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ADOPTING URBAN SYMBIOSIS FOR SUSTAINABLE URBAN WATER REDUCTION AND MANAGEMENT: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

This research aims to explore the feasibility of adopting urban symbiosis for sustainable urban water reduction and management through a bibliometric analysis of key literature. A Scopus-based systematic review was conducted to analyse journal articles related to urban symbiosis, water management, and water reduction, with a focus on their intersection towards achieving sustainability. The outcomes of the systematic review were analysed using bibliometric techniques to examine the evolution of publications, identify leading journals, and determine the authors and countries which have published the most papers on the topic. The research also conceptualised the benefits, barriers, and enablers associated with adopting urban symbiosis for water reduction and management. The findings of this study contribute to a deeper understanding of the potential implications and practical implications of urban symbiosis in the context of sustainable water management. The study contributes to the knowledge of the potential of urban symbiosis in addressing the challenges of water management in urban areas and gives insights to policymakers, urban planners, and practitioners interested in implementing sustainable water management practices in urban areas.

Keywords: *Barriers, Benefits, Urban Symbiosis, Water Management, Water Reduction.*

1. INTRODUCTION

Water scarcity is one of the most critical issues of the twenty-first century (Food and Agriculture Organization [FAO], 2018). Water is scarcity when the demand for fresh water in a particular area exceeds to water supply (Food and Agriculture Organization (FAO), 2012). Water scarcity refers to the condition of a lack of water supply for both human and environmental uses, and it is a severe and expanding issue on a global scale (White, 2014).

Four billion people out of the whole world's population face water scarcity once annually and half a billion people face water scarcity throughout the year (Gao et al., 2018). Moreover, water scarcity affected more than three billion people in 2021 (Carbon Disclosure Project [CDP], 2018). Half of the world's population would be living in water-stressed areas by 2025 (World Health Organization [WHO], 2019). By 2050, the world's

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population is expected to reach around nine billion people (Srinivasan et al., 2012). However, water consumption has risen twice the global population growth rate (Project World Impact [PWI], 2021). By 2050, most of the three billion additional people will live in developing countries, mainly in areas where water supplies are already depleted and increasingly in cities with inadequate water and additional water requirements (CDP, 2018). According to the authors, water scarcity will be in the future.

Climatic changes, water pollution, population growth and deforestation are some of the major reasons for water scarcity (Ellison et al., 2017; Porkka et al., 2016; Srinivasan et al., 2012). Climatic changes can affect water supply by changing precipitation and demand patterns (United Nation Environment Programme [UNEP], 2011). Different demography, political-economic, social, and technological developments, global energy consumption, developments in construction, GHG emissions and pollutants are the reasons for climatic changes (Alley et al., 2003). Water pollution is the consequence that makes water unfit for human consumption (Solar Impulse Foundation [SIF], 2021). However, many factors contribute to water pollution, including domestic sewage, industrial wastewater, stormwater runoff, septic tank water and agricultural practices (Chowdhary et al., 2019). As a result of population growth, food production has risen; as a result, water scarcity has increased significantly (Porkka et al., 2016). Ellison et al. (2017) stated that increased deforestation is expected to have the most significant impact on land-atmosphere interactions, resulting in less rain and increasing water scarcity.

Water management and water reduction are two strategies to reduce water scarcity (World Wide Fund [WWF], 2023). Many advantages for reducing water scarcity and enhancing water management in urban areas can be achieved through urban symbiosis (Estévez et al., 2022). Urban symbiosis can contribute to the creation of more sustainable and resilient cities by encouraging the reuse of wastewater and the optimal use of water resources(Estévez et al., 2022).

2. LITERATURE REVIEW

2.1 URBAN SYMBIOSIS

Urban symbiosis is a cooperative relationship between various urban actors (such as households, commercials, and institutions) that entails the exchange of resources and services for the benefit of both parties to increase resource efficiency and water efficiency and promote sustainability (Mulder, 2021). As an extended concept of urban symbiosis, which is an expanded idea of industrial symbiosis, investigates synergies in urban and industrial areas by converting municipal solid waste into industrial space and using industries to supply living resources, such as waste heat and hot water (Sun et al., 2017). Urban symbiosis is seen from a geographical perspective, optimises the regional metabolic network by allocating resources and infrastructures, hence minimising resource consumption, emissions and coordinating the interaction of industry with urban development (Sun et al., 2017).

