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Review Article

The correlation between water sensitive urban design and urban climate: A bibliometric analysis

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ABSTRACT

The rapid population growth in the past two centuries has caused a significant rise in urbanisation, leading to various environmental impacts. To address these negative consequences, the adoption of new technologies is crucial. One such approach is Water Sensitive Urban Design (WSUD). This study aims to investigate the relationship between Water Sensitive Urban Design (WSUD) and urban climate, particularly in the context of challenges posed by urban sprawl, such as the Urban Heat Island (UHI) effect and stormwater pollution. Employing a bibliometric analysis and utilising the similar visualisation software (VOSviewer), the research analyses publications from 2014 to 2023 to identify prominent countries, institutions, authors, journals, and emerging research trends. A total of 38 publications documented in the Scopus database were reviewed as of January 2024. The findings reveal that 2022 marked a peak in research output, with the Journal of Hydrology leading in publications and Simon C. Beecham recognised as the foremost author. Notably, Australia contributed 37% of the total publications, with Monash University identified as a key institutional contributor. The analysis uncovered critical themes related to water management, climate resilience, and sustainable urban practices, underscoring their interconnectedness. Despite these insights, the study identified a significant gap in the literature regarding the interplay between WSUD, low-impact development (LID), sustainable urban drainage (SUD), thermal comfort, and UHI. This gap indicates a fertile area for future research, presenting a roadmap for scholars to explore these connections more comprehensively.

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INTRODUCTION

The 21st century is witnessing an unprecedented surge in urbanisation, with the global urban population projected to reach a staggering 68% by 2050 [1]. This rapid growth presents significant challenges for urban environments, particularly in terms of water management and climate regulation. Traditional urban landscapes, characterised by extensive impervious surfaces, significantly disrupt the natural hydrological cycle. This results in increased surface runoff, straining drainage systems and exacerbating flooding risks [2, 3]. Additionally, the urban heat island (UHI) effect, caused by the absorption and re-radiation of heat by buildings and pave-

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ment, contributes to rising temperatures, impacting human health, air quality, and energy consumption [4].

In response to these challenges, a variety of stormwater management strategies have been formulated and adopted across different countries, These strategies encompass Low Impact Development (LID) and Best Management Practices (BMP) in the United States [5, 6], Water Sensitive Urban Design (WSUD) in Australia [7], Green Infrastructure (GI) in both the United States and the United Kingdom, and Sustainable Drainage Systems (SuDS) in the United Kingdom [8]. Additionally, Nature-based Solutions (NBS) have been employed in Europe [9], Ecosystem-based Adaptation (EbA) has been implemented in Canada and Europe [5], and the concept of sponge cities has gained traction in China [10, 11]. Collectively, these methodologies strive to alleviate the environmental consequences of urbanisation by supplanting traditional infrastructure with more ecologically harmonious systems, thereby enhancing surface permeability and augmenting water retention capabilities [5].

In this context, Water Sensitive Urban Design (WSUD) has emerged as a critical approach to urban planning and development. WSUD is a holistic strategy that integrates water management principles with urban design and landscape planning [12]. It aims to mimic natural hydrological processes by promoting infiltration, evapotranspiration, and slow release of stormwater runoff [13]. This paradigm shift from traditional "drain and discharge" methods towards a "source control" approach in Australia began in the early 1990s , emphasising the integration of water management with urban planning [12, 14]. Accordingly, The concept of WSUD was first articulated in Australia, with formative guidelines developed between 1987 and 1994, establishing a framework for managing the urban water cycle, which emphasises water balance, quality, and conservation [14, 15]. Today, WSUD is recognised as a vital strategy to foster sustainable urban environments globally, prompting further adaptation and application in diverse contexts beyond its Australian origins [14].

Firstly, WSUD plays a crucial role in flood mitigation. By mimicking natural drainage patterns and encouraging infiltration, WSUD can significantly reduce peak stormwater flows, lessening the burden on drainage infrastructure and minimising flood risks [16]. Secondly, it contributes to improved water quality. Pollutants are often carried by stormwater runoff, leading to the degradation of water bodies. WSUD practices like bioretention basins and rain gardens act as natural filters, removing pollutants and improving the quality of discharged water [17]. Furthermore, WSUD promotes water security and conservation. Techniques like rainwater harvesting and greywater reuse can capture and store valuable water resources, reducing reliance on potable water sources and promoting sustainable water use [18].

Beyond water management, WSUD offers significant benefits for urban climate regulation. Vegetative elements incorporated in WSUD, such as green roofs and street trees, contribute to evapotranspiration, a process that cools surrounding air and reduces UHI effects [19]. Furthermore, WSUD practices can increase shading and urban albedo (reflectivity), further mitigating heat absorption and promoting a more comfortable urban environment [20].

The field of WSUD is rapidly evolving, with ongoing research exploring its effectiveness in addressing urban water and climate challenges. A bibliometric analysis offers a valuable tool to examine this dynamic field. By analysing publication trends, authorship patterns, and keyword co-occurrence, bibliometric studies can shed light on the most significant research areas, emerging topics, and key actors driving the development of WSUD knowledge.

This paper presents a comprehensive bibliometric analysis of the intersection between WSUD and urban climate. Through a systematic review of the literature, we aim to:

•Identify the most prominent research themes and subthemes within the field.

•Examine the temporal trends in research focussing on WSUD and urban climate.

•Explore the geographic distribution of research activity in this field.

•Identify key authors, institutions, and collaborations contributing to this body of knowledge.

•Analyse the co-occurrence of keywords to understand the relationships between different research areas within this domain.

By providing a comprehensive picture of research on WSUD and urban climate, this analysis will contribute to a better understanding of this critical field. It will highlight areas of strong research focus and potential knowledge gaps, informing future research directions and facilitating the development of more effective WSUD strategies for mitigating the impacts of urbanisation on our climate.

METHODOLOGY

Materials and Methods

This review aims to examine the body of literature pertaining to Water Sensitive Urban Design (WSUD) and urban climate over the past decade. To achieve this objective, bibliometric analysis and visualisation methods were employed as presented in Figure 1. Bibliometric analysis involves studying specific subject areas and analysing the findings of relevant publications based on various characteristics [21]. The Scopus database was used to identify high-quality articles on the topic, excluding conference proceedings. On 13/01/2024, a search was conducted using keywords in the title, abstract, or keywords sections, with the 'Topic' option selected. Only English articles were included. The keywords used in the search included 'water sensitive urban design', 'sustainable urban drainage systems', 'low impact development', 'cooling', 'thermal comfort', 'urban climate', and 'urban heat island'. Scopus was chosen as the primary database due to its advanced tools for visualising, analysing, and tracking research output in various fields, including humanities, technology, and science

[22]. Additionally, a manual screening process was carried out to ensure the relevance of the publications to WSUD and urban climate, resulting in 38 remaining publications for further analysis. The exclusion criteria used for this screening process are presented in Figure 2. Figure 3 illustrates the identification of the analysed studies framework employed in this review.

