Water, Sanitation, and Hygiene in Urban Areas: A Review

Gabriela Souza [1], Cristina Santos [2,3,*] and Érico Lisboa [1]

1   Graduate Program in Development and Urban Environment, Universidade da Amazônia, Avenida Alcindo Cacela n° 287, Belém 66060-902, Pará, Brazil
2   Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal
3   CIIMAR—Interdisciplinary Centre of Marine and Environmental Research, University of Porto, 4450-208 Matosinhos, Portugal
*   Correspondence: csantos@fe.up.pt

Abstract

This paper provides a comprehensive bibliographic and bibliometric review of water, sanitation, and hygiene (WASH) in global urban areas, employing the Proknow-C methodology. The study categorizes WASH into four main themes: sustainability, urban areas, indicators and index, and urban planning, allowing for a detailed analysis of several multidimensional aspects. The review underscores the importance of providing basic infrastructure to adopt an integrated, sustainable, and socially inclusive approach, showcasing the resilience and adaptability of the WASH sector in tackling the dynamic challenges of urbanization. It is noticeable that the WASH area has undergone significant development, moving from a focus primarily on infrastructure to a more holistic approach. In general, the WASH framework is globally characterized by high irregularity/inequality in provision and access. The relationship between urban vulnerabilities and WASH is very clear, but also multifaceted and complex, and there is a crucial need to combine behavior change with infrastructure development while addressing economic challenges and prioritizing investments in WASH. The improvement of WASH conditions in urban areas should focus the interplay between urban development policies and the provision of WASH services, while focusing also on the role of multi-sectoral collaboration, stakeholder engagement, and policy implementation in overcoming barriers to effective WASH delivery.

Keywords: WASH; urban planning; Proknow-C methodology; sustainable development

1. Introduction

Access to clean and safe drinking water, adequate sanitation facilities, and proper hygiene practices is a fundamental human right, essential for sustaining health and achieving socioeconomic development. Collectively known as WASH (water, sanitation, and hygiene), these interrelated factors play a fundamental role in mitigating a multitude of health risks and supporting overall well-being within communities and nations [1]. The interrelated components of WASH function as a synergistic system: deficiencies in one domain inevitably compromise the others, magnifying risks to health, education, and economic productivity. For instance, poor hygiene practices can transform safely managed water supplies into vectors for disease and contaminated water sources can relegate the benefits of proper sanitation.

Despite noteworthy efforts by international organizations and governments, a substantial portion of the global population still faces severe challenges in accessing safe water sources, proper sanitation infrastructure, and hygiene knowledge. This persistent situation

has harsh consequences, particularly affecting vulnerable populations in low- and middle-income countries [2]. Inadequate access to clean water jeopardizes individual health and contributes to the spread of waterborne diseases such as cholera, dysentery, typhoid fever, and diarrheal diseases. It is estimated that nearly 2.2 billion people worldwide lack access to safely managed drinking water services, leading to approximately 432,000 preventable deaths each year. Similarly, poor sanitation facilities and practices compromise several sources of drinking water, and exacerbate the risk of infections, creating a vicious cycle that perpetuates poor health outcomes and hinders economic development [3]. On the other hand, and more recently, the COVID-19 pandemic has further emphasized the critical importance of WASH, especially in the aspect of hygiene practices (such as effective hand hygiene, including regular handwashing with soap) and access to functional sanitation facilities, which became indispensable preventive measures recommended by global health authorities to contain the transmission of the virus. Thus, the pandemic situation has underscored the urgent need for comprehensive WASH infrastructure and behavior change interventions, even in developed countries, to ensure societal resilience against infectious diseases [4].

Addressing WASH as the basis for the development of societies is a moral imperative and also a strategic investment. Enhancing WASH infrastructure and services paves the way for increased economic productivity, reduction in healthcare expenditures, and the empowerment of marginalized populations, leading to overall societal progress [4]. Beyond directly mitigating health risks, WASH interventions contribute to achieving several Sustainable Development Goals (SDG) outlined by the United Nations, such as Good Health and Well-being (SDG3), Clean Water and Sanitation (SDG6), Sustainable Cities and Communities (SDG11), and, indirectly, No Poverty (SDG1), Zero Hunger (SDG2), and Reduced Inequalities (SDG10), among others.

Bearing in mind the importance of this topic, this study conducts a thorough review of the literature, that elucidates the current challenges of achieving universal access to WASH, explores the multifaceted consequences of its absence, and highlights the compelling justifications for investing in comprehensive and sustainable WASH initiatives in urban areas. By critically analyzing and synthesizing existing research and knowledge on WASH, this study intends to provide a comprehensive understanding of the issues at hand. This, in turn, will enable policymakers, researchers, and practitioners to make informed decisions and develop evidence-based interventions and strategies to bridge the persistent gaps in WASH. Ultimately, the findings of this review of the literature will play a vital role in advancing global health and sustainable development by shaping future research directions, policy formulation, and program implementation in the field of WASH. To this end, this study strategically considers the topic of WASH as a single topic, without separating its different components, and considers the relationship between urban vulnerabilities and WASH, underscoring the paramount importance of addressing these challenges for the well-being of urban populations. The identification of vulnerabilities encompasses a comprehensive examination of factors, such as inadequate water supply, insufficient sanitation facilities, and poor hygiene practices, that can give rise to waterborne diseases and impact overall community health.

In sum, urban areas face unique challenges, including rapid population growth, informal settlements, and aging infrastructure, all of which contribute to increased vulnerabilities in WASH. By shedding light on these vulnerabilities, it is possible to highlight the urgency of implementing effective WASH interventions, fostering resilience in urban communities, and promoting equitable access to clean water and sanitation services for all residents.

2. Methodology

This research is characterized as exploratory and descriptive [5], as it promotes reflection and generates knowledge for researchers, aiming to understand the problem and to describe it systematically, in order to provide information that can serve the formulation of hypotheses and further investigations.

In this case, the review of WASH conditions in urban areas was conducted in accordance with the Constructivist-Knowledge Development Process (Proknow-C) [6]. Proknow-C is a widespread method in scientific circles and is composed of three main stages: selection of the article portfolio; bibliometric analysis; and systemic analysis [7]. Following its terms, in the first stage, a search for articles was carried out in databases (Science Direct, Scopus, and Web of Science) concerning the topic of interest. Articles aligned with the research topic were selected, observing the specificities of the population that was intended to be studied, in this case, urban residents. The second stage, composed of bibliometrics, intended to identify, among the articles in the portfolio, their relevance considering the following: the number of citations, the journals and authors that published the studies, and the most common keywords. The third stage consisted of a systemic analysis, through which an analysis of the content of the articles was carried out, using thematic axes that also help in the organization and construction of the literature review.