2.2 THE CONCEPT OF URBAN SYMBIOSIS FOR WATER REDUCTION AND MANAGEMENT

A promising strategy for reducing water use and enhancing water management in cities has been identified as urban symbiosis (Wadström et al., 2023). Under this strategy,

several urban organisations, including municipal governments, businesses, and households, work together to share and utilise water resources (Wadström et al., 2023).

Urban symbiosis success in managing water can be attributed to its ability to encourage the reuse and recycling of water, minimise distribution network losses, and maximise water consumption through effective technology and procedures (Santos et al., 2023; Tom et al., 2021). Also, urban symbiosis collaborative character can encourage innovation and create novel opportunities for sustainable water management (Valentine, 2016).

Urban symbiosis encourages the effective use and recycling of water resources in cities, which might help to reduce water scarcity (Estévez et al., 2022). In order to reduce the demand for freshwater and available water supplies, various urban actors might cooperate to cooperatively identify options for sharing and recycling water resources. The development of water reuse networks, in which wastewater from one user is treated and reused by another, is an illustration of this strategy (Santos et al., 2023).

Urban symbiosis involves attaining economic, environmental, and social benefits in urban areas by collaborating and sharing resources, knowledge, and experience (Raymond et al., 2017). The effective management of water resources is one of the main advantages of urban symbiosis. Urban symbiosis can help urban areas use water sustainably by encouraging efficient water usage, minimising wastewater generation, and encouraging water reuse (Estévez et al., 2022). A key component of urban symbiosis that can reduce water usage in cities is efficient water use. Urban symbiosis encourages water-saving techniques like rainwater collection, greywater reusing, and the use of low-flow plumbing equipment to reduce water consumption (López Zavala et al., 2016). In conclusion, urban symbiosis can have a big impact on water management and water use reduction in urban areas. Urban symbiosis' key components, efficient water utilisation, reduced wastewater production, and encouragement of water reusing can support the sustainable use of water resources in urban environments.

3. RESEARCH METHODOLOGY

To complete the present study, a systematic review of the literature was used as the methodological basis. Hence, by a systematic review of the Scopus database, it was first recognised that key literature was published indicating the intersection of the fields of water use reduction, urban symbiosis, and water management. This Scopus-based review article presents the first insights into the growth of urban symbiosis for water reduction and management from 2016 to 2023.

Using the keywords "water reduction," "urban symbiosis," and "water management," the Scopus database was searched for relevant titles, abstracts, and documents published from 2016 to 2023 [TITLE-ABS-KEY ("water reduction" AND "water management" OR "urban symbiosis"]. The Scopus search tool's filters, I DOCUMENT TYPES=(Articles) AND (ii) SOURCE TYPE=(Journals), were used to further narrow down the initial 133 articles to find the best literature. In light of this, 67 journal articles were chosen as the foundation for the bibliometric study.

Two (02) chosen indicators of the co-occurrence of words and the number of articles illustrating the intersection of the fields of water management, water reduction, and urban symbiosis were used to conduct the analysis of the literature. Leading journals that have published on the intersection of water management, water use reduction, and urban

symbiosis, as well as the top authors who have published a significant number of articles combining these fields, as well as the top publishing countries, were identified through this evolution in the number of journal articles published over time. The literature was chosen in accordance with the selected bibliometric indicators in order to comprehend how water management, water reduction, and urban symbiosis connect.

4. RESULTS AND DISCUSSION

This section of the paper presents the key research findings related to two major areas: (i) outcomes of bibliometric analysis, and (ii) urban symbiosis for water reduction and management. The bibliometric analysis identified the most influential publications, authors and countries in the field of urban symbiosis, highlighting the growing interest in this area of research.

4.1 OUTCOMES OF BIBLIOMETRIC ANALYSIS

As the initial step, a Scopus-based systematic review was conducted to collect data related to the evolution of the urban symbiosis concept for water reduction and management. The collected data for the period from 2016 to 2023 was analysed using bibliometric analysis. The results were organised under four key headings: (i) evolution of the number of journal articles published, (ii) leading journals that published articles related to urban symbiosis for water reduction and management, (iii) analysis of the leading authors in this field, and (iv) analysis of leading countries of journals that published articles on the topic. This analysis provides valuable insights into the trends and patterns of research in this area, highlighting the growing interest in urban symbiosis as a promising approach to water management in urban areas.

