architects like Le Corbusier and Mies van der Rohe experimented with water's architectural

potential, creating tranquil environments like the reflective pool in Le Corbusier's Chandigarh Capitol Complex and the serene reflecting pool in Mies van der Rohe's Barcelona Pavilion.

Contemporary architects continue to explore water's dynamic possibilities, integrating minimalist pools, water walls, and interactive sculptures into urban spaces. The Therme Vals, designed by Peter Zumthor, offers visitors a sensory journey inspired by ancient bathing traditions. Built over thermal springs in Switzerland, the spa resembles a cave and utilizes locally quarried Valser Quarzite slabs, blending with the natural surroundings. Protected as a heritage site, the spa's four chambers provide various therapeutic experiences through water, stone, and mountain elements mentioned Burroughs [3]. The historical perspective on water in architecture underscores its enduring influence on aesthetics and functionality. From ancient irrigation systems to Renaissance fountains and modernist designs, water has shaped architectural spaces. Understanding water's multifaceted role in contemporary urban design draws upon centuries of human experience, contributing to the creation of fluid environments prioritizing urban inhabitants' health and happiness.

3. Review Methodology

Scopus is a comprehensive abstract and citation database covering a wide range of disciplines. It's often used by researchers, academics, and institutions to track and analyze scholarly literature. In the context of reviewing methodology, Scopus can be a valuable tool for conducting systematic literature reviews or meta-analyses. Scopus provides advanced search features that allow researchers to narrow down their search criteria by keywords, authors, publication dates, and more, aiding in the precise identification of relevant studies. Out of 71 papers, 42 were chosen, indicating the selection process's effectiveness.

3.1 Keyword search

The subsequent procedural phase entailed the development of meticulously selected keywords to accurately represent the precise focus of the systematic review. To enhance search precision, the strategic use of Boolean operators occurred in conjunction with the “topic search” functionality. The devised keywords were intentionally crafted to comprehensively encompass the principal themes of the research: "Blue Space" OR "Mental Health" AND "Water Conservation" OR "Urban Water Feature" AND "Waterscapes".

3.2 Screening

The initial methodology involved setting a cutoff for publication years, excluding papers released before 2010. This temporal constraint aimed to focus the review on recent research developments. A second method involved limiting the types of publications eligible for assessment. Specifically, only peer-reviewed papers, reviews, and early access papers from indexed journals were considered for inclusion. This criterion emphasized the importance of rigorous peer review processes to ensure the quality and reliability of selected studies.