In view of the objectives set for this study, it is important to understand how urban planning and governance can enhance WASH conditions in urban areas by exploring the context of urban WASH, the role of urban planning in addressing its challenges, and the barriers hindering WASH improvements. In this scope, three main questions were stated in order to guide the intended analysis: (1) What are the WASH conditions in urban areas? (2) What is the relationship between WASH and urban planning? (3) What obstacles prevent WASH improvements in urban areas? Based in these questions, the research axes were then defined as follows: "Sustainability"; "Indices and indicators"; "Urban areas"; and "Urban planning and management". After that, a selection of 3 databases was made, resulting in the following: Science Direct, Scopus, and Web of Science. The last step was to establish the keywords and combinations of keywords to search in the selected databases, resulting in the following: "water sanitation and hygiene", and ["water sanitation and hygiene" and "WASH"].

Results from each database (a total of 5970 articles) were then imported into Microsoft Excel® and, to refine and manage the alignment of these articles to the research topic, the sequential steps presented in Figure 1 were performed. The topics considered as the exclusion criteria for each research axis were as follows: language (only articles in English, Portuguese, or Spanish were considered), the theme (different or incomplete approach to WASH; wrong population; not addressing urban areas), old publication dates (excluding articles before 2003), and type of document (only journal articles were considered).

At the end, 96 articles were selected. The use of this high number of references in the article is justified by the complex and multidisciplinary nature of the WASH topic. As a final stage, a full reading was performed, followed by a systematic review to identify the conditions of WASH in urban areas. In that process, the articles were divided into four categories, according to the thematic axis initially stipulated, and three subsections were created into each category.
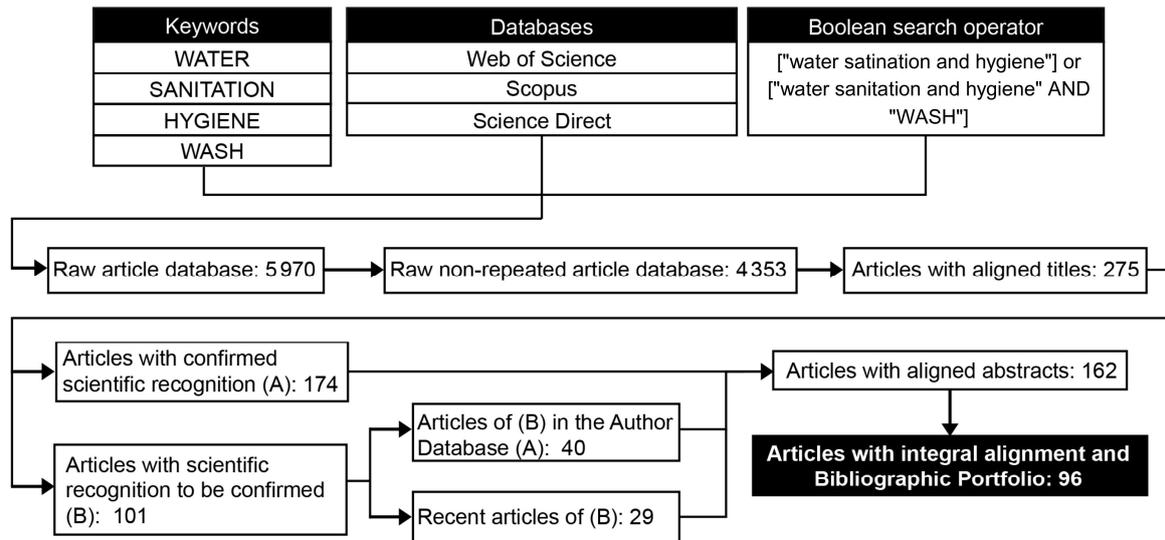
Keywords	Databases	Boolean search operator
WATER	Web of Science	["water satiation and hygiene"] or
SANITATION	Scopus	["water sanitation and hygiene" AND
HYGIENE	Science Direct	"WASH"]
WASH		

Raw article database: 5 970 → Raw non-repeated article database: 4 353 → Articles with aligned titles: 275

Articles with confirmed scientific recognition (A): 174

Articles with scientific recognition to be confirmed (B): 101

Articles of (B) in the Author Database (A): 40

Recent articles of (B): 29

Articles with aligned abstracts: 162

Articles with integral alignment and Bibliographic Portfolio: 96

Figure 1. Methodological flowchart.

3. Bibliometric Analysis

After selecting the relevant papers for the bibliographic portfolio (BP), the corresponding bibliometric analysis was performed, aiming to provide information through the analysis and quantification of its characteristics. Subsequently, the systemic analysis will be described, exploring the most-studied theories, variables, and future research opportunities.

To visualize the scientific interest in the research topic, Figure 2 shows the number of articles in the BP (a total of 96 papers, as presented previously) according to the year of publication. Between 2003 and 2011, there were no articles in the BP, either because they were not aligned with the researched topic or because they did not have sufficient scientific relevance for the analysis. Thus, the year 2012 marks the beginning of the interest in this subject in the scientific community. The cumulative sum of the articles shows a linear rise over the years which demonstrates a growing trend in publications related to the subject of WASH.
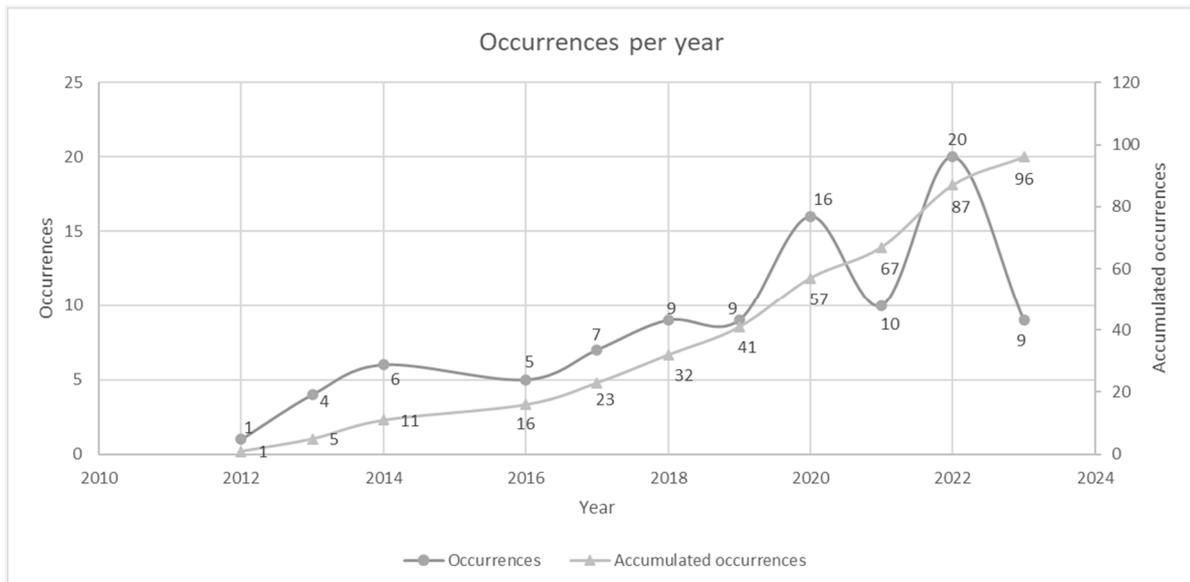
Figure 2. Occurrences per year.