4.1.1 Evolution of the Number of Journal Articles Published on Urban Symbiosis for Water Reduction and Management

The systematic review analysed a total of 67 journal articles published between 2016 and 2023, focusing on the intersection of urban symbiosis for water reduction and management. The evolution of the number of journal articles published on this topic in the Scopus database is presented in Figure 1.

The analysis revealed that 13 articles was published in 2016, but the number of articles is reduced as 9 and 8 respectively in 2017 and 2018. In 2019, increased to 11 articles, followed by 8 and 7 in 2020 and 2021, respectively. As shown in Figure 1, the number of publications peaked in 2016 with a total of 13 articles, while three articles were published in the first three months of 2023. The overall trend indicates a decreasing number of publications on urban symbiosis for water reduction and management from 2016 to 2018, followed by an increasing trend in 2019 and beyond. After 2019, it again decreased until 2021. But in 2022, it little bit increased publishing 8 articles. Many of the published articles focused on water management and sustainability, highlighting the growing interest in this topic.

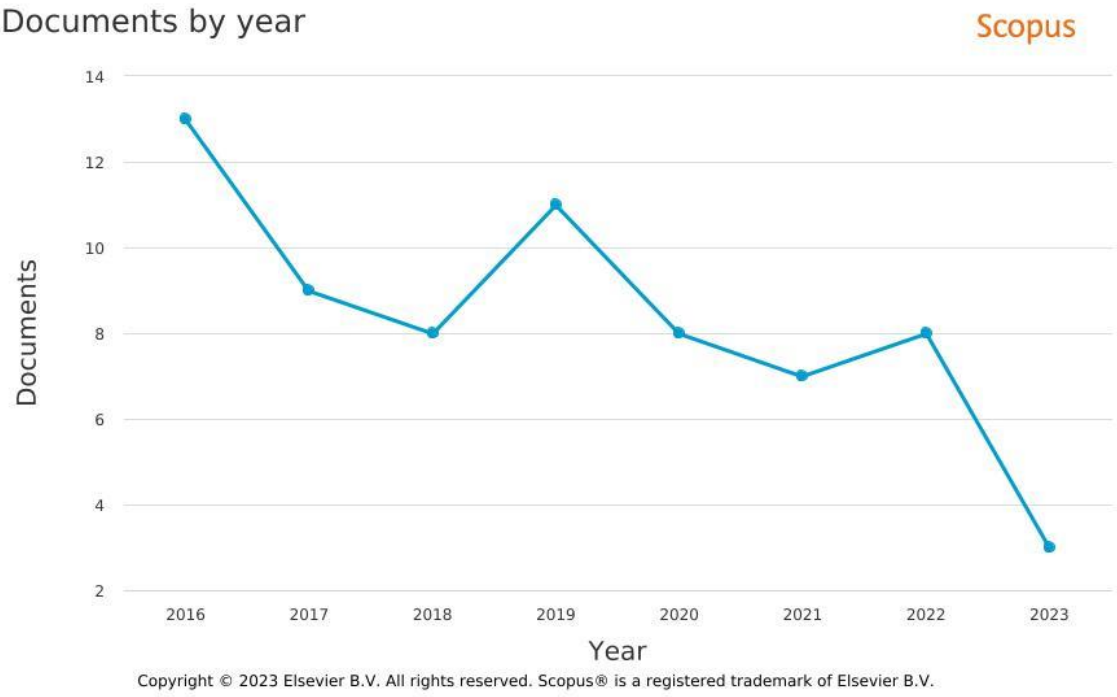

Figure 1: Evolution of the number of articles
Source: Scopus-based systematic review

4.1.2 Leading Journals Published Urban Symbiosis for Water Reduction and Management

Urban water symbiosis has emerged as a revolutionary concept in today's world, with a limited number of journals currently dedicated to its publication. Figure 2 presents the leading journals that published articles on the intersection of urban symbiosis for water reduction and management between 2016 and 2023. According to the analysis, the Journal of Cleaner Production published the highest number of articles (three) on this topic during the period. Other leading journals that published a high number of articles include Agriculture Water Management, Desalination and Water Treatment, Science of the Total Environment, and Water Science and Technology: Water Supply.