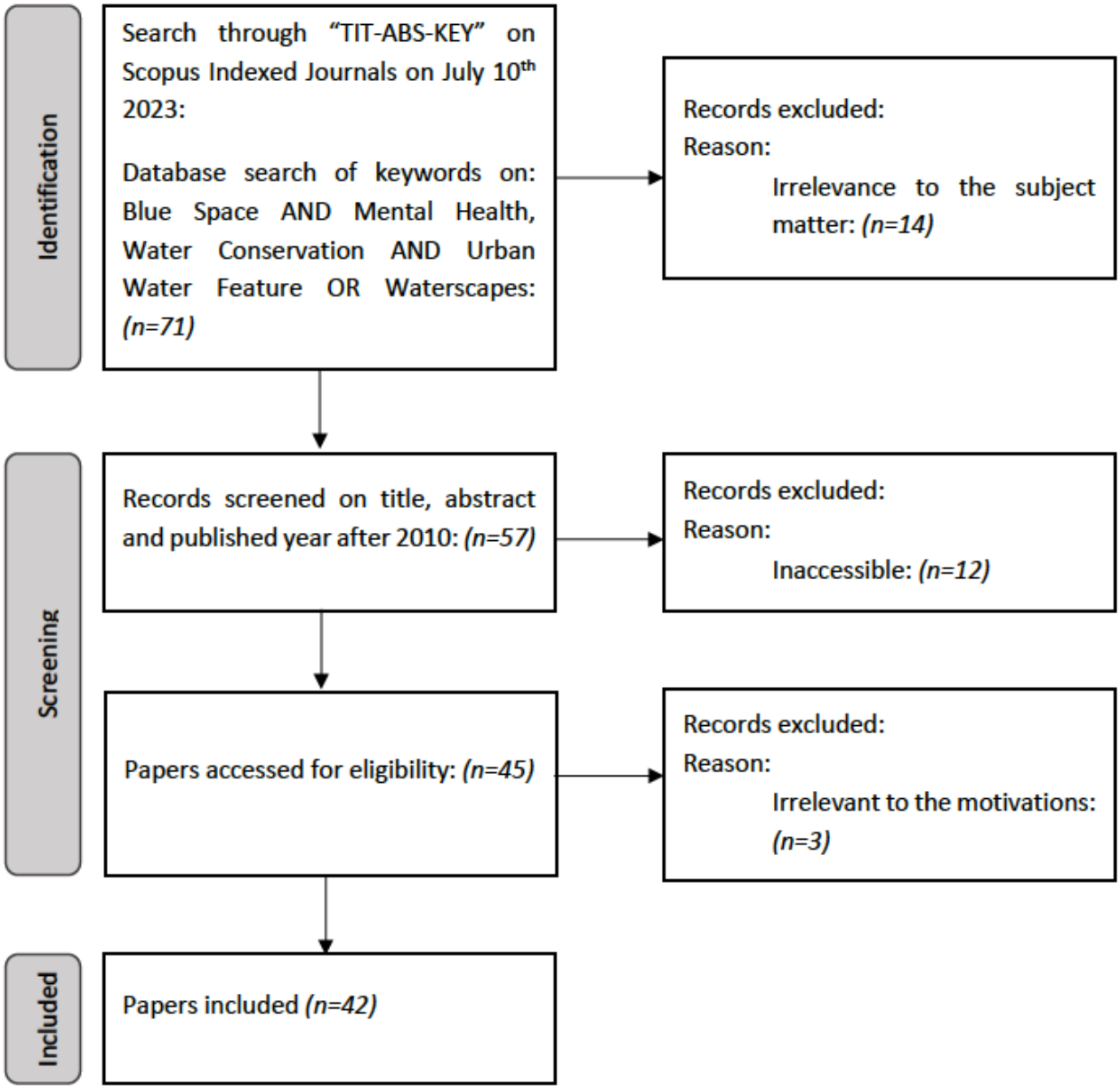

Fig. 1. Process of screening

3.3 Bibliometric Analysis

A bibliometric analysis was utilized to map the scholarly data collected, analyze themes, study data trends, and process a wide range of information as per Khan *et al.,* [14]. Moreover, employing bibliometric analysis allows for the assessment of journal impact, article influence, institutional contributions, country involvement, subject areas, and keyword significance. This method provides robust indicators for policymaking across diverse subject domains and helps mitigate subjective biases in the literature. VOSviewer, a tool employed in this study, generates visual representations of academic landscapes in terms of publications, researchers, institutions, countries, keywords, or terms.

Leveraging metrics like co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation, VOSviewer identifies connections and assesses the overall strength of those connections, visually presenting them through network visualization. This research integrates bibliometric analyses involving keyword co-occurrence using VOSviewer. Figure 1 illustrates the framework of bibliometric analysis adopted in this study.

3.3.1 Co-occurrence of keyword analysis

Examining co-occurring keywords in a study provides valuable insights into topic frequencies and their connections. Figure 1 visually illustrates significant keywords identified in the eligibility phase, with colors indicating similarity and connections, and circle size reflecting importance. Keywords positioned closer together signify stronger associations based on co-occurrence links, often indicating interdependencies and relationships. This mapping offers a cognitive understanding of research topics and their interrelations, facilitating the identification of clusters and research gaps as per Khan *et al.,* [14]. Utilizing tools like VOSviewer, this method analyzes paper titles, abstracts, and keywords to generate objective insights. Out of 122 keywords, 7 met the thresholds whereby nature contact, well-being, therapeutic landscapes and ecosystem services hold the scalable clusters.

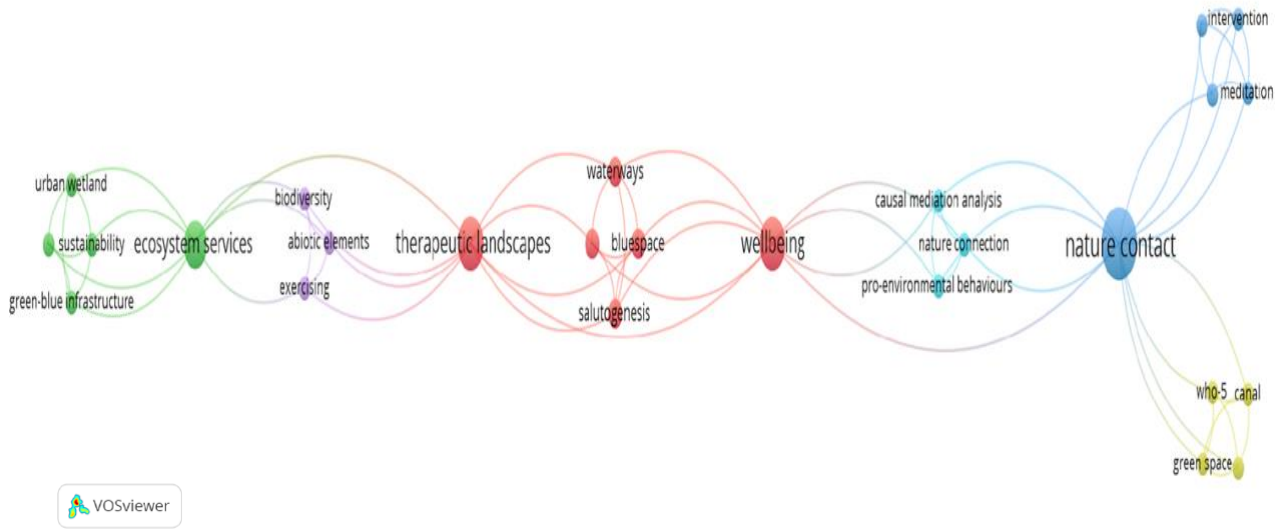

Fig. 2. Network visualisation co-occurrence of keyword analysis

4. Result and Discussion

4.1 Psychological Impacts of Water

Water has been a fundamental element in human existence, shaping civilizations, ecosystems, and the human psyche. Throughout history, humans have been drawn to water, not only for its physical necessity but also for its profound psychological and physiological effects. Water-related spaces encompass a wide range of environments, from serene lakeshores to tumultuous oceans, and each has its own unique impact on the human experience. This essay explores the integration of water elements

and its impact on architectural designs, shedding light on the profound ways in which water influences our well-being, behavior, and overall health.

4.1.1 Stress reduction and relaxation

Research indicates that exposure to natural sounds, particularly those associated with water, has a significant ability to induce relaxation and reduce stress levels explained Thoma *et al.,* [34]. In a well-designed study, participants exposed to recorded water sounds experienced a notable decrease in cortisol response, a reliable marker of stress activation. These findings suggest that the calming effects of water sounds translate into tangible physiological benefits by reducing the body's stress response. This can be attributed to the soothing and rhythmic nature of water sounds, which facilitate relaxation. The gentle lapping of waves, the babbling of a brook, or the patter of rain evoke feelings of calm and connection to nature, offering a powerful tool to counteract modern life stressors stated Thoma *et al.,* [34]. As stress-related issues affect many, incorporating natural sounds into daily routines or therapeutic practices holds promise as a simple yet effective strategy to mitigate stress and promote well-being. Whether through mindful listening, meditation, or environmental design, natural sounds represent a holistic approach to stress reduction that aligns with our innate connection to the natural world. Waterscapes, including oceans, rivers, and lakes, are increasingly recognized for their therapeutic benefits on psychological well-being, offering emotional mitigation said Zhang *et al.,* [42]. The auditory stimuli provided by waterscapes, particularly water sounds, play a significant role in promoting psychological health, offering diverse sensations from calm trickles to roaring waterfalls. Studies have measured sound levels associated with different water features, with lower decibel water sounds being more favorably received, contributing to noise reduction in urban environments and benefiting mental health stated Zhang *et al.,* [42].