It is important to point out the increasing number of articles from 2020 onwards, which have more citations compared to articles published before that year. A possible reason for that is the interconnection between WASH and the outbreak of the COVID-19 pandemic. The topic gained particular relevance in 2020, as personal hygiene emerged as a key factor in controlling the spread of the virus, and access to clean water and adequate sanitation was also directly linked to reducing the number of infections [8–12].

The five most cited papers reflect the situation of WASH in developing countries and the relationship between water infrastructures with cases of diarrhea and sanitation-related diseases. In addition, they address the attitudes and public policies necessary to achieve sustainability at the global level [13–17].

On the other hand, there are 52 different journals in the BP, and Figure 3 presents the 15 journals with more than 1 article. The most prominent journal to the subject is the *Journal of Water Sanitation and Hygiene for Development*, which is the source of 17 articles. This is due to the fact that the name of the journal coincides with the researched subject, so the focus of the journal is directly related to the topic of WASH. Other journals also deserve to be highlighted in the BP, as they have articles with high numbers of citations, including the *International Journal of Environmental Research and Public Health*, which appears in the third position with six articles, and the *Science of the Total Environment*, which appears in the fourth position with five articles. Regarding the relevance of the authors, it was noticed that only Saroj et al. [18,19] and Yates et al. [20,21] have more than one article included in the BP. This may be an indication that the topic of WASH is widespread among the scientific community, being investigated by several universities and researchers, with growing interest.
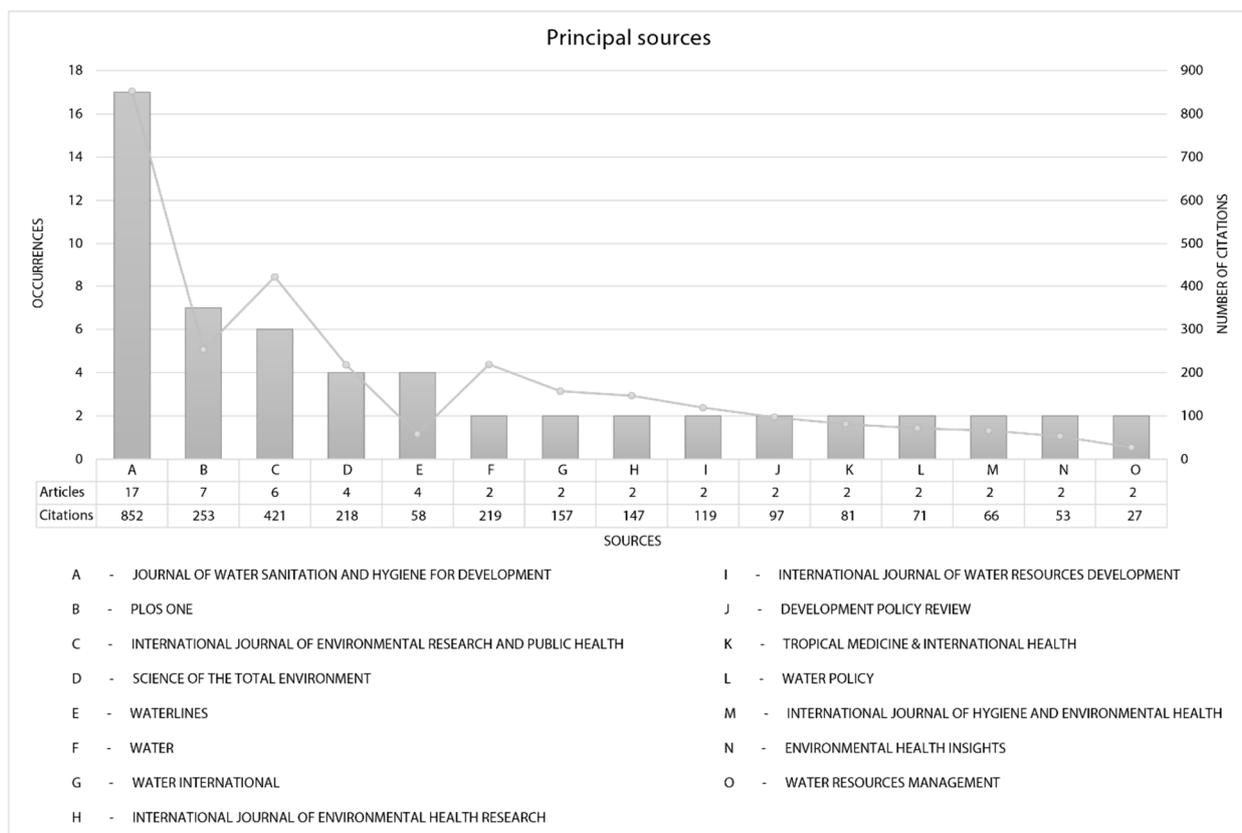

Principal sources

Sources	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Articles	17	7	6	4	4	2	2	2	2	2	2	2	2	2	2
Citations	852	253	421	218	58	219	157	147	119	97	81	71	66	53	27

A - JOURNAL OF WATER SANITATION AND HYGIENE FOR DEVELOPMENT

B - PLOS ONE

C - INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH

D - SCIENCE OF THE TOTAL ENVIRONMENT

E - WATERLINES

F - WATER

G - WATER INTERNATIONAL

H - INTERNATIONAL JOURNAL OF ENVIRONMENTAL HEALTH RESEARCH

I - INTERNATIONAL JOURNAL OF WATER RESOURCES DEVELOPMENT

J - DEVELOPMENT POLICY REVIEW

K - TROPICAL MEDICINE & INTERNATIONAL HEALTH

L - WATER POLICY

M - INTERNATIONAL JOURNAL OF HYGIENE AND ENVIRONMENTAL HEALTH

N - ENVIRONMENTAL HEALTH INSIGHTS

O - WATER RESOURCES MANAGEMENT

Figure 3. Principal sources.