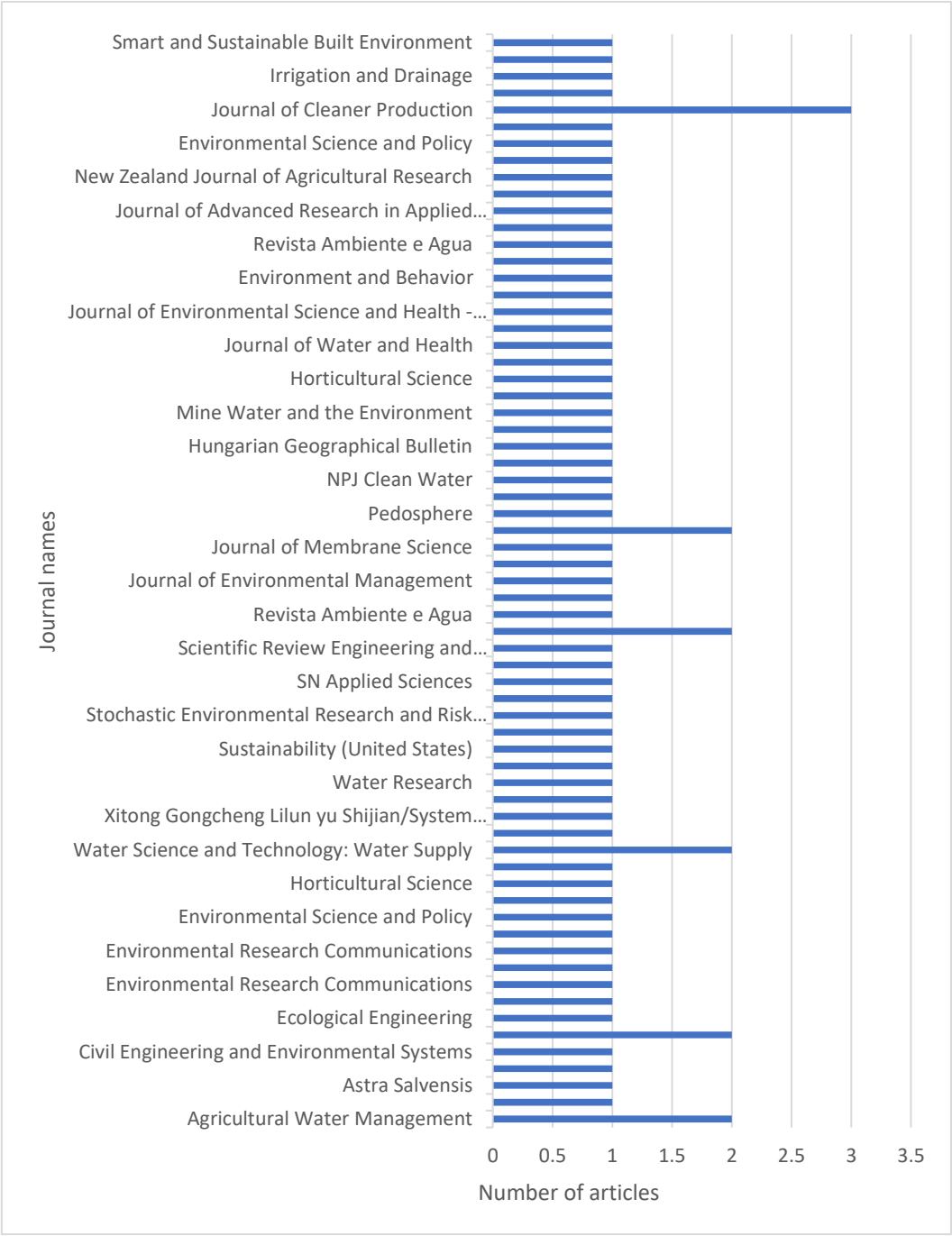

Figure 2: Leading journals that published most articles
Source: Scopus-based systematic review

4.1.3 Leading Authors in the Concept

Figure 3 displays the leading authors who have contributed to the adoption of urban symbiosis for water reduction and management. The analysis of the data from Scopus for the period between 2016 and 2023 reveals that Moghini and Sepaskhah published the most articles (three) on this topic. Other authors who have made significant contributions include Kanakpudis V, Klingel P, and Mastaller M, each of whom has published two articles in Scopus.