4.1.2 Enhanced creativity and cognitive function

Water-related environments have been associated with heightened creativity and improved cognitive function. Research indicates that the sound of water can stimulate the brain's creative centers, leading to enhanced problem-solving and innovative thinking. Additionally, simply being near water can clear the mind and enhance concentration. A study by Song *et al.* [32] investigated the efficiency of attention and the recovery effect of nature sounds following attention-demanding tasks. It compared the impact of nature sounds versus urban sounds on attention, prefrontal cortex and autonomic nervous system activity, as well as participants' mood states. Drawing inspiration from previous research by Alvarsson *et al.,* [2] Medvedev *et al.,* [22], this study utilized functional Near-Infrared Spectroscopy (fNIRS) to measure autonomic nervous system and prefrontal cortex activity, alongside subjective evaluations. Key findings include attention to task. Although there was no significant difference in the attention task between water and urban sounds, participants reported slightly higher attention scores with nature and water sounds. Physiological indicators; Water sounds led to decreased HbO concentration (indicating increased brain oxygen utilization), higher ln (HF) values (linked to parasympathetic nervous system activity), and lower heart rate. Similar trends were observed during the Sound + Rest period. Psychological indicators; Participants felt more comfortable, relaxed, and natural with water sounds. Negative mood states were lower, while positive mood states were higher compared to urban sounds. These findings suggest that the positive effects of water sounds may be rooted in humans' evolutionary history in natural environments. Despite increasing urbanization, the human body appears inherently adapted to nature.

4.1.3 Emotional well-being and mood enhancement

Participating in activities in water-related environments profoundly impacts emotional well-being. These spaces, with the captivating beauty of water and its soothing sounds, uniquely elevate mood and alleviate symptoms of depression and anxiety. Activities such as swimming and boating trigger the release of endorphins, known as "feel-good" hormones, intensifying feelings of happiness and relaxation. This holistic and therapeutic experience offers emotional rejuvenation and mental tranquility amidst the serene embrace of aquatic settings Zhang *et al.,* [42].

4.1.4 Social interaction and community building

Water-related spaces, such as beaches, riverbanks, and lakeside parks, have a unique ability to foster social interaction and community building. The calming presence of water draws people together, encouraging them to share experiences, stories, and laughter. These settings provide a backdrop for picnics, sports, or simply lounging by the water's edge, all of which facilitate connections and the formation of friendships. This sense of community and belonging has a profound impact on mental health, reducing feelings of isolation and stress. Additionally, these spaces often host events and activities, further strengthening the support network within the community and promoting overall well-being explained De Bell et al., [5].

4.1.5 Mindfulness and meditation

Water-related spaces serve as natural sanctuaries for mindfulness and meditation conducted by Djernis et al., [7]. The soothing cadence of waves crashing on the shore or the serene flow of a river acts as a meditative soundtrack, water fountain guiding individuals into deep relaxation. The perpetual ebb and flow of water invite a profound sense of presence, allowing one to detach from everyday concerns and find mental clarity. In these tranquil environments, stress dissipates, and the mind can fully engage in the practice of mindfulness, leading to improved emotional well-being. Water's calming influence and connection to the present moment make it an ideal partner for those seeking solace and self-awareness through meditation.

4.1.6 Therapeutic benefits

Hydrotherapy, a time-tested therapeutic approach harnessing water's properties, has played a significant role in promoting both physical and mental health for centuries. Water-related spaces, particularly hot springs, exemplify the healing potential of water. The warmth and buoyancy of hot springs ease muscle tension, alleviate pain, and enhance blood circulation, contributing to physical well-being. Simultaneously, the relaxation induced by these environments aids in reducing stress and anxiety, thereby nurturing mental health. The combination of physical and psychological benefits makes water-related spaces a holistic resource for enhancing overall psychological well-being, reinforcing the enduring relevance of hydrotherapy as a vital element in healthcare practices throughout history explained by Mooventhan *et al.,* [25]. Hydrotherapy has a range of effects on different bodily systems; The cardiovascular system experiences improved blood circulation, reduced blood pressure, and enhanced heart function. The respiratory system benefits from enhanced lung function, decreased asthma attacks, and improved breathing. In the musculoskeletal system, hydrotherapy reduces pain, stiffness, and inflammation in muscles and joints, along with improving mobility. The nervous system benefits from reduced stress, anxiety, and depression, and improved sleep quality. The digestive system experiences enhanced digestion, reduced constipation, and

improved appetite. Hydrotherapy boosts the immune system and improves the body's ability to fight infections. Lastly, hydrotherapy improves skin health, reduces acne, and enhances the appearance of scars.

4.2 Physiological Impacts of Water

4.2.1Reduced heart rate and blood pressure

The presence of water offers potent therapeutic potential, inducing significant physiological changes. Research by Coss & Keller [4], consistently shows water-related environments lowering heart rate and blood pressure, promoting better cardiovascular health by reducing stress. Their studies, involving 73 participants, respectively, found that viewing water, whether a swimming pool or natural water bodies, notably lowered blood pressure and heart rate compared to non-water elements. These findings highlight water's profound impact on overall well-being, emphasizing its importance for relaxation and heart health.