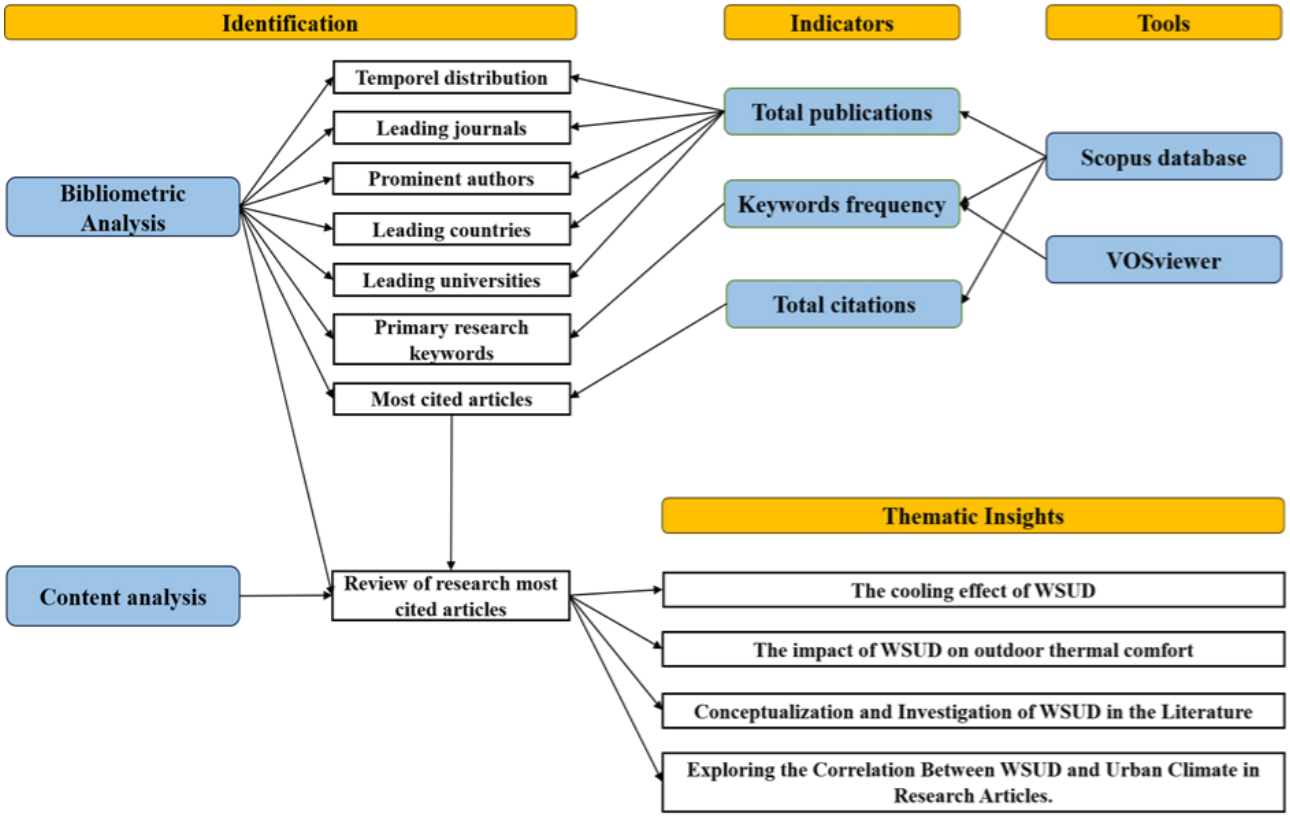

Figure 1. Analysis framework. (Author,2024)

The Bibliometric Analysis

The study also employed bibliometric analysis as a method. This approach allowed for the identification of the most frequently used keywords, cited journals, published journals, and countries conducting research on the subject. Additionally, the analysis examined the relationships between keywords, authors, and the most cited authors. To visualise the bibliometric networks, the VOSViewer software, a widely used program, was utilised. The purpose of this review is twofold. Firstly, it aims to explore the relation between Water Sensitive Urban Design and urban climate mitigation, which has become a significant research area due to the lack of existing studies. Secondly, the review seeks to utilise a reliable machine learning method to analyse a substantial amount of literature and provide insights into the current state of research and trends in this cooling strategy.

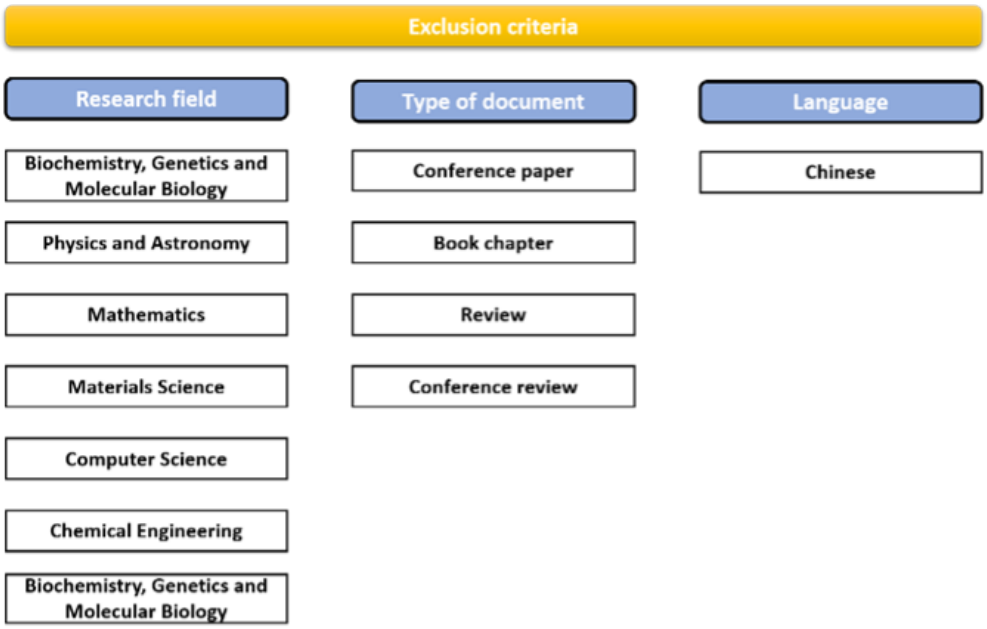

Figure 2. Exclusion criteria for data screening (Author,2024)