Figure 4 shows a map, based on text data, that presents a term co-occurrence with title and abstracts of publications that make up the BP. Considering a threshold of terms with at least five occurrences, the result is the 102 most common keywords out of 2343 used in total. In the Figure 4, the greater the number of occurrences, the greater the weight of the term. The lines between the terms represent links between them: the shorter the distance between the nodes, the stronger the keywords' relationship. This analysis was performed using the open-source software VOSViewer (version 1.6.20). It is possible to see that the most used terms in BP are as follows: "sustainable development goals", "sector", "intervention", "practice", "survey", and "system". In addition, the least used terms from the 102 most common are "hygiene sector", "safe water", "value", "action" and "adoption". The concepts in yellow are related to Wash intervention, while those in red are more related to governance issues; those in green address the theme of sustainability, and those in blue address social aspects in developing countries. The identification of these terms is important for facilitating systematic information gathering and for defining the coherent literature review strategy.
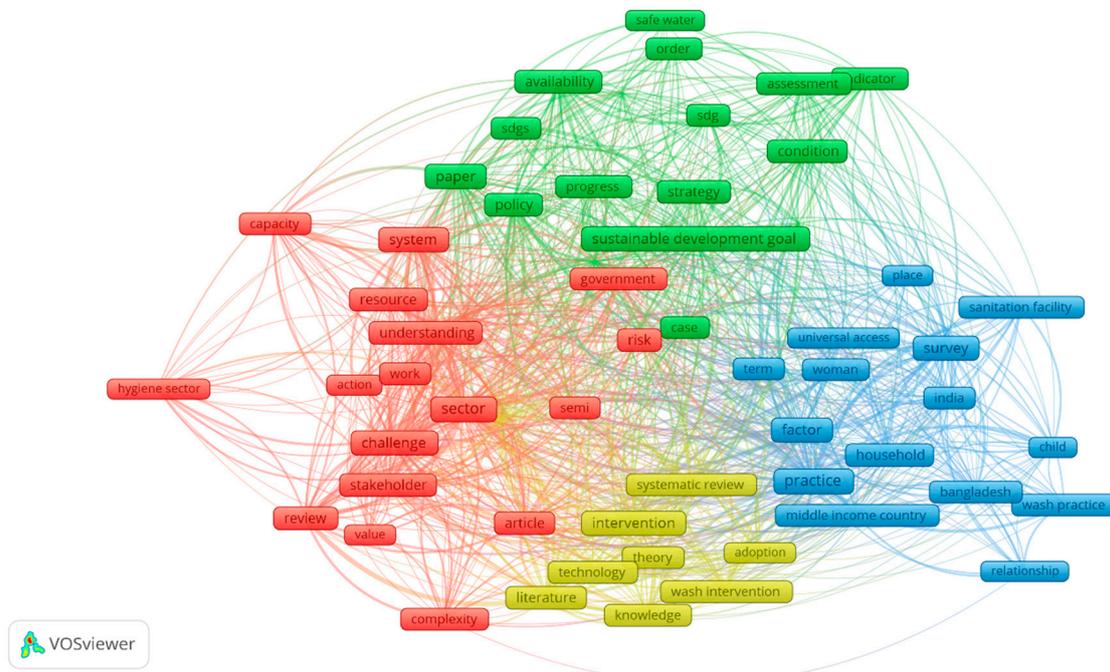

Figure 4. Map based co-occurrence title and abstract.

The occurrences of the terms were also analyzed each year, to know when the approaches on the researched subject began. In Figure 5, it is possible to infer that the themes related to sustainable development, such as the terms "SDG", "government", "case", and "progress", in addition to the approaches on "developing countries" and "WASH practices", come from studies starting in 2020. While terms aimed at "literature review", "WASH interventions", and "identification of challenges" are subjects addressed since 2018. Thus, this bibliometric analysis shows that, until 2019, WASH studies used a more theoretical approach and identified bottlenecks and challenges. Over the years, more in-depth discussion of issues related to advocacy, identification of stakeholders, and practices have become more frequent. Today, the most recent studies seek to introduce issues of sustainable development, sectorization of WASH, and stimulation of WASH practices.

Figure 5. Terms association.

Finally, the most common keywords in the bibliographic data were analyzed, including the co-occurrence of all keywords in the BP. Results show a total of 411 occurrences, of which 228 (55%) are distinct keywords. Figure 6 presents the ones with a frequency above three, and it can be seen that the most frequent are water, WASH, and health. These results may be due to (1) the importance that access to clean and safe drinking water is having to prevent waterborne diseases and ensure general well-being, and also (2) because adequate sanitation facilities are vital for maintaining hygiene practices and reducing the spread of disease, especially in densely populated areas.

Figure 6. Keywords occurrence.

4. Systemic Analysis

By a deeper analysis of articles related to water sanitation and hygiene, it is possible to understand the importance of WASH practices and their impact in urban areas. This was the core of this work. The data were tabulated to identify trends among the studies, in addition to contextualizing and synthesizing results. As previously referenced, after reading the full articles they were separated according to the referred thematic axes. Each category was then divided into three subcategories (Figure 7), in order to assist the process of relating the articles to each other and understand the main trends in addressing the topic of WASH.

Figure 7. Thematic axes.

The categorization was essential for the organization of the literature review, because, although the articles presented different main subjects, they ended up being organized in a balanced way. The largest category contains 27 articles (28%) and the smallest contains 22 articles (23%), which highlights the coverage of the selected BP and the relationship of the subjects between each other.

Inside each category, the subdivisions helped to understand the evolution of the different aspects that make up this research field. The average of each subcategory was seven articles, where the largest was urban infrastructure (12 articles) and the lowest was urban technologies (four articles), both of which are part of the "Urban Areas" category.

4.1. Sustainability

4.1.1. Sustainable Development Goals

WASH is indeed closely related to sustainability and plays a crucial role in achieving the Sustainable Development Goals (SDG), especially SDG6, which refers to ensuring clean water and sanitation for all. The work of Sarkar & Bharat [22] and Lue et al. [23] highlights the main difficulties in achieving the sustainable development goals in the area of WASH, using a review of the literature and semi-structured interviews with researchers from small- and medium-sized developing countries. Okewu et al. [24] propose a technology to

monitor the evolution of SDG 6 in a community in Nigeria, through software that supports decision-making by identifying areas of open defecation.