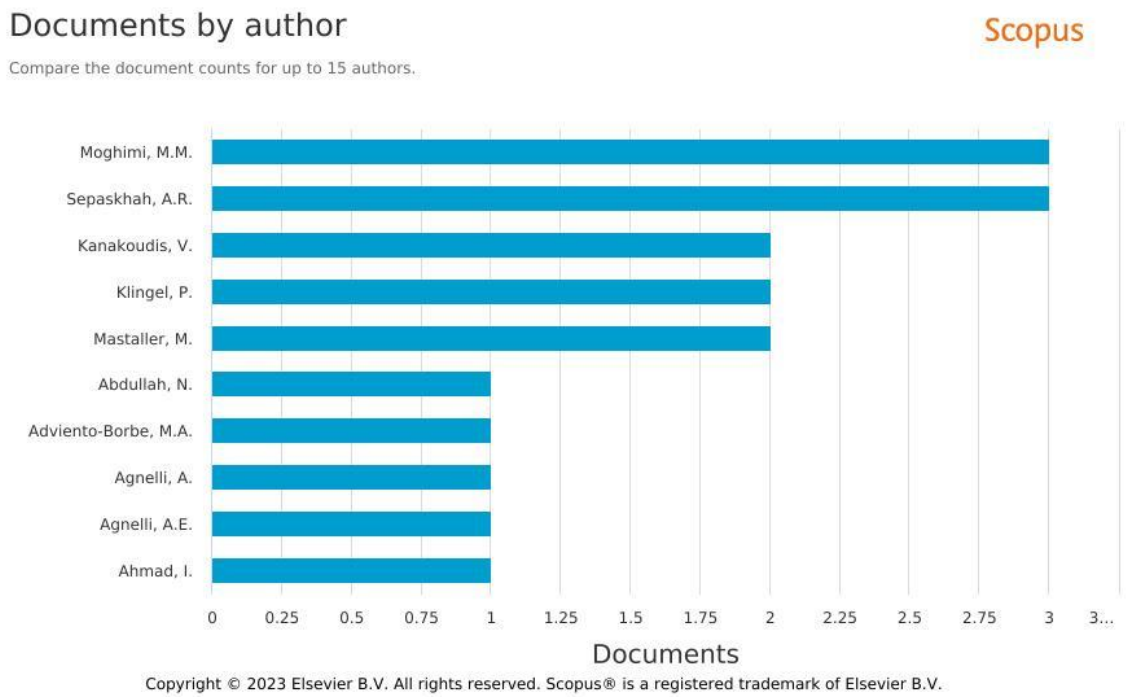

Figure 3: Leading authors in the field
Source: Scopus-based systematic review

4.1.4 Leading Countries in the Concept

The leading journal countries that have published most articles considering urban symbiosis for water reduction and management intersection over the period from 2016 to 2023 are presented in Figure 4. As shown in Figure 4, China is the leading country that published the highest number of articles on the intersection of water management, water reduction and urban symbiosis during the period from 2016 to 2023. China is one of the countries which is used the urban symbiosis concept for water reduction and management (Li et al., 2021). The United State is the second leading country that published a journal for urban symbiosis, water management and water reduction. United Kingdom, Iran, Italy, Australia, Greece, Malaysia, Brazil and Canada are the other leading countries which published journals regarding urban symbiosis for water reduction and management.