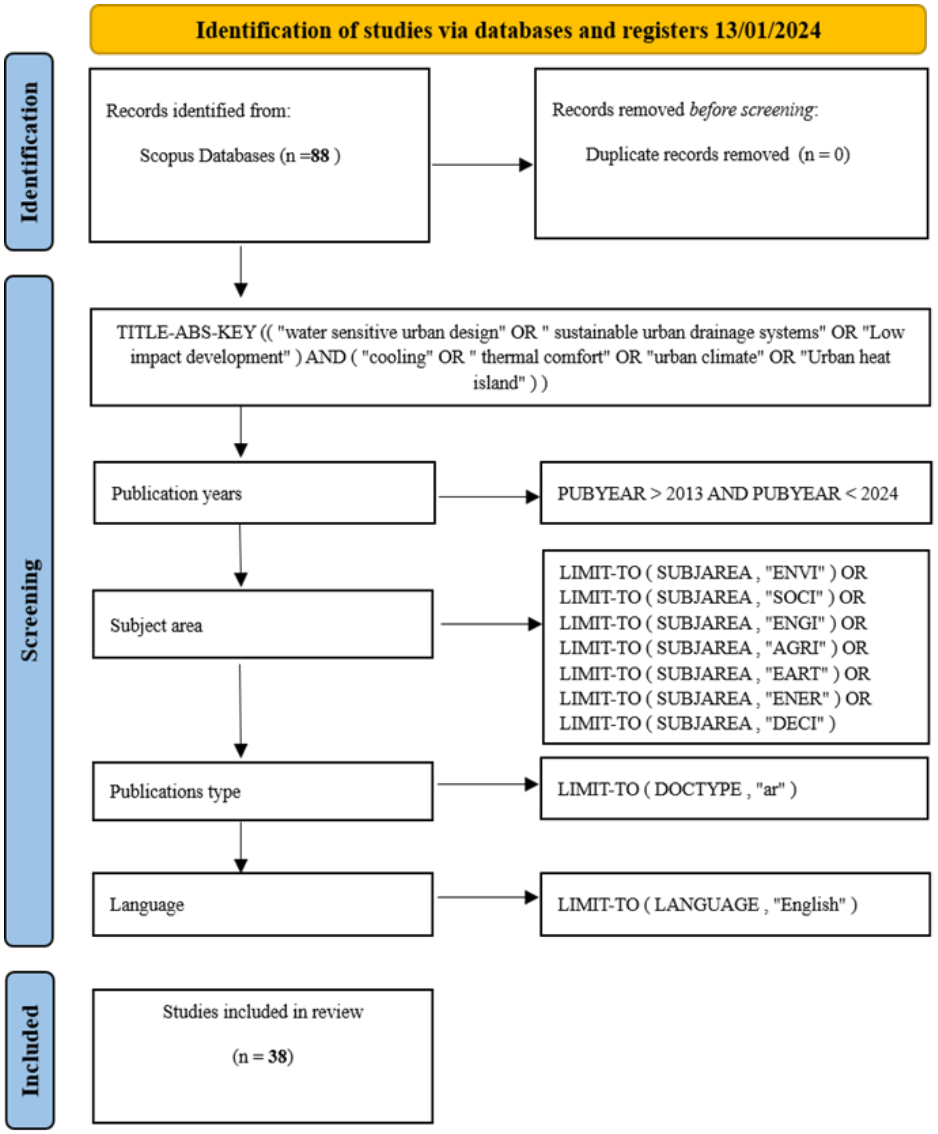

Figure 3. Identification of the Analysed studies (Author,2024)

FINDINGS

The objective of this research is to analyse the literature on the correlation between Water Sensitive Urban Design and urban climate over the past ten years. The results of this literature review were examined in accordance with the research questions.

Research Question 1

What is the temporal distribution of publications on the correlation between water sensitive urban design and urban climate research areas over the last decade? The first finding was addressed by conducting an analysis of the publication year of articles published in the past decade. It was observed that the majority of publications (8) were released in the year 2022, followed by (6) publications in 2014, and (4) publications each in 2021 and 2018. The remaining publications were distributed across the remaining years, as illustrated in Figure 4.

Notably, this analysis revealed a pronounced increase in publications on the correlation between water-sensitive urban design (WSUD) and urban climate, with a notable peak in 2022. This upward trend suggests a growing recognition of the urgency to incorporate sustainable practices in urban planning, likely driven by the increased frequency of extreme weather events and climate considerations. The gradual rise prior to 2022 indicates a long-standing interest in this area, underlining the importance of ongoing research to respond to climate challenges and inform effective policy development.

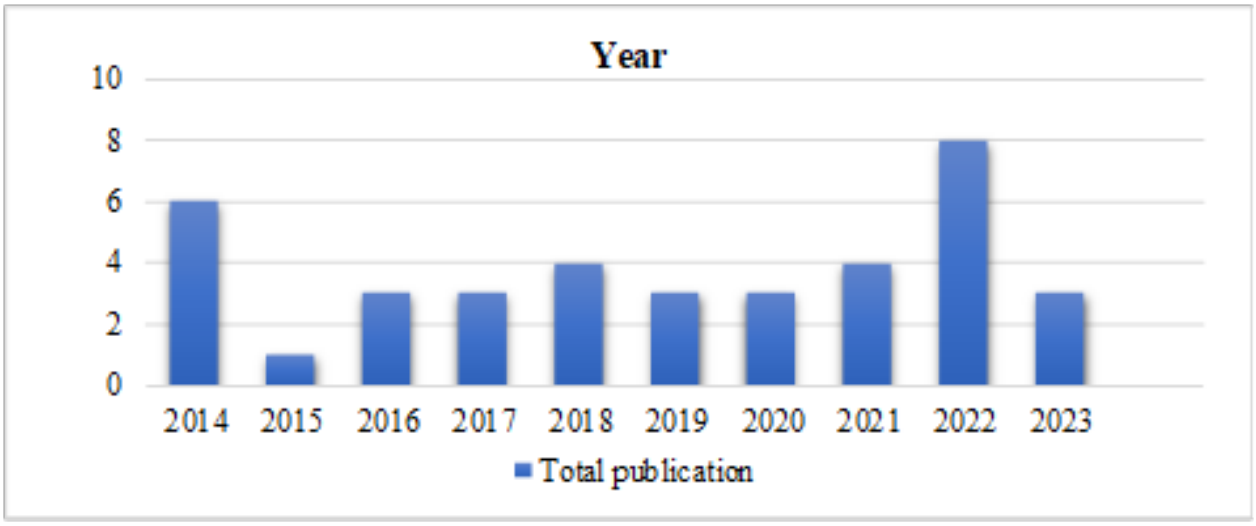

Figure 4. Distribution of publications by years (2014–2023) (Author,2024)

Research Question 2

What are the most prominent journals and authors in the correlation between water sensitive urban design and urban climate research areas? This finding was addressed by conducting an analysis, with the following criteria selected for analysis: 'Journal,' 'Total Publication,' 'Total Citation,' 'Cite Score of the journal,' Rank,' and 'Publisher,' as presented in Table 1.