4.2.2 Pain management and rehabilitation

Water therapy, including aquatic exercise and hydrotherapy, is a widely used method in physical rehabilitation, known for its effectiveness. Water's unique properties make it ideal for pain management and injury recovery. Its buoyancy reduces strain on joints and muscles, aiding individuals in exercises and movements with less pain, especially beneficial for arthritis or post-surgery. Additionally, water's gentle resistance improves muscle strength and flexibility, leading to a faster and more comfortable rehabilitation process explained by Mooventhan *et al.,* [25].

4.2.3 Improved sleep quality

Spending time in water-related spaces can enhance sleep quality, as emphasized in a review by Billings *et al.* [2]. The study emphasizes the influence of an individual's living and sleeping environment on their sleep health. While it mainly discusses various physical and social aspects, it highlights how water-related spaces, like lakes or coastal areas, can significantly improve sleep quality. These tranquil environments promote relaxation, aiding in faster sleep onset and deeper sleep. Additionally, water bodies can mitigate environmental noise, further enhancing the sleep environment. Overall, incorporating water-related spaces into living environments can positively influence sleep health and improve sleep quality.

4.2.4 Stress hormone reduction

The stress-relieving effects of water-related spaces extend to significant physiological changes, including the reduction of stress hormones like cortisol. Lower cortisol levels are linked to decreased risks of chronic stress-related diseases, such as cardiovascular issues, weakened immunity, and mental health disorders said Zhang *et al.,* [42]. Spending time in these environments helps regulate cortisol levels, promoting overall well-being and reducing long-term health risks associated with chronic stress. Water-related spaces offer natural sanctuaries for relaxation, contributing to both physical and mental health. Water-related spaces profoundly impact human psychology and physiology, from reducing stress to enhancing emotional well-being, cardiovascular health, and immune function. Incorporating these environments into daily life can lead to a healthier and happier existence. Whether

it's a lakeside retreat, ocean waves, or urban bluespace, water-related spaces continue to play a vital role in our well-being stated Zhang *et al.,* [42].

4.3 Previous Studies on Water Well-Being in Urban Environments

The interplay between water and human well-being in urban environments has garnered increasing attention from researchers and urban planners. The recognition that access to water, whether in the form of natural bodies of water or carefully integrated water features, can significantly impact psychological, physiological, and overall well-being has fueled an expanding body of research. This review delves into key studies that have explored the multifaceted relationship between water and well-being in urban contexts.

4.3.1 "Blue Space" and mental health

A seminal study by White M. *et al.* [40] significantly contributed to understanding the relationship between water and psychological well-being in urban environments. Investigating "blue space," encompassing water-rich natural or built environments, the study explored its effects on individuals' preferences, emotions, and perceived restorative qualities of surroundings. Through experiments exposing participants to scenes with and without water elements, including lakes, rivers, and built water features, the study found that exposure to blue space consistently led to higher preferences, more positive emotional states, and perceived restorativeness. These findings highlighted the psychological benefits of incorporating water elements into urban settings, suggesting that water's presence can reduce stress, enhance mood, and promote psychological restoration and well-being among residents and visitors.

4.3.2 Water elements and stress reduction

In 2011, Völker and Kistemann [38] conducted a notable study titled "The Impact of Blue Space on Human Health and Well-Being – Salutogenetic Health Effects of Inland Surface Waters: A Review." This research explored how water features like ponds or fountains in urban parks affect visitors' psychological well-being. Their study advanced our understanding of water elements' positive effects on health, particularly in reducing stress and enhancing overall well-being.

The study focused on the stress-reducing potential of water features in urban parks, crucial in addressing stress in modern urban life. Urban green spaces, recognized for mitigating stress, were found more effective in reducing stress levels when they included water features. An important finding was the significance of visibility and accessibility of water features. Those easily seen and accessed by park-goers had a more pronounced stress-reducing effect, emphasizing the importance of thoughtful design and placement of water elements in urban parks.

4.3.3 Urban waterfronts and social interaction

The study of Ma et al., [21] offers valuable insights into the transformation of urban waterfronts and their impact on the well-being of residents. This research examined the redevelopment of a former industrial waterfront area, the West Bund in Shanghai, and revealed the multifaceted benefits of such regeneration projects. The West Bund's transformation from an industrial site into a vibrant urban space served as a compelling case study. The study's findings underscored the positive influence of waterfront regeneration on residents' well-being in several key dimensions:

4.3.4 Physical activity and leisure

The presence of water bodies and well-designed public spaces within the regenerated waterfront area provided residents with opportunities for physical activity and leisure. This included activities such as walking, jogging, cycling, and recreational sports. Accessible waterfront promenades and parks created inviting environments that encouraged residents to engage in active and healthy lifestyles explained Ma *et al.,* [21].

4.3.5 Social interaction and community building

One of the remarkable outcomes of waterfront regeneration was the fostering of social interactions and the development of a sense of community among residents. The availability of attractive waterfront spaces acted as natural gathering points, where people came together to socialize, connect, and enjoy shared activities. These interactions contributed to a stronger sense of community and belonging explained Ma *et al.,* [21].

4.3.6 Enhanced overall well-being

The study's results highlighted that the combination of water bodies and well-designed public spaces in the regenerated waterfront had a cumulative effect on residents' overall well-being. Engaging with the waterfront environment not only improved physical health but also enhanced mental and emotional well-being. Residents reported higher levels of life satisfaction and a greater sense of happiness and contentment explained Ma *et al.,* [21].

4.3.7 Cultural and recreational activities

The revitalization of waterfront areas has transformed them into bustling centers for cultural and recreational activities, including festivals, art exhibitions, and community events. These activities inject vibrancy into urban spaces, enriching residents' lives and offering avenues for cultural enrichment and entertainment explained Ma *et al.,* [21].

The example of the West Bund in Shanghai illustrates how waterfront regeneration projects can extend beyond mere aesthetic improvements. They actively contribute to residents' well-being by providing spaces for physical activity, social interaction, cultural engagement, and overall improvement in quality of life. These findings underscore the importance of thoughtful waterfront development for urban planners and policymakers, as they aim to create healthier, more connected, and vibrant urban communities.