The Theory of Behavior Change is covered in three SGD-related articles. Yasmin et al. [25] addresses this issue by relating it to humanitarian emergencies and refugees at the global level. Martin et al. [26], through a review of the literature, established a comparison between WASH interventions and their impacts on changing the lives of the population, concluding that there is a need to develop behavior-change models that emphasize factors related to sustainable development that are different from the models initially addressed.

Afzal et al. [27] related the consequences of knowledge, attitude, and practice (KAP) with daily WASH practices to achieve sustainable community development. Therefore, this theory addressed by these authors is considered fundamental in the search for a sustainable future and solving multidimensional community problems, which requires large-scale changes in human behavior with regard to their health, social and physical activities, and long-standing habits.

Some articles highlight key strategies, such as water conservation, climate resilience, partnerships and collaboration, and monitoring and evaluation, concluding that WASH interventions can contribute significantly to the achievement of the sustainable development goals. However, one of the key economic issues related to WASH is the cost of implementing and maintaining WASH interventions. The initial investment in infrastructure development, such as building water supply systems and sanitation facilities, can be substantial. By addressing these economic challenges and prioritizing investments in WASH, it is possible to achieve sustainable development goals while promoting economic growth and improving the well-being of communities [28–30].

4.1.2. Climate Change

Advocacy for WASH in the context of climate change involves a multi-faceted approach. In the works of Alhassan & Hadwen et al. [31], Mora-Alvarado & Portuguez-Barquero [32] and Kohlitz et al. [33], analyses are carried out between vulnerability and the specific challenges that countries face in relation to WASH and climate change. This analysis helps to identify the most vulnerable populations and to develop targeted interventions to address their needs. Partnerships and collaboration among governments, NGO, communities, and other stakeholders are essential for achieving sustainability objectives in a climatically uncertain future. This collaboration mobilizes resources, shares knowledge, and implements effective WASH interventions.

In emergency situations and natural disasters, rapid response and coordination among various stakeholders are essential to ensure the immediate provision of clean water, sanitation facilities, and hygiene promotion. This means that when unforeseen events or crises occur, such as earthquakes, floods, or conflicts, the need for sustainability interventions becomes heightened [20,34]. In addition, climate migrants are subject to substantial water scarcity, insufficient drainage systems, lack of sanitation facilities, tube wells, and bathing facilities, inadequate hygiene management, lack of essential skills needed for urban jobs, and low wages and lack of income [12].

Yates et al. [21] states that understanding the specific challenges posed by climate risks, such as increased occurrences of flooding or prolonged periods of drought, is essential for tailoring WASH strategies to effectively achieve sustainable development. This proactive approach not only helps strengthen the resilience of ecosystems but also plays a significant role in mitigating the potential impact of climate-related disasters on vulnerable communities [35]. Furthermore, by collecting and analyzing relevant data, organizations can identify trends and patterns that indicate the effects of climate variability on WASH

interventions. This information can then be used to support decision-making processes and adapt strategies to address the evolving challenges posed by climate change [16].

4.1.3. Health

The intersection of WASH initiatives and health is vital for sustainability. Improved water and sanitation systems enhance public health and promote behavior change by preventing diseases and supporting overall well-being [14,36]. Case studies presented by Im et al. [37] and Regassa et al. [38] show that household disease transmission in urban areas is influenced by water sources and WASH practices, with improved infrastructure significantly reducing risks. On the other hand, the research conducted by Exum et al. [39] and by Prinsloo et al. [11] highlights how sanitation facilities impact microbial loads in homes, contributing to fecal pathogen transmission. Better WASH infrastructure not only reduces health risks but also improves socioeconomic conditions, as evidenced historically through advancements in the WASH sector and their positive impacts on global health [17,40]. Thus, risk analysis and mitigation strategies are considered essential for addressing health threats related to WASH.

4.2. Urban Areass
4.2.1. Behavior Change

Behavior change is vital for achieving sustainability, as WASH directly influences public health and broader well-being, aligning with SDG6 [41]. Improved sanitation facilities and waste management systems reduce water contamination risks in urban areas, but education and awareness initiatives are fundamental to assure their effectiveness [42]. Simple daily habits like proper hygiene practices, such as handwashing with soap and safe water storage, are essential to reduce waterborne diseases and improve community health. Integrating behavior change strategies into emergency relief efforts addresses immediate needs while fostering long-term sustainability [10,43]. Also, studies such as the one presented by Kang & Aldstadt [44] demonstrate the significant impact of water and hygiene interventions in reducing intestinal infections in resource-limited settings. Thus, integrating WASH into urban planning ensures sustainable access to sanitation, addressing population growth and enhancing resilience against climate change. But combining behavior change with infrastructure development is a key factor for long-term WASH sustainability in urban settings [45].

4.2.2. Urban Infrastructure

The works of Anthonj et al. [46], Rhodes-Dicker et al. [47], Jiménez et al. [48], and Nimbannavar & Mane [49] results in challenging contexts such as humanitarian crises, marginalized communities, and resource-constrained environments that are the hardest to reach with conventional WASH approaches. Access to WASH services in challenging contexts is complex, and ensuring that those communities are not left behind in pursuit of SDG6 means that intersecting complexities affecting WASH access in these contexts need to be considered. The United Nations uses the term "leaving no one behind" to re-enforce that people with disabilities experience greater difficulties in accessing sanitation facilities and practicing hygienic behaviors than their peers without disabilities [50,51]. Currently, WASH governance structure lacks the financial capacity and the budgetary/administrative authority to accommodate local interests not covered through the external/donor support framework. This means that, to achieve SDG6, it is essential to address the specific challenges faced by vulnerable populations. These may include people living in remote areas, those affected by conflicts or natural disasters, women and girls, people with disabilities, and the elderly. In addition to addressing financial capacity and administrative authority,

enhancing WASH governance structures should prioritize infrastructure development to ensure equitable access, particularly for vulnerable populations [52].

Jagnoor et al. [53] established that a lack of WASH infrastructure can also be responsible for cases of drownings in open wells and surface catchments, as users use faulty and dangerous platforms. They found that 66% of drownings occurred in ponds, which are the main source of water for homes without a private water supply. Similarly, 56% of drownings in Bangladesh were found to occur while washing or bathing.