According to Table 1, the journal 'Journal of Hydrology' had the highest number of publications (4996) and citations (52,147) in general and 4 publications related to the relationship between water sensitive urban design and urban climate. It was followed by 'Urban Climate' with a total of 840 publications and 7349 citations in all fields and 3 publications about WSUD and urban climate, and 'Ecological Engineering' with 1124 publications and 8506 citations and 2 publications in the relation between WSUD and urban climate. The distribution of the most productive journals in this area is displayed in Table 1.

Furthermore, the second research question also focused on identifying the most prolific authors in the field of water sensitive urban design and urban climate. To conduct the analysis for these authors, a set of criteria including 'Author,' 'Year of 1st publication,' 'Total Publications,' 'h-index,' 'Total Citations,' 'Current Affiliation,' and 'Country' were utilised and presented in Table 2.

Table 2 presents a list of ten highly productive authors in the field of urban climate research, specifically in the correlation between water-sensitive urban design and urban climate. Among these authors, Simon C. Beecham stands out as the most prolific author, with 4 publications in the specific area of investigation and boasting a total of 185 publications across all fields, accompanied by an h-index of 38. Furthermore, Beecham's work has garnered 4950 citations and is affiliated with an institution in Australia. 'Ashley Mark Broadbent' ranks second, with 3 publications in this field, and a total of 30 publications across all fields, an h-index of 17, and 936 citations. Additionally, Broadbent is affiliated with an institution in the United States. Notably, 'Andrew M'. 'Coutts, Matthias Demuzere', and 'Razzaghmanesh Mostafa' also share a similar publication count to Broadbent. The remaining authors who have contributed significantly to research in the area of the correlation between water-sensitive urban design and urban climate are also listed in Table 2.

Table 1. The top 10 highly productive journals on correlation between water sensitive urban design and urban climate in the years (2014–2023)

Journal	TP	TPA	TCA	Cite Score (2022)	Rank	Publisher
Journal of Hydrology,	4	4996	52 147	10.4	Q1	Elsevier
Urban Climate	3	840	7349	8.7	Q1	Elsevier
Ecological Engineering	2	1124	8506	7.6	Q1	Elsevier
Landscape and Urban Planning	2	834	12 047	14.4	Q1	Elsevier
Science of the Total Environment	2	28 506	479 285	16.8	Q1	Elsevier
Sustainability Switzerland	2	48 515	281 274	5.8	Q2	MDPI
Water Switzerland	2	13 633	74 947	5.5	Q1	MDPI
Agricultural and Forest Meteorology	1	1504	16 081	10.7	Q1	Elsevier
Applied Sciences Switzerland	1	38 930	176 120	4.5	Q2	MDPI
Ecological Indicators	1	4722	48 457	10.3	Q1	Elsevier

Table 2. The top 10 highly productive authors on correlation between water sensitive urban design and urban climate in the years (2014–2023)

Author	Year of 1st Publication	TP	TPA	h-Index	TCA	Current Affiliation	Country
Beecham, Simon C.	1994	4	185	38	4950	University of South Australia, Adelaide, Australia	Australia
Broadbent, Ashley Mark.	2014	3	30	17	936	Arizona State University, Tempe, United States	United States
Coutts, Andrew M.	2003	3	35	22	3377	Monash University, Clayton, Australia	Australia
Demuzere, Matthias.	2008	3	95	38	5763	Ruhr-Universitat Bochum, Bochum, Germany	Germany
Razzaghmanesh, Mostafa.	2012	3	17	13	846	United States Environmental Protection Agency, Washington, D.C., United States	United States
Rey-Mahía, Carlos,	2019	2	7	3	32	Universidad de Oviedo, Oviedo, Spain	Spain
Tapper, Nigel J.	1995/1977	2	142	45	7505	Monash University, Clayton, Australia	Australia
Adams, Russell.	1995	1	36	13	530	Agri-Food and Biosciences Institute, Belfast, Belfast, United Kingdom	United Kingdom
Alexander, Paul John.	2014	1	14	9	1194	Central Statistics Office, Cork, Ireland	Ireland
Alvizuri, J.	2017	1	1	1	12	Cooper Union for the Advancement of Science and Art, New York, United States	United States

TP (total publication in the correlation between WSUD and urban climate field) / TPA (total publication in all fields) /TCA (total citation in all fields)

In synthesising these findings from the focused examination of the literature, it becomes evident that the ongoing discourse surrounding water-sensitive urban design (WSUD) and its interaction with urban climate is not just confined to individual scholarly contributions, but is indicative of a broader and more interconnected research framework. This highlights a significant trend wherein influential journals such as the "Journal of Hydrology," "Urban Climate," and "Ecological Engineering" not only facilitate the dissemination of critical research but also foster fruitful collaborations among leading researchers. In particular, the preeminence of Simon C. Beecham, as showcased in the subsequent data, underscores the central role that certain authors play in advancing this field. Consequently, the concentration of scholarly output among a select group of researchers reinforces the notion that collaborative efforts and diverse expertise are essential in addressing the multifaceted challenges posed by the urban environment. This integration of findings not

only enhances our understanding of the current landscape of urban climate research but also invites further inquiry into the potential for innovative solutions that emerge from such collective endeavours.

Research Question 3

What are the most productive countries in the correlation between water sensitive urban design and urban climate research areas? The objective of this study is to identify the leading countries in terms of productivity in the field of water sensitive urban design and urban climate research. In order to achieve this, an analysis was conducted, using the criteria of 'country', 'total publications', 'most cited article,' and 'total citation'. The results are presented in Table 3.

Table 3. The top 10 highly productive countries on correlation between water sensitive urban design and urban climate in the years (2014–2023)

Rank	Country	TP	Most cited article	TC
1	Australia	14	Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation [23]	156
2	China	7	Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation [23]	156
3	United States	7	The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia [20]	140
4	Belgium	4	The cooling effect of irrigation on urban microclimate during heatwave conditions [24]	77
5	Spain	4	Urban regreeneration: Green urban infrastructure as a response to climate change mitigation and adaptation [25]	17
6	Germany	2	Sustainable stormwater management under the impact of climate change and urban densification [26]	39
7	Singapore	2	Using water management infrastructure to address both flood risk and the urban heat island [27]	32
8	South Korea	2	Application of green blue roof to mitigate heat island phenomena and resilient to climate change in urban areas: A case study from Seoul, Korea [28]	36
9	Thailand	2	Bridging the Form and Function Gap in Urban Green Space Design through Environmental Systems Modeling [29]	14
10	Brazil	1	A year-assessment of the suitability of a green façade to improve thermal performance of an affordable housing [30]	2

TP (total publication in the correlation between WSUD and urban climate field) / /TC (total citation)

Table 3 displays the top 10 countries in terms of productivity in the correlation between water sensitive urban design and urban climate research field. This table outlines the distribution of research topics among the highest producing countries and regions. From a country-specific perspective, it is evident that the listed countries/regions have consistently shown interest in research field related to the correlation between water sensitive urban design and urban climate. For instance, the highest producing country was Australia, with a total of 14 publications (37% of total publications), and the most cited article being 'Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation', with 156 citations. Following by China with 7 publications (19% of total publications), sharing the same most cited article as Australia, and the United States with an equal number of publications as China. The most cited article for the United States was 'The Role of Green Roofs in Mitigating Urban Heat Island Effects in the Metropolitan Area of Adelaide, South Australia', with a total of 140 citations. Additionally, Table 3 also presents data on other prolific countries in the field of WSUD and urban climate.