4.3.8 Water features in healthcare settings

Ulrich et al. found that water elements in hospitals could alleviate stress and anxiety in patients, offering emotional support and comfort. Patients in such environments reported feeling more relaxed, potentially expediting their recovery process stated Ulrich *et al.,* [36]. Their research underscores the significant role of water features in healthcare design, beyond aesthetics, as they contribute to healing environments that prioritize patient well-being. By reducing stress and enhancing the healthcare experience, water elements become crucial components of evidence-based healthcare design stated Ulrich *et al.,* [36]. These findings have practical implications for healthcare planners and designers, emphasizing the importance of incorporating elements promoting well-being and comfort. As

healthcare shifts towards patient-centered care, integrating calming water features is essential for improving overall health and well-being in healthcare settings.

4.4 The Integration of Water in Indoor and Outdoor Spaces

4.4.1 Influence of indoor water features

In contemporary urban living, where concrete jungles dominate the landscape, the integration of water indoors has become a powerful tool for enhancing well-being. Several key aspects highlight the importance of indoor water features;

4.4.1.1 Improved noise perception

Indoor water features offer more than just visual appeal; they create serene havens within indoor spaces. The sound of trickling water acts as a natural auditory therapy, offering relief from the hustle and bustle of modern life. It induces a sense of tranquility, allowing individuals to relax, unwind, and find comfort in their environment. Additionally, incorporating water into indoor settings fosters a feeling of calmness, enhancing the overall atmosphere. Whether it's in a corporate office, healthcare facility, or home, integrating water features contributes to a sense of well-being mentioned Thoma *et al.,* [34]. In such environments, people are more likely to experience improved mental and emotional states, emphasizing the importance of including water as a fundamental element in interior design.

4.4.1.2 Aesthetic enhancement

Indoor water features can enhance the aesthetics of interior spaces. The visual appeal of water features, combined with the soothing sounds they produce, can contribute to a more visually and aurally pleasing environment. Water elements add a touch of elegance and beauty to indoor spaces. From sleek, modern water walls to traditional Japanese koi ponds, these features enhance the overall aesthetic appeal of interiors. Water's reflective qualities can also make rooms appear more spacious and visually appealing.

4.4.1.3 Thermal comfort

Water features can assist in regulating indoor temperatures by leveraging evaporative cooling in hot climates and adding moisture to the air in colder regions. Seputra [31], conducted research on indoor cooling with evaporative water features, revealing insights into achieving desired temperatures. Despite external temperatures reaching 33°C, none of the simulated cases achieved indoor temperatures below 27.1°C. Subsequent adjustments aimed to reach lower temperatures while maintaining relative humidity below 80%, following Chow *et al.,* [5] standards. Among the cases examined, ToB surpassed TeB, with an average indoor temperature of 31.48°C compared to 31.57°C.

4.4.2 Influence of outdoor water features

While indoor water features offer respite from the urban hustle and bustle, outdoor water features play a crucial role in transforming urban landscapes into inviting and rejuvenating environments. Here are some key ways in which water is integrated into outdoor spaces for the betterment of urban well-being.

4.4.2.1 Urban cooling

Urban Heat Islands (UHI), characterized by higher temperatures in densely built areas, can have detrimental effects on human health. Water features like fountains, ponds, and lakes provide a natural cooling effect through the process of evaporation. These aquatic elements help mitigate the urban heat island effect, making outdoor spaces more comfortable during hot summer months. Enhancing surface reflectance, such as incorporating water features or applying white paint to surfaces, can lead to a reduction in urban air temperatures of approximately 1 to 3.5 degrees Celsius. Various water elements or features related to be introduced to deter UHI according to research by Tong et al., [35];

Water Retentive Pavement and Water Retentive Wall refer to surfaces and walls designed to retain water, aiding in stormwater management and runoff reduction. Mesh Shade and Water Supply likely involve mesh or shading materials combined with water supply systems to provide cooling and diminish heat absorption. Water Retentive Block shares similarities with water-retentive pavement and walls, designed to retain water. Water Surface denotes exposed water bodies like ponds, pools, or reservoirs, while Water Cooling Bench refers to benches with built-in cooling systems utilizing water to lower surface temperatures. Watering encompasses the general process of applying water to plants, soil, or surfaces, affecting evaporative efficiency and cooling. Overall, these terms underscore the importance of integrating water-related elements into urban environments to create comfortable and environmentally friendly spaces.

4.4.2.2 Biodiversity and habitat creation

Ponds, wetlands, and other aquatic features can serve as oases of biodiversity within concrete jungles. They provide essential habitats for a diverse range of species, including birds, amphibians, fish, and aquatic plants. These water bodies offer nesting sites, food sources, and shelter for wildlife, fostering a healthier urban ecosystem. Moreover, these aquatic ecosystems can help manage stormwater, reducing the risk of flooding and improving water quality. Incorporating water bodies into urban planning represents a sustainable approach to harmonizing human development with nature, enriching urban life, and fostering biodiversity in our increasingly urbanized world explained by Alikhani et al., [1].

4.4.2.3 Recreation and social spaces

Urban water features like splash pads and waterfront promenades are essential for enhancing urban life quality. Splash pads offer safe spaces for families to cool off and play during hot weather, fostering social interactions and physical activity. Swimming pools, both indoor and outdoor, are popular for exercise and relaxation, providing venues for swimming lessons and sports said Schneider *et al.,* [30]. Waterfront promenades along rivers or lakes encourage outdoor activities like walking and biking, promoting community health and reducing carbon emissions. Overall, these features contribute to vibrant urban environments where people can connect and enjoy water-related benefits daily.