WASH initiatives, together with a risk-integrating context, are essential to guarantee the resilience and effectiveness of government initiatives. By systematically assessing potential hazards and vulnerabilities, stakeholders can develop and implement strategies to mitigate risks associated with WASH issues. Furthermore, the WASH framework is characterized by high irregularity/inequality in provision and access, a high proportion of non-functional infrastructure, low coverage of services for vulnerable locations and poor individuals, a high incidence of self-help among citizens, and the uncompromising use of market-based solutions [54,55].

Studies involving the analysis of WASH services in urban slums reveal gaps in WASH practices, in addition to lack of coverage. Shared WASH facilities in communities require sustainable changes in behavioral practices for safe and appropriate use [56]. Improved sanitation and drinking water sources play a crucial role in preventing childhood diarrhea and waterborne illnesses, but in rural areas, despite having toilets, many residents choose to urinate outside due to habitual behaviors and sociocultural factors, as can also be highlighted in Section 4.2.1. Community and home toilet construction is an effective strategy for addressing subpar sanitation habits, but health education is essential for preventing open defecation [57].

4.2.3. Urban Technology

In the work of Murthy et al. [58], smartphones were presented as a tool for instant access to information, allowing remote communities to share and receive real-time updates on water quality, sanitation practices, and hygiene guidelines. This accessibility promotes a more informed and receptive population. Once the use of smartphones is strongly intertwined with social media platforms, WASH organizations can leverage these channels to disseminate information, raise awareness, and engage communities in discussions on best practices in water conservation, sanitation, and hygiene. In addition, smartphones play a crucial role in streamlining the application of questionnaires and conducting quality analysis in WASH initiatives, such as the Joint Monitoring Program. The literature reviews on disaster risk reduction, resilience, public–private partnerships, and sustainability assessment tools for WASH projects were prepared by Johannessen et al. [59] and Win et al. [60]. Their search identified the need to strengthen collaboration with local government to ensure that communities receive post-implementation support from local authorities, to encourage community participation and promote a sense of ownership, and to build the capacity of community bodies to monitor water and sanitation facilities. The studies propose new approaches to strengthen the relationship between government and population, in addition to suggesting strategies for public and private investments

Also, the use of Big Data analytics tools is currently being conducted by collecting different types and formats of data, being a preferred tool for collecting data for the WASH sector through the help of mobile phones (while others are collected from sensors, applications, and use of geographic information systems). In the age of Big Data, it is possible to use advanced data acquisition, management, and analysis mechanisms. In this way, Big Data analytics can be very useful for monitoring, visualizing, and using data

for equity and sustainability, post-implementation monitoring, and accountability of the WASH sector [61].

4.3. Indicators and Indices

In Sierra Leone, a questionnaire-based study made by Sesay et al. [62], and focused on KAP related to WASH systems, reveals a high proportion of households with access to improved sources of WASH facilities. However, in India [20,21], India's Human Development Surveys demonstrate inequalities in WASH performance, emphasizing economic, educational, and socio-religious disparities within and between cities.

Global initiatives, such as the United Nations Inter-Agency and Expert Group on SDG Indicators [63] and the Joint Monitoring Program on Water Supply and Sanitation [11,64], employ statistical data analysis to assess the proportion of populations using safely managed water and sanitation services. In this scope, a high range of methodologies are being covered by several studies, including semi-structured interviews [65], documentation from local authorities [66], systematic reviews [67,68], and case studies [69]. The Water Poverty Index in Argentina, for example, incorporates several dimensions such as availability, infrastructure, coverage, access, planning, participation, use, impact, and satisfaction [70]. Also, Multicriteria Decision Analysis is applied in Kenya [51] to prioritize factors influencing water quality and sanitation facilities, providing valuable information for WASH interventions. A questionnaire made by Kansal et al., also in Sierra Leone [71], considered financial, institutional, administrative, and technical aspects, contributing to the estimation of a Human Development Index. The studies also delve into vulnerability and risk analysis. In Mongolia [72], a KAP questionnaire addresses the hazards transmitted by WASH, revealing correlations between poor infrastructure and a low standard of living. In Ethiopia [70], a water questionnaire investigates WASH systems and domestic environments, shedding light on practices in pastoralist communities. The Census and the National Survey of Family Health in India [73] employ indices to measure poverty in terms of clean water, poverty in terms of sanitation, and poverty in terms of hygiene. Bangladesh, in turn, uses a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to understand the women-specific SWOT of slum dwellers with disabilities, emphasizing the need for inclusive management approaches [74].

It is noticeable that there are a wide range of indices that are being used to assess the cumulative impact of academic output and performance in the field of WASH research [75]. Overall, these diverse methodologies and indices underline the complexity of the WASH sector, emphasizing the need for comprehensive and context-specific approaches to address the numerous challenges associated with WASH practices in different regions and communities.

4.4. Urban Planning and Management

4.4.1. Urban Planning

Engaging in partnerships and promoting multi-stakeholder collaboration can help mobilize resources, share knowledge, and implement effective WASH interventions. The initial step in this collaborative process may involve interviews with representatives from organizations responsible for WASH, which allows for a comprehensive understanding of their perspectives, challenges, and contributions [76]. Then, the identification of key actors is essential in mapping out the network of individuals and entities involved in WASH initiatives. This identification process not only helps in understanding the current context but also lays the groundwork for targeted and coordinated efforts [10,17,77].

Identifying and addressing management failures is important for urban planning considering WASH: analyzing the shortcomings in governance and management practices

provides valuable insights into areas that require improvement. This, in turn, allows the development of strategies and policies aimed at enhancing the efficiency and effectiveness of WASH interventions [78]. Companies play a significant role in the development of WASH and in understanding their role in the creation of sustainable urban systems. Thus, identifying these various players in the sector and assessing their contributions helps in ensuring a well-rounded and integrated approach to address water and sanitation challenges [79,80].

In sum, effective urban planning for WASH requires a holistic and collaborative approach that involves partnerships, actor identification, addressing management failures, recognizing the role of companies, understanding the sector's players, identifying stakeholders, and engaging in advocacy. Stakeholder identification is a fundamental step in urban planning for WASH. Recognizing the diverse range of stakeholders involved and understanding their interests, capacities, and influence is essential for developing inclusive and equitable strategies. Additionally, advocacy initiatives can bridge gaps between various actors and promote behavioral changes that are conducive to sustainable WASH practices [81,82].