What are the most productive universities in the correlation between water sensitive urban design and urban climate research areas? The current study aims to identify the most productive universities in the field of water sensitive urban design and urban climate research. In order to achieve this objective, an analysis was conducted to determine the most productive universities in this research area. The following criteria were considered in the analysis: 'university,' 'total publication', 'most cited article,' 'total citation,' and 'country.' These criteria were illustrated in Table 4.

Table 4. The top 10 highly productive universities on correlation between water sensitive urban design and urban climate in the years (2014–2023)

University	TP	Most cited article	TC	Country
Monash University	5	The cooling effect of irrigation on urban microclimate during heatwave conditions [24]	77	Australia
University of South Australia	4	The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia [20]	140	Australia
KU Leuven	3	The microscale cooling effects of water sensitive urban design and irrigation in a suburban environment [31]	51	Belgium
Griffith University	3	Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation [23]	156	Australia
Cooperative Research Centre for Water Sensitive Cities	2	The cooling effect of irrigation on urban microclimate during heatwave conditions [24]	77	Australia
Arizona State University	2	The cooling effect of irrigation on urban microclimate during heatwave conditions [24]	77	United States
Universidad de Oviedo	2	Evaluating the thermal performance of wet swales housing ground source heat pump elements through laboratory modelling [32]	10	Spain
Thammasat University	2	Bridging the Form and Function Gap in Urban Green Space Design through Environmental Systems Modeling [29]	14	Thailand
Peking University	2	An in-situ measurement method of evapotranspiration from typical LID facilities based on the three-temperature model [33]	13	China
The University of Western Australia	2	The microscale cooling effects of water sensitive urban design and irrigation in a suburban environment [31]	51	Australia

Table 4 presents the top 10 most productive universities in the field of research on the correlation between water sensitive urban design and urban climate. The data displayed in these sources highlight the distribution of research topics among the leading affiliations. Analysis from affiliation perspective reveals a light interest among the universities in water sensitive urban design and urban climate field. For instance, Monash University in Australia emerges as the most productive university with a total of 5 publications, including the highly cited article 'The cooling effect of irrigation on urban microclimate during heatwave conditions' with 77 citations. Following closely is the University of South Australia, also in Australia, with 4 publications, and the most cited article is 'The role of green roofs in mitigating urban heat island effects in the metropolitan area of Adelaide, South Australia' with 140 citations. KU Leuven in Belgium ranks third with 3 publications and the article 'The microscale cooling effects of water sensitive urban design and irrigation in a suburban environment' with 51 citations. Additional prominent universities in this field can be found in Table 4. Moreover, through a comprehensive assessment of 94 affiliations, it can be deduced that Australian universities hold the predominant position with a representation of 19%, followed by French universities accounting for 15% and Chinese universities with 13% of the total affiliations.

Ultimately, these findings underscore the necessity for increased international collaboration in addressing the complex issues associated with urban climate change. While Australia's research efforts in Water Sensitive Urban Design (WSUD) are commendable, the global nature of climate challenges necessitates diverse input and innovation from various countries. Moreover, Australia's proactive approach demonstrates the potential benefits of innovative urban planning strategies tailored to its unique climate context. In fact, the most-cited article shared between Australia and China exemplifies the importance of international collaboration in tackling shared environmental concerns, thereby suggesting that nations can enhance their responses by adapting successful WSUD practices identified in research across different contexts. Furthermore, strengthening academic discourse and fostering partnerships will not only facilitate knowledge sharing but also contribute to the development of sustainable urban practices, eventually leading to more resilient cities that are capable of confronting pressing global environmental challenges.

Research Question 4

What are the most cited articles in the correlation between water sensitive urban design and urban climate research areas? The primary objective of this study is to identify the most frequently cited articles in the fields of water sensitive urban design and urban climate research. In order to achieve this goal, an analysis was conducted, which involved the examination of various criteria, including title, authors, publi-

cation year, total citations, and journals. These criteria were presented in detail in Table 5.

Table 5 presents a list of ten highly cited articles in the field of urban climate research, specifically in the correlation between water sensitive urban design and urban climate. Among these articles, the most cited was 'Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation' published in the 'Land Use Policy' journal with a total of 164 citations. The second most cited article was 'The role of green roofs in mitigating urban heat island effects in the metropolitan area of Adelaide, South Australia' with 146 citations, which is published at 'Urban Forestry & Urban Greening', followed by 'Scale dynamics of extensive green roofs: Quantifying the effect of drainage area and rainfall characteristics on observed and modeled green roof hydrologic performance' from the 'Ecological Engineering' journal, which ranked third with 89 citations. The remaining articles that have contributed significantly to research in the area of the correlation between water sensitive urban design and urban climate are also listed in Table 5.

Notably, the identification of the most cited articles emphasises the importance of practical applications of WSUD in mitigating urban heat island effects and enhancing environmental sustainability. These influential studies illustrate not only the technical benefits of WSUD strategies but also their potential for guiding policy and practice. Moreover, the prominence of these articles indicates a collective inclination towards empirical research that directly addresses urban climate challenges, strengthening the case for WSUD as a vital component in urban planning frameworks aimed at improving liveability and environmental resilience.

Research Question 5

In bibliometric analysis, the frequency of keywords is quantitatively measured to examine their role in conveying the content of articles. Furthermore, the numerical value representing the correlation between pairs of keywords is used to determine the strength of their relationship, with a higher value indicating a stronger link [37].

What are the primary research keywords for the last decade of the correlation between water sensitive urban design and urban climate research area? The bibliometric analysis focused on the most commonly used keywords. In VOSviewer, 'Co-occurrence' was used as the analysis type and 'Authors keywords' as the unit for the first analysis, and a minimum of 3 keyword occurrences was set to identify influential keywords. The initial analysis identified 12 keywords from the dataset, as seen in Figure 5. For the second keyword analysis, 'all keywords' was used as the unit, and a minimum of 3 keyword occurrences was also set. This analysis identified 68 keywords from the dataset, as shown in Figure 6.