4.4.2.4 Aesthetics and landscaping

Water bodies play a crucial role in urban park design, enhancing the aesthetic appeal and experiential qualities of public spaces. Features like reflecting pools create captivating mirror-like surfaces that reflect the surroundings, adding depth to the landscape. Waterfalls offer a multisensory experience with their cascading water and soothing sound, fostering relaxation and mindfulness. Decorative ponds, adorned with aquatic plants and ornamental features, introduce biodiversity and

serve as artistic elements. These water features become iconic landmarks, drawing people together for leisure and contemplation stated Schneider *et al.,* [30]. Ultimately, incorporating water bodies in urban park design provides spaces for people to connect with nature and appreciate the blend of art and nature in their surroundings.

4.3.3 Challenges and considerations

4.4.3.1 Sustainability

Water management in urban environments is critical for sustainability, necessitating responsible design practices to prevent strain on local water resources and ecosystems. Rainwater harvesting systems are key in reducing the environmental impact of water features by collecting and storing rainwater for irrigation and other uses, easing pressure on municipal water supplies mentioned Teston *et al.,* [33]. Recycled water from wastewater, produced through centralized or decentralized systems, offers another sustainable solution. Developed countries often opt for centralized systems that treat wastewater to meet environmental standards, albeit with energy-intensive pumping processes. In contrast, developing countries and water-scarce regions employ decentralized systems to reuse treated water for non-potable purposes, with Australia pioneering distributed water recycling systems like sewer mining. Additionally, selecting drought-resistant plants and implementing low-water landscaping practices, such as xeriscaping, reduces water usage and maintenance needs, further contributing to sustainable water management in urban areas said Paul *et al.,* [28].

4.4.3.2 Maintenance

Water features in urban landscapes, including decorative ponds and fountains, require consistent and careful maintenance to preserve their functionality and visual appeal. Neglected water bodies can deteriorate quickly, becoming breeding grounds for pests like mosquitoes and posing health risks to the public mentioned Huzortey *et al.,* [12]. Adequate planning for ongoing maintenance is crucial, involving regular inspections to address issues like debris buildup, algae growth, or pump malfunctions. Skilled maintenance personnel should be tasked with cleaning, repairing, and treating the water as necessary, which includes balancing chemical levels, maintaining water quality, and preventing the spread of harmful microorganisms.

4.4.3.3 Safety

Safety considerations are paramount in designing spaces with water features, particularly in areas frequented by children and families. Several measures are crucial for creating safe environments around water features. First, installing appropriate fencing or barriers around water bodies is essential to prevent accidental entry, especially by children. Fences should meet safety standards and have self-closing and self-latching gates. Visible signage is also crucial, indicating the presence of water features, warning about potential hazards, and providing instructions on safe behavior. Effective signage should use symbols, text, and visuals to convey the message clearly. Safe design principles should be incorporated into the layout of water features, ensuring appropriate water depths and providing gradual entry and exit points for wading areas while avoiding steep edges to prevent slipping or falling. In areas with children, supervision by lifeguards or responsible adults is advisable, especially in public spaces like pools or splash pads. Additionally, equipping the area with life-saving equipment such as lifebuoys, life vests, and reaching poles is essential to respond effectively to emergencies.

4.4.3.4 Accessibility

Public spaces featuring water elements should prioritize accessibility for all community members, including those with disabilities. Thoughtful design incorporating ramps, pathways, and sensory elements can enhance inclusivity in water-centric areas. Accessibility significantly impacts people's frequency of using waterscapes and indirectly affects their psychological well-being. Research indicates that proximity to water bodies, within a 15-minute walk and 300-meter distance, correlates with accessibility. A study conducted by Zhang *et al.,* [42] in Northern Utah revealed that as the distance from an access point increased by 10 meters, residents were less likely to engage with waterscapes. Conversely, households located adjacent to riversides were more inclined to interact with these areas, benefiting from the positive influence of riverside activities and experiencing the sights and sounds of water. These accessibility patterns have psychological health implications, particularly concerning the Psychological Restoration Theory (PSRT).

Table 1 Key findings and its implication to architecture

Section	Subsection	Description	Key Findings	Implications for Architecture	References
Psychological Impacts of Water	**Stress reduction and relaxation**	Water-related environments can significantly reduce stress and promote relaxation through natural sounds and visual elements.	Exposure to natural water sounds reduces cortisol levels and stress. Lower decibel water sounds contribute to better mental health.	Incorporate water features in therapeutic spaces, urban parks, and residential areas to leverage their stress-relieving benefits.	Thoma et al. [34]; Zhang et al. [42]
	Enhanced creativity and cognitive function	Water environments can enhance cognitive function and creativity by stimulating brain activity and improving mood.	Water sounds can improve attention, brain oxygen utilization, and mood. Participants showed higher attention and relaxed states with water sounds compared to urban sounds.	Design workspaces and learning environments near water features to boost creativity and cognitive function.	Song et al. [32]; Alvarsson et al. [2]; Medvedev et al. [22]
	Emotional well-being and mood enhancement	Activities in water-related settings improve mood and alleviate symptoms of depression and anxiety through endorphin release.	Water activities like swimming and boating enhance emotional well-being and mental tranquility.	Integrate water elements into recreational and therapeutic environments to enhance emotional well-being.	Zhang et al. [42]
	Social interaction and community building	Water spaces encourage social interaction and community building by providing shared experiences and activities.	Water-related spaces foster connections, reduce isolation, and enhance community bonds.	Create community spaces with water features to promote social interaction and community engagement.	De Bell et al. [5]