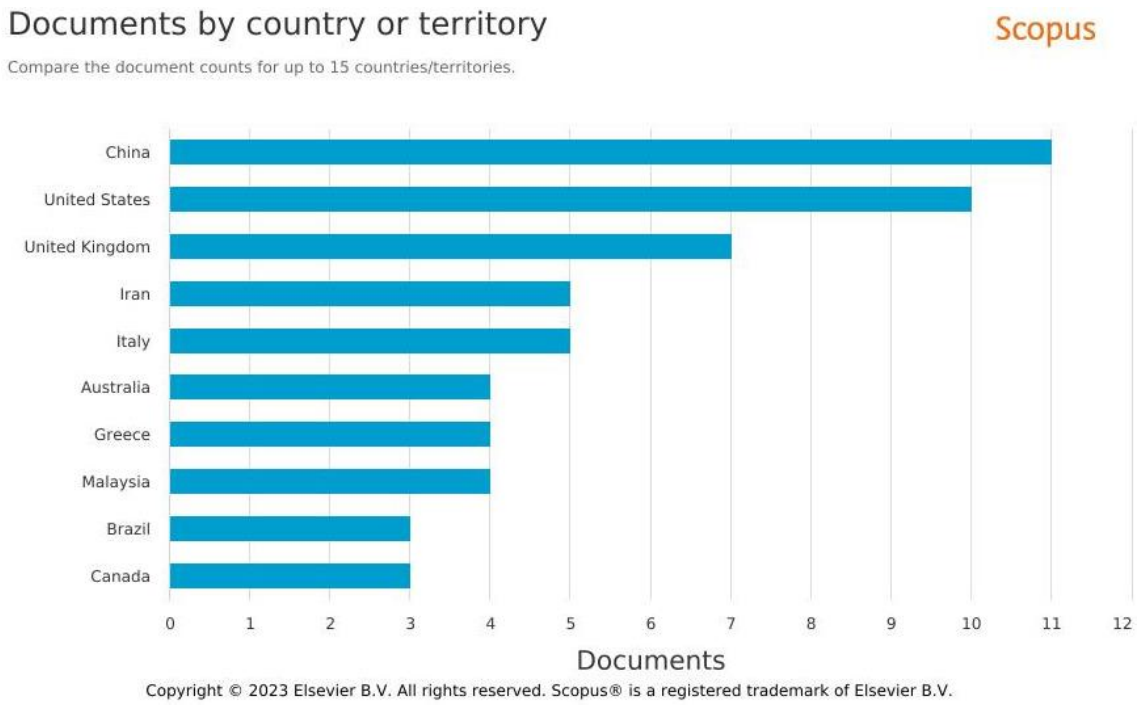

Figure 4: Documents by countries
Source: Scopus-based systematic review

According to the analysis, the concept of urban symbiosis is evolving as a developing study worldwide. The current application of urban symbiosis is focused on water reduction and management.

4.2 ADOPTING THE URBAN SYMBIOSIS CONCEPT FOR WATER REDUCTION AND WATER MANAGEMENT

Urban water symbiosis has gained significant attention and adoption by numerous countries worldwide due to its potential to address multiple challenges associated with water management in urban areas. This innovative concept promotes the integration and collaboration of various urban water systems to achieve greater resource efficiency, sustainability, and resilience.

Recent journal articles suggest that adopting the concept of urban symbiosis can be an effective approach to reducing water consumption and managing water resources in urban areas. For example, discovered that urban symbiosis-based strategies, such as water collection and reuse, can significantly reduce water use in residential building(Tian et al., 2017). Another study by Bao et al., (2019) looked at how urban symbiosis might help public places to reduce the consumption of water. The study discovered methods based on urban symbiosis, such as using recycled wastewater in daily works of the residential area. Furthermore, a recent review by Tian et al., (2017) highlighted the potential of urban symbiosis for water management in China.

An urban symbiosis is a promising approach for reducing water consumption and improving water management in urban areas(Byrne et al., 2020). One of the key benefits of urban symbiosis is its potential to create more efficient and sustainable water systems. For example, green infrastructure-based approaches, such as rain gardens and bioswales, can be used to capture and collect stormwater runoff, which can then be used for irrigation

or other non-potable uses (Byrne et al., 2020). Another benefit of urban symbiosis is its potential to promote circular economies and reduce waste. For instance, industrial symbiosis-based approaches, such as the reuse of treated wastewater for industrial processes, can help reduce the demand for freshwater resources (Tian et al., 2017). In addition, urban symbiosis can also help reduce water pollution by promoting the use of more sustainable practices and technologies (Sun et al., 2017). Overall, these benefits highlight the potential of urban symbiosis to improve water management and reduce water-related challenges in urban areas.

Urban symbiosis has been used in a variety of countries to enhance water management and reduction. For example, the government of China has established a national urban symbiosis program to promote the exchange of resources, energy, and water among facilities (Tian et al., 2017). Participating organisations' water consumption and wastewater output have decreased as a result of the program (Li et al., 2021). Another example is Colombia, where a project to promote urban symbiosis has been implemented in public places to lessen wastewater generation and encourage the reuse of water resources (Park et al., 2018). Other countries that have implemented urban symbiosis projects for water reduction and management include South Korea, Japan, the United States, Brazil, South Africa and India (Neves et al., 2020)

Despite the potential benefits of urban symbiosis in water reduction and management, several barriers can hinder its implementation. One of the key issues is the lack of institutional and regulatory frameworks that support collaborative resource management and exchange (Andersson et al., 2019). Andersson et al., (2019) stated that because of this, it could be challenging for various urban actors to collaborate and gain access to the infrastructure and resources needed to create symbiotic partnerships. Uncertainty about urban symbiosis and its potential advantages is another barrier, which can make it challenging to involve stakeholders and build support for cooperation (Neves et al., 2020). The implementation of urban symbiosis might also be limited by financial and economic barriers because symbiotic relationships may be more expensive to establish and maintain than traditional water management strategies (Park et al., 2018). Finally, cultural and societal barriers can also play a role, since attitudes and ideas about ownership, competition, and privacy may limit collaboration and the sharing of resources (Andersson et al., 2019).