When Figure 5 is examined, the most used keywords in the studies are listed as "Low impact development" (Occurences "Oc" = 11/ Total link strength "TLS" = 9), "Urban heat island" (Oc=7/ TLS=7), "Green roofs" (Oc =3/ TLS= 5), ""Water sensitive urban design" (Oc=7/TLS= 5). Green roof (Oc=4/TLS=4), water-sensitive urban design (Oc=3/TLS=4), nature based solutions (Oc=3/TLS=3), stormwater management (Oc=3/ TLS=3), urban planning (Oc=3/TLS=3), and low impact development (lid) (Oc=3/ TLS=2). Moreover, The Vosviewer map categorises keywords into four distinct clusters, each representing critical aspects of sustainable urban development, as indicated by our suggested titles, with a total of 12 keywords across all clusters. Cluster 1, designated in red and titled "Sustainable Urban Drainage," consists of 4 keywords and emphasises specific technologies and planning approaches that utilise green solutions for effective water management in urban settings. Cluster 2, represented in green with the suggested title "Climate Change Mitigation via Nature-Based Solutions," includes 3 keywords and addresses strategies aimed at alleviating the adverse climatic impacts associated with urbanisation, particularly those leveraging natural processes. The blue-hued Cluster 3, titled "UHI & Water Management," contains 3 keywords and delves into the synergy between the urban heat island (UHI) phenomenon and water-sensitive design, advocating for integrated approaches to mitigate urban heat challenges. Lastly, Cluster 4, marked in yellow and named "Stormwater Management Strategies," consists of 2 keywords that specifically pertain to handling stormwater runoff through Low Impact Development (LID) techniques to lessen environmental footprints. Overall, the organisation of these clusters illustrates a coherent thematic framework that links water management with climate resilience and the adoption of nature-based solutions, highlighting the interconnectedness of these critical areas within the context of sustainable urban planning.

Table 5. The top 10 cited articles on correlation between water sensitive urban design and urban climate in the years (2014–2023)

Title	Authors	Publicat-ion year	TC	Journal
Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation [23]	Bao-Jie Hea Jin Zhua Dong-Xue Zhaob Zhong-Hua Gouc Jin-Da Qia Junsong Wang	2019	164	Land Use Policy
The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia [20]	Mostafa Razzaghmanesha Simon Beechama Telma Salemi	2016	146	Urban Forestry & Urban Greening
Scale dynamics of extensive green roofs: Quantifying the effect of drainage area and rainfall characteristics on observed and modeled green roof hydrologic performance [19]	Raha Hakimdavar Patricia J. Culligan Marco Finazzi Stefano Barontini Roberto Ranzi	2014	89	Ecological Engineering
The cooling effect of irrigation on urban microclimate during heatwave conditions [24]	Ashley M. Broadbent Andrew M. Coutts Nigel J. Tapper Matthias Demuzere	2018	77	Urban Climate
The hydrological behaviour of extensive and intensive green roofs in a dry climate [34]	M. Razzaghmanesh S. Beecham	2014	77	Science of The Total Environment
The microscale cooling effects of water sensitive urban design and irrigation in a suburban environment [31]	Broadbent, Ashley M. Coutts, Andrew M. Tapper, Nigel J. Demuzere, Matthias Beringer, Jason	2018	52	Theoretical and Applied Climatology
Simulating the impact of urban development pathways on the local climate: A scenario-based analysis in the greater Dublin region, Ireland [35]	P.J. Alexander R. Fealy G.M. Mills	2016	51	Landscape and Urban Planning
Sustainable stormwater management under the impact of climate change and urban densification [26]	Lea Rosenberger Jorge Leandro Stephan Pauleit Sabrina Erlwein	2021	43	Journal of Hydrology
Valuing environmental services provided by local stormwater management [36]	Brent, D.A. Gangadharan, L. Lassiter, A. Leroux, A. Raschky, P.A.	2017	37	Water Resources Research
Application of green blue roof to mitigate heat island phenomena and resilient to climate change in urban areas: A case study from Seoul, Korea [28]	Shafique, M. Kim, R	2017	36	Journal of Water and Land Development

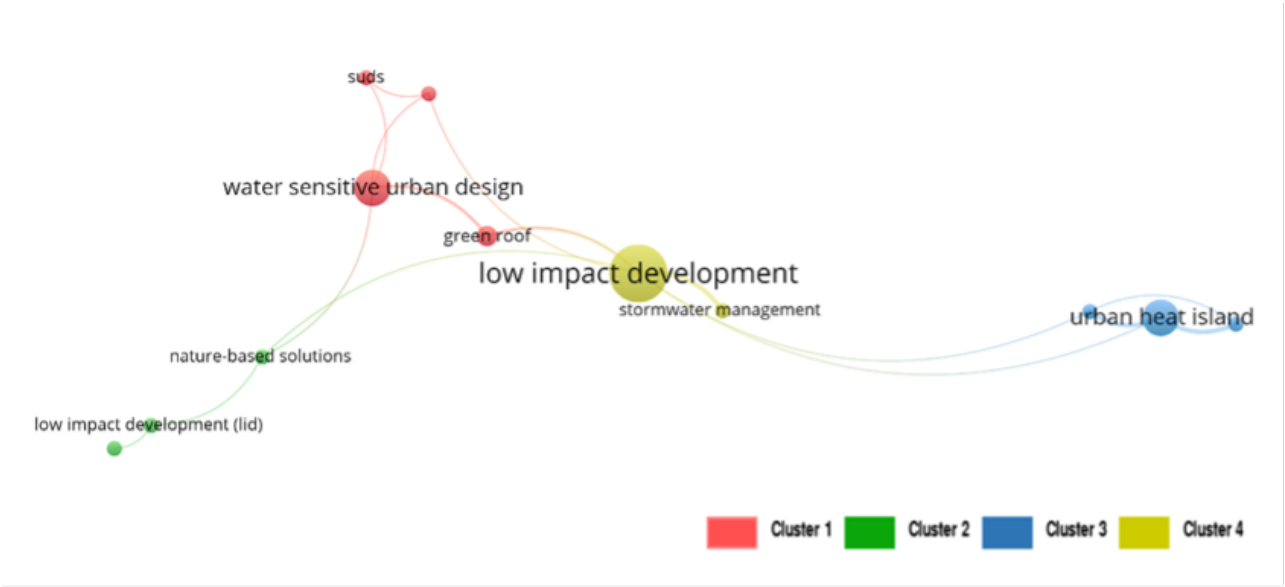

Figure 5. Analysis results of publications by authors' keywords (Author, 2024)