4.4.2. Assistance in Decision-Making

Effective decision-making, planning, and management are critical in navigating WASH initiatives. Gosling et al. [83] emphasize the importance of practical experience and robust project documentation for understanding WASH complexities, while Perez-Foguet & Giné-Garriga [84] highlight comprehensive approaches to project analysis. Chirgwin et al. [13] address gaps in WASH research, advocating for decision support systems, data analysis, and participatory methods to ensure evidence-based decisions tailored to specific regional contexts.

In their turn, Wells et al. [85] demonstrate the interconnectedness of monitoring, learning, and capacity development in WASH, showing how effective monitoring fosters informed decision-making and learning. Okolie et al. [86] and Gelting et al. [87] focus on the challenges of WASH financing, urban legislation, and bottlenecks, providing strategies to enhance financial sustainability and regulatory frameworks.

It is important to note the importance of stakeholder engagement, as highlighted by Mattos et al. [88] and Taylor et al. [89], which is essential for inclusive WASH projects. Involving diverse perspectives through questionnaires and participatory processes strengthens decision-making and ensures the effectiveness of WASH initiatives.

4.4.3. WASH Practices

The assessment of WASH practices involves a thorough examination of water uses and programs developed. Understanding the diverse applications of water and the evolution of targeted programs is crucial in addressing the intricate challenges within the WASH domain [90]. An essential step in this exploration is the division of barriers into physical, institutional, and social categories. Examining the relationship of disabled people to WASH is particularly critical, involving interviews on environmental/physical barriers, social barriers, institutional barriers, and the ones associated with body function. This approach facilitates a nuanced understanding of the challenges faced by different demographic groups in accessing and benefiting from WASH services [91].

Identifying barriers and facilitators is a multifaceted process that should highlight key points grouped into relevant WASH themes, and promote self-reflection and engagement with a purpose. This is crucial for fostering a sense of ownership and responsibility among individuals and communities. Considering sustainability at all scales and contexts, generating ideas for individual and sectoral actions, and reflecting on the power of, and

considerations for, co-producing future processes, are integral components of this approach. Group debates can be considered as a platform for collaborative discussion and for the generation of innovative solutions [92,93].

In this scope, exploring public financing in WASH at national and subnational levels in Vietnam offered valuable insights into structuring and writing articles on this topic [94], with potential implications for similar contexts like Brazil. The identification of stakeholders is, also in this context, essential to understand the dynamics of WASH financing and ensure the equitable distribution of resources.

The implementation of science through the literature review and urban planning questions adds a scholarly dimension to the study of WASH practices. Identification of such policies in Africa and Asia, with a focus on barriers in environments related to children and adolescents, programs, projects, and socioeconomic data analysis, provides a comprehensive overview of the policy framework. This examination is critical for devising strategies that address the specific needs of vulnerable populations and contribute to sustainable WASH practices [95,96].

5. Discussion

This bibliometric analysis shows that, until 2019, WASH studies used a more theoretical approach and identified bottlenecks and challenges. Over the years, more in-depth discussion of issues related to advocacy, identification of stakeholders, and practices have become more frequent. Today, the most recent studies seek to introduce issues of sustainable development, sectorization of WASH, and stimulation of its practices. It should be noted that, from 2020 onwards, there has been an increasing number of articles, and that the five most cited papers reflect the situation of WASH in developing countries and the relationship between the infrastructure and health issues.

Regarding the goal of this bibliographic review, the adopted methodology, and the resulting systematic analysis, it is now possible to identify the key aspects related to the proposed research questions:

1. *WASH conditions in urban areas*. Studies show that, in the context of rapidly growing urban areas, particularly in developing countries, the relationship between urban vulnerabilities and WASH is very clear, but also multifaceted and complex. Vulnerabilities often arise from a combination of socio-economic disparities, environmental hazards, and systemic governance failures that compromise access to essential services like clean water, proper sanitation, and hygiene. Urban vulnerabilities are thus deeply intertwined with inadequate water supply and insufficient sanitation facilities. Informal settlements, which often house a significant portion of urban populations in many cities, are particularly affected by the lack of infrastructure. Particularly in these contexts, the absence of reliable water sources or sewage systems heightens the risk of water contamination, facilitating the spread of waterborne diseases like cholera, typhoid, and dysentery. Rapid population growth further exacerbates these pressures, overwhelming already limited resources and infrastructure. Furthermore, informal settlements often lack adequate regulatory oversight, reducing accountability and the effectiveness of service delivery. This leads to irregularity and inequality in WASH provision and access. Studies also show that gender dimensions are also critical: women and girls often bear the brunt of inadequate WASH services, as they are primarily responsible for water collection and household hygiene, exposing them to safety risks and limiting opportunities for education and economic participation. In urban areas, climate change and environmental degradation will add further complexity. Increasingly erratic rainfall patterns, flooding, and water scarcity can disrupt existing WASH systems, disproportionately affecting vulnerable urban populations.

This underscores the need for resilient urban planning and adaptive strategies that integrate WASH considerations into broader environmental and infrastructural policies. Addressing these challenges requires context-specific, holistic approaches. Diverse methodologies and indices in the WASH sector highlight local disparities and vulnerabilities, emphasizing that one-size-fits-all solutions are insufficient. Policies must prioritize equity, inclusivity, and participatory governance, ensuring that marginalized communities are not left behind in the pursuit of the Sustainable Development Goals. By linking WASH improvements with social protection, health, and urban planning strategies, cities can strengthen the resilience of vulnerable populations while promoting sustainable urban development.

2. *The relationship between WASH and urban planning.* Aging infrastructure further deepens the urban vulnerabilities in the WASH sector. Many cities, particularly in the Global South, inherited infrastructure that was never designed to accommodate current population densities or urban expansion. Over time, the deterioration of pipes, sewage systems, and wastewater treatment plants leads to frequent breakdowns, inefficiencies, and service interruptions. Consequently, even when water supply and sanitation systems exist, they often fail to meet population needs, resulting in intermittent water access, unreliable sanitation, and heightened exposure to waterborne diseases. These infrastructure failures disproportionately affect marginalized communities, rising inequalities and susceptibility to poor health outcomes. In many vulnerable urban settings, residents may not have access to the resources necessary for proper hygiene, such as soap, clean water for handwashing, or adequate facilities for waste disposal. Coupled with insufficient hygiene education, this perpetuates cycles of poor health, particularly among children, the elderly, and other high-risk populations. Thus, urban planning must prioritize the improvement and modernization of water and sanitation systems to enhance public health, promote behavioral change, and prevent disease. Risk analysis and mitigation strategies are essential, focusing on the identification of the most vulnerable populations and the development of targeted interventions. In this scope, risk analysis and mitigation strategies are essential, considering the identification of the most vulnerable populations and developing targeted interventions to address their needs. In fact, mapping sector actors and assessing their roles ensures a coordinated, integrated approach, while recognizing physical, institutional, and social barriers will highlight opportunities for innovation. Investments in resilient and adaptive infrastructure—supported by inclusive governance, community engagement, and technological innovation—can address both current deficiencies and future urban growth pressures. By linking infrastructure improvements with health promotion, education, and social policies, cities can build WASH systems that are equitable, sustainable, and capable of supporting the well-being of all urban residents.