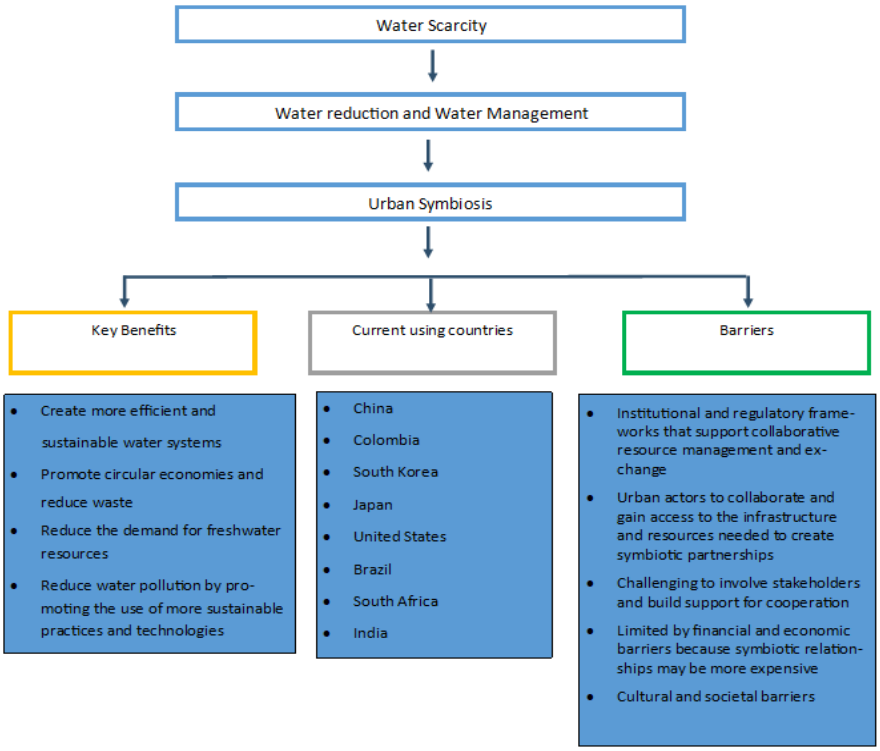

Figure 5: Summary of details for adopting urban symbiosis for water reduction and management

5. CONCLUSIONS

This study has conducted a systematic review of key literature published in the Scopus database between 2016 and 2023 to explore the feasibility of adopting urban symbiosis for sustainable urban water reduction and management. The bibliometric analysis outcomes contribute significantly to identifying the number of published journals, leading journal authors, and countries in the field of urban symbiosis. It is evident from the analysis that urban symbiosis is an evolving and growing area of study worldwide, with a particular focus on water reduction and management. Through the analysis of existing literature, several key findings have emerged regarding the implementation of urban symbiosis for water reduction and management. The identified benefits of adopting urban symbiosis include the creation of more efficient and sustainable water systems, the promotion of circular economies, waste reduction, and the reduction of freshwater resource demand and water pollution through sustainable practices and technologies. Countries such as China, Colombia, South Korea, Japan, the United States, Brazil, South Africa, and India have already implemented urban symbiosis projects for water reduction and management. However, certain barriers need to be addressed when implementing urban symbiosis. These include the lack of institutional and regulatory frameworks that support collaborative resource management and exchange, gaining access to the infrastructure and resources needed to create symbiotic partnerships, challenges to involve stakeholders and build support for cooperation, and financial and economic barriers because symbiotic relationships may be more expensive to establish and maintain than traditional water management strategies and attitudes and ideas about ownership, competition, and privacy may limit collaboration and the sharing of resources. In

conclusion, this research provides valuable insights into the feasibility and potential of adopting urban symbiosis for sustainable urban water reduction and management. The study serves as a guide to identifying the benefits, barriers, and countries implementing urban symbiosis in the water sector. It is hoped that this work will contribute to the development of more effective strategies and approaches for sustainable water management in urban areas.

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