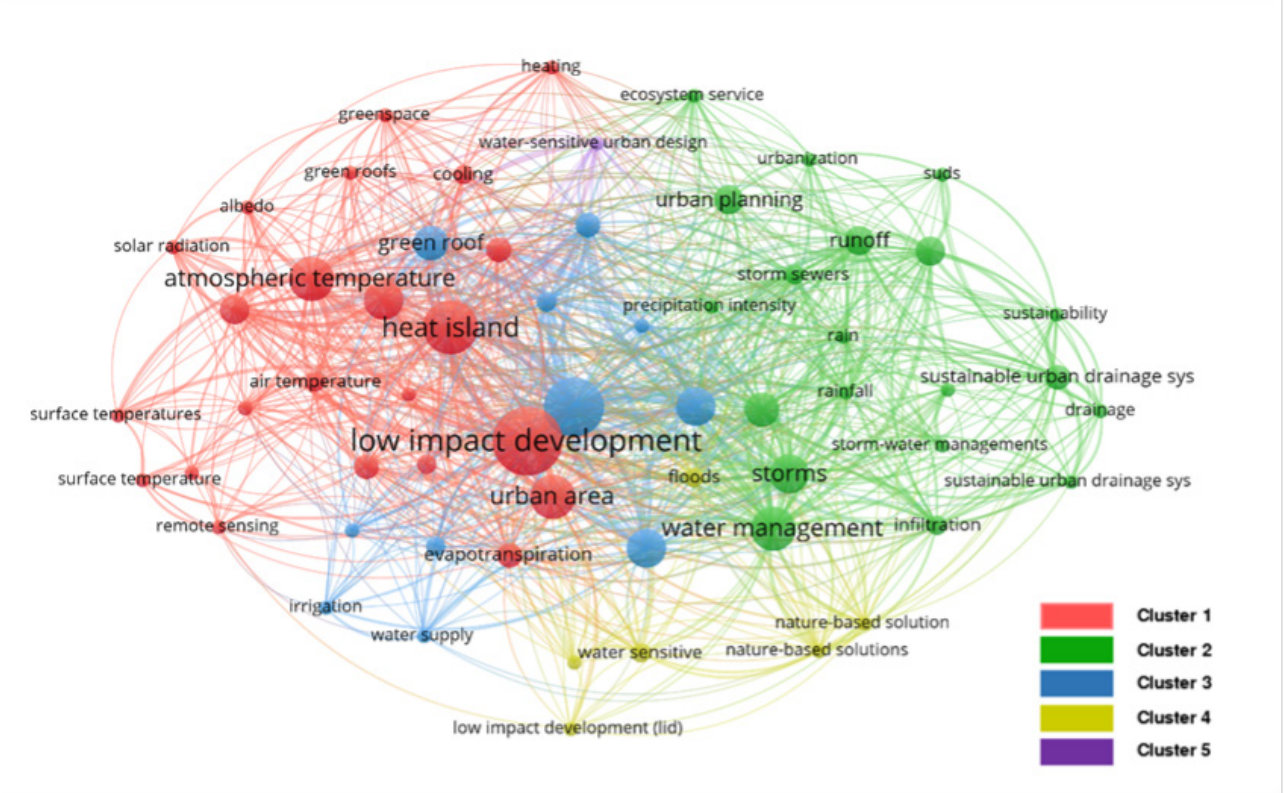

Figure 6. Analysis results of publications by All keywords (Author, 2024)

When Figure 6 is examined the most used keywords in the studies are listed as "urban design" (Occurences "Oc" = 12/ TLS= 148), "heat island" (Oc = 11/TLS =133), "low impact development" (Oc = 14/ TLS=117), "stormwater" (Oc=8/ TLS=116), "storms" (Oc=8/ TLS=107), Water management (Oc = 9/ TLS=104), Atmospheric temperature (Oc=9/ TLS= 92), Water sensitive urban design (Oc = 8/ TLS= 83), Green roof (Oc= 7/ TLS= 81), Water sensitive urban designs (Oc = 5/ TLS= 77). Furthermore, the VOSviewer map illustrates the organisation of keywords across five distinct clusters that reflect various approaches to urban environmental challenges, as indicated by our suggested titles. Cluster 1 (Red), titled "Urban Thermal Environment and Green Solutions," comprises 23 keywords that delve into the dynamics of the urban thermal environment, including air temperature, surface temperature, microclimate, and solar radiation, while exploring the implementation of green solutions such as green roofs and green infrastructure to alleviate the urban heat island (UHI) effect. In Cluster 2 (Green), titled "Stormwater Management and Urban Water Cycle," 20 keywords focus on the intricacies of stormwater management—encompassing elements like rain and runoff—within the broader framework of the urban water cycle, which considers infiltration and precipitation intensity. Cluster 3 (Blue), identified as

"Water-Sensitive Urban Design and Environmental Protection," comprises 11 keywords that integrate water-sensitive urban design (WSUD) with pressing environmental concerns, including water quality and supply, and emphasises the significance of urban planning and design. Cluster 4 (Yellow), with the title "Nature-Based Solutions for Urban Water Resilience," highlights the utilisation of nature-based solutions (NBS) to address urban water challenges, particularly flooding, within the context of increasing urbanisation. Lastly, Cluster 5 (Purple) denotes a concentrated focus on the term "Water-Sensitive Urban Design," encapsulating a specific aspect of the overall discourse. Together, these clusters represent interrelated themes in urban planning, climate adaptation, and environmental management.

In summary, this bibliometric analysis of keywords reveals a coherent framework surrounding the concepts of water-sensitive urban design, low-impact development, urban heat islands, and stormwater management. Moreover, the organisation of keywords into thematic clusters highlights the interconnectedness of various urban environmental challenges, signalling a strategic approach to urban planning. In addition, this structured understanding encourages interdisciplinary collaboration among researchers, promoting comprehensive solutions that address the multifaceted nature of urban sustainability challenges.

Research Question 6: (Review of Research Most Cited Articles on the Correlation Between Water Sensitive Urban Design and Urban Climate):

What is the current state of knowledge regarding the correlation between water-sensitive urban design and urban climate, as evidenced by a review of the most cited research articles on this topic? This research aims to synthesise the current state of knowledge on the relationship between water sensitive urban design (WSUD) and urban climate. To achieve this objective, a content analysis was conducted focussing on the ten most cited research articles in the field. This analysis sought to explore the established relationship between WSUD and urban climate, and the findings were organised around the following key questions:

What is the magnitude of the cooling effect associated with Water Sensitive Urban Design (WSUD)?

The analysed papers indicate that WSUD techniques, such as green roofs, water bodies, and irrigation, can provide significant cooling effects in urban areas [19, 20, 23, 26, 31, 35].

The cooling effect is primarily achieved through evapotranspiration and shading, which lower surface and air temperatures [19, 20, 23, 31]. Green roofs, in particular, can reduce urban temperatures by as much as 8–9°C compared to traditional roofs [28, 34].

The cooling effects of WSUD can also contribute to improved stormwater management, reduced energy consumption for cooling, and enhanced thermal comfort in urban areas [20, 26, 36]. Additionally, WSUD has been found to be a financially feasible and environmentally friendly approach to mitigate urban heat island effects and promote sustainable urban development [23].