3. *Obstacles that prevent WASH improvements in urban areas.* The hypothesis that urban vulnerabilities significantly influence WASH conditions, approached by several researchers, underscores the urgency of addressing these challenges for the health and well-being of urban populations. The identification of these vulnerabilities highlights the urgent need for targeted, context-specific, and effective WASH interventions. Mitigating the risks associated with urban vulnerabilities requires integrated approaches that tackle the root causes of inadequate water, sanitation, and hygiene. Addressing economic constraints and prioritizing investments in resilient infrastructure—such as improved water storage systems, upgraded sanitation facilities, and decentralized sanitation models—can reduce pressure on existing systems and enhance service reliability. Moreover, addressing urban vulnerabilities requires a multi-sectoral approach, which not only includes improving water and sanitation infrastructure but

also ensures equitable access to services for marginalized groups, including informal settlements, women, children, and the elderly. However, building resilience in urban communities goes beyond infrastructure improvements: it requires developing local capacity to manage and maintain WASH services effectively. Additionally, policies should prioritize inclusive governance that guarantees equitable access to water and sanitation, regardless of socio-economic status, while fostering accountability, collaboration, and community engagement. Integrating WASH interventions with broader urban planning, health, and social policies enhances the effectiveness of these measures. By addressing urban vulnerabilities systematically, cities can reduce the burden of waterborne diseases, improve public health outcomes, and ensure that all residents enjoy reliable access to safe water and sanitation services.

4. Overcoming WASH challenges in vulnerable urban areas requires investments in resilient and innovative infrastructure, including the modernization of water and sanitation networks, continuous maintenance, decentralized systems, and water reuse technologies. To move forward in urban planning and governance to enhance WASH conditions in urban areas, it is imperative to embrace technological advancements that can enhance data collection, analysis, and monitoring efforts within the WASH sector, facilitating more targeted interventions and informed decision-making. Leveraging existing databases, particularly those focusing on SDG and climate change, can provide valuable insights into the intersections between WASH, environmental sustainability, and resilience in urban areas. To this end, ensuring equity and inclusion is critical, providing access to water and sanitation services for marginalized populations, such as residents of informal settlements, women, children, and the elderly. Also, community capacity building, hygiene education, and participatory governance strengthen system maintenance and the sustainability of interventions. Finally, a greater effort on adequate financing policies and subsidies, combined with transparency and accountability mechanisms, must be integrated in any strategy to promote WASH.

6. Conclusions

This structured review presents a comprehensive exploration of WASH in urban areas, focusing on sustainable development, indices and indicators, and urban planning and management. It is noticeable that the WASH area has undergone significant development, moving from a focus primarily on infrastructure to a more holistic approach. The selected portfolio presents the global movement of integration between WASH and current issues, such as the use of data management systems, geoprocessing, attention to climate change, and the global concern for health, greatly impacted by WASH.

In summary, studies show that WASH conditions in urban areas are critical yet complex, especially in rapidly growing cities in developing countries. Vulnerabilities stem from socio-economic disparities, environmental risks, and systemic failures, compromising access to clean water, sanitation, and hygiene. There is a crucial need to combine behavior change with infrastructure development, while addressing economic challenges and prioritizing investments in WASH. It is clear that improved water and sanitation systems enhance public health and promote behavior change by preventing diseases and supporting overall well-being. So, addressing these challenges requires modernizing infrastructure, integrating risk analysis, and designing targeted interventions for the most vulnerable. For that, a coordinated approach—recognizing the diverse range of stakeholders involved and understanding their interests, capacities, and influence—is essential for developing inclusive and equitable strategies that can be supported by effective monitoring plans. Bringing

together physical, institutional, and social dimensions can reduce inequalities, strengthen resilience, and ensure WASH systems support urban well-being and sustainable growth.

The portfolio demonstrates that better WASH infrastructure not only reduces health risks but also improves socioeconomic conditions. Future research, related to the improvement of WASH in urban areas, should focus on examining the interplay between urban development policies and the provision of WASH services. This could involve exploring case studies of cities that have successfully integrated WASH improvements within urban planning frameworks and identifying key governance mechanisms that have driven these changes. Additionally, it is important to analyze the role of multi-sectoral collaboration, stakeholder engagement, and policy implementation in overcoming barriers to effective WASH delivery. Forthcoming studies should also evaluate the impact of specific urban planning models on the sustainability of WASH infrastructure and services, with an emphasis on equity, accessibility, and resilience to climate change. Research could further explore innovative financing mechanisms, such as public–private partnerships and community-driven initiatives, that enable scalable and cost-effective WASH solutions. Understanding the social and behavioral dimensions of water, sanitation, and hygiene— such as community perceptions, cultural practices, and educational interventions—will be critical to ensure the long-term adoption and proper use of WASH services. The current assessment of WASH in urban areas is based on a varied system of indicators used for other purposes, so it is also essential to develop a versatile and effective methodology, based on specific indices for WASH, that can effectively reproduce the situation of a given urban area and provide continuous monitoring. Such a methodology should integrate spatial analysis, real-time data collection, and predictive modeling to anticipate emerging challenges, including population growth, urban densification, and climate-related stresses. By combining quantitative metrics with qualitative insights, future research can provide a holistic understanding of urban WASH dynamics and inform evidence-based policies that promote inclusive, resilient, and sustainable urban environments.

A continued dedication to research, innovation, and collaborative efforts is fundamental to shape a future where access to water, sanitation, and hygiene is not merely a fundamental right but also serves as a roadmap for achieving sustainable urban development globally. This emphasizes the necessity of ongoing commitment to addressing the multifaceted challenges of WASH in urban areas to ensure equitable and sustainable outcomes for all urban residents.

Abbreviations

The following abbreviations are used in this manuscript:

SDG	Sustainable Development Goals
WASH	Water, Sanitation and Hygiene
KAP	knowledge, attitude and practice

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