	Mindfulness and meditation	Water settings act as natural sanctuaries for mindfulness and meditation, aiding in relaxation and mental clarity.	Water's rhythmic patterns and sounds support mindfulness, stress reduction, and self-awareness.	Incorporate water features in meditation rooms, wellness centers, and peaceful outdoor spaces to support mindfulness practices.	Djernis et al. [7]
	Therapeutic benefits	Hydrotherapy using water's properties contributes to physical and mental health, easing muscle tension and reducing stress.	Hydrotherapy improves cardiovascular, respiratory, musculoskeletal, nervous, digestive, immune, and skin systems.	Design therapeutic spaces with hydrotherapy options and incorporate water elements to enhance overall health and well-being.	Mooventhan et al. [25]
Physiological Impacts of Water	**Reduced heart rate and blood pressure**	Viewing or interacting with water can lower heart rate and blood pressure, promoting cardiovascular health.	Significant reductions in heart rate and blood pressure are observed with water exposure.	Use water features in healthcare settings and relaxation areas to support cardiovascular health and relaxation.	Coss & Keller [4]
	Pain management and rehabilitation	Aquatic therapy reduces joint and muscle strain, aiding in pain management and rehabilitation.	Buoyancy of water reduces strain, aiding recovery, especially for arthritis or post-surgery patients.	Integrate water-based therapy in rehabilitation centers and physical therapy facilities to enhance recovery processes.	Mooventhan et al. [25]
	Improved sleep quality	Water-related spaces can positively impact sleep quality by promoting relaxation and reducing environmental noise.	Water environments improve sleep onset, quality, and duration by creating a calming atmosphere.	Include water features in bedroom designs and relaxation areas to enhance sleep quality and overall restfulness.	Billings et al. [2]
	Stress hormone reduction	Water environments help lower stress hormones like cortisol, reducing risks associated with chronic stress.	Reduced cortisol levels in water-related spaces correlate with lower stress and improved health outcomes.	Incorporate water features in environments where stress reduction is a priority, such as offices and wellness centers.	Zhang et al. [42]

Previous Studies on Water Well-Being in Urban Environments	**"Blue Space" and mental health**	Studies on "blue space" show that exposure to water environments enhances emotional states and perceived restorativeness.	Higher preferences, more positive emotions, and perceived restorativeness are linked to water-rich environments.	Design urban spaces with integrated water elements to improve residents' psychological well-being and emotional states.	White M. et al. [40]
	Water elements and stress reduction	Water features in urban parks can significantly reduce stress levels and enhance well-being.	Visibility and accessibility of water features are crucial for their stress-reducing effects in urban parks.	Prioritize visible and accessible water features in urban park design to maximize their stress-reducing benefits.	Völker and Kistemann [38]
	Urban waterfronts and social interaction	Redevelopment of urban waterfronts enhances social interaction, community building, and overall well-being.	Waterfront regeneration projects improve physical activity, social interaction, and overall quality of life.	Focus on waterfront redevelopment to foster social connections, physical activity, and community engagement.	Ma et al. [21]
	Physical activity and leisure	Well-designed waterfronts offer opportunities for physical activity and leisure, contributing to residents' health and well-being.	Access to waterfront spaces encourages walking, jogging, and other recreational activities, enhancing physical health.	Incorporate accessible and inviting waterfront areas in urban planning to support active and healthy lifestyles.	Ma et al. [21]
	Social interaction and community building	Waterfront areas provide natural gathering points for social interaction and community development.	Attractiveness of waterfront spaces fosters community bonds and social interactions.	Develop waterfront spaces that encourage social activities and community events to strengthen community ties.	Ma et al. [21]
	Enhanced overall well-being	Regenerated waterfronts contribute to improved overall well-being through various benefits, including physical and mental health.	Residents report higher life satisfaction, happiness, and contentment due to well-designed waterfronts.	Design urban waterfronts to include features that enhance both physical and mental well-being.	Ma et al. [21]

	Cultural and recreational activities	Revitalized waterfronts support cultural and recreational events, enriching urban life.	Vibrant waterfronts host festivals, art exhibitions, and community events that enhance cultural and recreational experiences.	Include spaces for cultural and recreational activities in waterfront designs to enrich urban life and provide diverse experiences.	Ma et al. [21]
	Water features in healthcare settings	Water elements in healthcare settings reduce stress and enhance patient comfort, potentially improving recovery outcomes.	Patients in healthcare environments with water features report reduced stress and faster recovery.	Incorporate calming water elements in healthcare settings to support patient well-being and recovery.	Ulrich et al. [36]
	Influence of indoor water features	Indoor water features enhance well-being through improved noise perception, aesthetic appeal, and thermal comfort.	Water features create tranquility, enhance visual appeal, and regulate indoor temperatures.	Integrate water features into indoor spaces for improved ambiance, aesthetics, and climate control.	Thoma et al. [34]; Seputra [31]
	Influence of outdoor water features	Outdoor water features contribute to urban cooling, biodiversity, recreation, and aesthetics.	Water features mitigate urban heat, support biodiversity, offer recreational opportunities, and enhance urban aesthetics.	Design urban outdoor spaces with water features to improve cooling, biodiversity, and recreational opportunities.	Tong et al. [35]; Alikhani et al. [1]; Schneider et al. [30]
	Sustainability	Sustainable water management practices are essential for minimizing environmental impacts and conserving resources.	Rainwater harvesting, recycled water use, and drought-resistant landscaping are key to sustainable water management.	Implement sustainable practices in water feature design to ensure environmental responsibility and resource conservation.	Teston et al. [33]; Paul et al. [28]
	Maintenance	Regular maintenance is required to ensure functionality, prevent pest issues, and prolong the lifespan of water features.	Routine cleaning and upkeep are essential to prevent problems and maintain water features' effectiveness and aesthetics.	Establish maintenance plans and schedules to ensure long-term functionality and cleanliness of water features.	Huzortey et al. [12]

	Safety	Proper safety measures must be in place to prevent accidents, especially in public and accessible water features.	Barriers, signage, and supervision are crucial to ensuring the safety of users around water features.	Design water features with safety measures to prevent accidents and ensure user safety, particularly in public spaces.	Huzortey et al. [12]
	Accessibility	Designing water features to be accessible ensures all users, including those with disabilities, can enjoy them.	Accessible design principles should be followed to accommodate diverse user needs and promote inclusivity.	Incorporate accessible design features into water installations to ensure inclusivity for all users.	Zhang et al. [42]

Table 2 Suggestion and consideration of urban water elements

Aspect	**Description**	**Key Studies**	**Case Studies**	**Design Suggestion**	**User Experience**	**Economic Considerations**
Psychological Impacts of Water	Water influences well-being through stress reduction, relaxation, enhanced creativity, emotional well-being, social interaction, mindfulness, and therapeutic benefits.	Thoma et al. [34], Zhang et al. [42], Song et al. [32], Djernis et al. [7], Mooventhan et al. [25]	Serene lakeshores and therapeutic gardens have shown stress reduction benefits.	Integrate natural water sounds and calming water features in design to enhance relaxation and creativity.	Water features in public spaces enhance mood and reduce stress.	Investing in water features can yield long-term mental health benefits, reducing healthcare costs and improving community satisfaction.
Physiological Impacts of Water	Water can lower heart rate and blood pressure, aid in pain management, improve sleep quality, and reduce stress hormones.	Coss & Keller [4], Mooventhan et al. [25], Billings et al. [2], Zhang et al. [42]	Hot springs and therapeutic pools offer documented pain relief and improved sleep quality.	Design water features to include elements for physical and psychological benefits, such as hot springs or cooling fountains.	Water therapy is highly effective for pain management and stress relief.	The initial investment in water therapy facilities can be offset by reduced healthcare costs and improved quality of life.

Previous Studies on Water Well-Being	Examines the role of water in urban environments, highlighting its benefits for mental health, stress reduction, social interaction, and overall well-being.	White M. et al. [40], Völker and Kistemann [38], Ma et al. [21], Ulrich et al. [36]	Urban waterfronts like the West Bund in Shanghai show enhanced community well-being.	Ensure water features in urban areas are accessible, visible, and integrated into community spaces.	Urban waterfronts foster social interaction and community building.	Waterfront developments can boost local economies by increasing property values and attracting tourism.
Integration of Water in Spaces	Discusses the impact of indoor and outdoor water features on urban well-being, including their role in cooling, biodiversity, recreation, aesthetics, and sustainability.	Thoma et al. [34], Seputra [31], Schneider et al. [30], Alikhani et al. [1], Tong et al. [35]	Splash pads and urban cooling features help combat heat and enhance public spaces.	Use water features to cool urban environments and enhance aesthetics; ensure maintenance and accessibility.	Indoor water features improve mental and thermal comfort; outdoor features enhance community health and aesthetics.	Water features can reduce cooling costs and improve property values while requiring ongoing maintenance investment.
Challenges and Considerations	Addresses sustainability, maintenance, safety, and accessibility of water features in urban design.	Teston et al. [33], Paul et al. [28], Huzortey et al. [12], Zhang et al. [42]	Case studies highlight the need for careful planning and maintenance of urban water features.	Plan for sustainable water use, regular maintenance, and safe, accessible designs.	Accessibility to water features impacts their use and associated well-being benefits.	Sustainable design and maintenance practices can lower long-term costs and improve community health.

5. Conclusion

The discourse surrounding the impact of water in urban environments emphasizes its role as a catalyst for holistic well-being. This research delves into the intricate relationship between the historical trajectory of water-centric infrastructure, the integration of water elements into architectural designs, and water accessibility in improving urban life quality. Integrating water elements into urban landscapes can mitigate stress, enhance mood, and foster a sense of well-being among urban dwellers. Moreover, the significance of water extends to broader societal and environmental dimensions,

offering solutions to challenges posed by rapid urbanization. Understanding the nuanced relationship between water and human experience is crucial for effective urban design interventions. Tailored approaches are necessary to maximize the positive effects of water elements while ensuring sustainability and inclusivity. As urbanization continues to shape the global landscape, prioritizing well-being in urban design becomes increasingly urgent, particularly in addressing challenges such as overcrowding, pollution, and social isolation. Water emerges as a powerful tool for reimagining urban environments as vibrant, inclusive, and sustainable spaces.

Limitations: Despite the promising findings, there are several limitations to this research. The applicability of water elements in urban design may vary based on specific climatic conditions and cultural contexts. For example, the benefits of water features in Malaysia's hot and humid climate may differ from those in temperate regions. Additionally, the research may not fully account for the economic constraints and practical challenges involved in implementing water-centric designs on a large scale. There is also a need for more comprehensive studies to explore the long-term sustainability and maintenance of urban water features.

Implications: The findings underscore the importance of incorporating water elements into urban planning to enhance individual well-being and address broader environmental and societal challenges. Effective integration of water features can lead to improved mental health, increased social cohesion, and enhanced ecological sustainability. Urban planners and policymakers should consider these benefits when designing and implementing water-centric interventions. However, it is crucial to balance the aesthetic and functional aspects of water features with practical considerations such as cost, maintenance, and environmental impact.

Future Recommendations: Future research should focus on conducting localized studies to assess the impact of water elements in diverse climatic and cultural settings. In Malaysia, for instance, research tailored to hot and humid conditions could provide insights into optimizing the comfort and effectiveness of water features. Additionally, exploring innovative and cost-effective design solutions can help address economic and practical challenges. Collaborative efforts between designers, policymakers, and communities are essential to ensure that water-rich environments are accessible and inclusive for all residents. By prioritizing equity and sustainability, future urban designs can leverage the full potential of water to create healthier, more resilient, and vibrant cities.

In summary, integrating water elements into urban design represents a transformative approach to creating healthier, more resilient, and more equitable cities. By leveraging the psychological, physiological, and ecological benefits of water, designers and policymakers can shape urban environments that enhance quality of life for all residents. Through collaborative, interdisciplinary efforts and attention to localized needs, cities can become nurturing and inspiring places to live, work, and thrive.

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