In summary, the analysed papers highlight the significant cooling benefits of WSUD strategies, including green roofs, water bodies, and irrigation, which can help create more comfortable and resilient urban environments by reducing surface and air temperatures [19, 20, 23, 26, 28, 31, 34, 35, 36, 38].

How does the implementation of Water Sensitive Urban Design (WSUD) affect human thermal comfort in outdoor spaces?

The analysed papers indicate that WSUD has a significant positive impact on outdoor thermal comfort in urban areas [20, 23, 28, 31, 35, 36, 38].

WSUD techniques, such as green roofs, green spaces, water bodies, and irrigation, can lower surface and air temperatures through evapotranspiration and shading [23, 31, 38]. This can create cooler and more pleasant outdoor environments, reducing heat stress and improving overall livability for residents and visitors [20, 23].

The cooling benefits of WSUD can enhance outdoor thermal comfort, promote outdoor activities and social interaction, and contribute to energy savings and climate change mitigation [23, 35, 36]. Specifically, studies have shown that irrigation can reduce microscale air temperatures during heatwaves by up to 2.31°C, potentially improving human thermal comfort [31].

Furthermore, the incorporation of WSUD into urban planning and design can create more liveable and sustainable outdoor environments that prioritise the comfort and health of residents [20, 28]. WSUD has the potential to mitigate urban warmth and enhance human thermal comfort in outdoor spaces [31].

In summary, the analysed papers highlight the significant positive impact of WSUD on outdoor thermal comfort, demonstrating its ability to create cooler, more pleasant, and healthier urban environments [20, 23, 28, 31, 35, 36, 38].

How does these articles conceptualise and investigate Water Sensitive Urban Design (WSUD)?

The articles discuss the use of WSUD techniques to address various urban challenges, including mitigating the urban heat island effect, improving outdoor thermal comfort, and promoting sustainable urban development.

Several articles highlight the cooling effects of WSUD:

WSUD was the focus of [20] and [23] where they discuss the effectiveness of WSUD strategies like green roofs, green spaces, and water bodies in lowering temperatures and improving comfort in urban areas. Additionally, [31] and [38] specifically address the cooling potential of irrigation and artificial water bodies within WSUD.

Moreover, the cooling effects of WSUD were discussed by [26] and [36] highlighting its potential to mitigate the urban heat island effect and create more comfortable living environments, contributing to sustainability and climate change mitigation.

The articles also discuss the role of WSUD components in

addressing urban hydrology and stormwater management:

WSUD was emphasised by [19], [34] and [35] highlighting how through the use of green infrastructure like green roofs, WSUD can help to mitigate the impacts of urbanisation on the urban water cycle and address hydrological problems.

Additionally, [28] specifically address the application of green blue roofs as a WSUD practice to mitigate heat island effects and enhance climate resilience in urban areas.

Several articles also emphasise the broader benefits of incorporating WSUD in urban planning and design:

The concept of WSUD is thoroughly examined by [23] and [35] who recognise it as a crucial aspect of urban planning, as it can integrate water management with the built environment to improve human thermal comfort, manage flood hazards, and increase overall urban resilience.

Furthermore, [20] and [28] discuss the role of WSUD in creating more liveable and sustainable outdoor environments that prioritise the comfort and health of urban residents.

In summary, the analysed articles extensively address the various ways in which WSUD, through its components and strategies, can contribute to cooling urban environments, improving outdoor thermal comfort, enhancing stormwater management, and promoting sustainable and resilient urban development.

How did the articles explore the correlation between Water Sensitive Urban Design and the urban climate?

The articles highlight the significant relationship between WSUD and urban climate, specifically in the context of mitigating the urban heat island (UHI) effect and creating more resilient urban environments.

WSUD was the focus of [23] which explains how WSUD techniques, such as low-impact development and sustainable drainage systems, can combat urban flooding and reduce surface and air temperatures, thereby mitigating the adverse effects of climate change in urban areas. They also discuss the cooling effects of blue infrastructure like wetlands and water bodies.

In addition, the impact of green roofs—a key WSUD strategy—on stormwater management and the urban hydrological cycle in dry climates was addressed by [20] and [34]. They explore how green roofs can contribute to water-sensitive urban design while also influencing the urban climate through their thermal and hydrological properties.

Moreover, the importance of incorporating nature and natural processes in urban areas through WSUD was emphasised by [19] and [26]. This approach can significantly improve the urban microclimate and address pressing issues such as increased runoff and flood risks associated with urbanisation.

Similarly, the cooling effects of WSUD strategies, such as irrigation and water bodies, and their potential to mitigate heat stress while improving human thermal comfort in urban environments were investigated by [31] and [38].

Furthermore, [35] and [36] discuss how WSUD practices that promote green infrastructure and distributed stormwater management can influence the local urban climate, leading to decreases in peak urban temperatures and improvements in landscape amenity and human thermal comfort.

Additionally, [28] specifically address the application of green blue roofs as a WSUD practice to mitigate the urban heat island effect and enhance climate resilience in urban areas.

Overall, the articles emphasise the strong correlation between WSUD and urban climate, highlighting how WSUD strategies can help create more climate-resilient urban environments by reducing surface and air temperatures, improving urban water balance, and mitigating the negative impacts of urbanisation on the local climate.

To synthesise these findings, the reviewed articles collectively affirm the significant cooling effects that water-sensitive urban design (WSUD) strategies can have on urban environments, particularly in relation to mitigating the urban heat island (UHI) effect and improving outdoor thermal comfort. Also, research demonstrates that the integration of green infrastructure, such as rain gardens, permeable pavements, and green roofs, not only manages stormwater more effectively but also reduces surface temperatures in densely built environments. Consequently, these cooling effects promote a more favourable microclimate, which can enhance outdoor comfort, encourage increased outdoor recreational activity, and ultimately contribute to improved public health outcomes. Furthermore, the consensus across the literature highlights that adopting WSUD principles is essential for creating sustainable urban spaces that are resilient to the impacts of climate change. As such, these findings advocate for the prioritisation of WSUD in urban planning and policy-making processes, urging stakeholders to recognise its multifaceted benefits in combating climate-related challenges while simultaneously enhancing the overall living conditions in urban areas.

DISCUSSION

The bibliometric analysis conducted in this study offers valuable insights into the research landscape surrounding the correlation between Water Sensitive Urban Design (WSUD) and urban climate. The findings reveal a growing interest in this area, as evidenced by the increasing number of publications in recent years, particularly in 2022. However, the overall number of publications remains relatively low, highlighting the need for further research to advance our understanding of this critical topic.

Notably, the analysis identified several prominent journals and authors contributing to this field. The Journal of Hydrology, Urban Climate, and Ecological Engineering emerged as the top journals publishing research on the relationship between WSUD and urban climate. These journals' high impact factors and citation scores underscore the significance of this research area within the broader scientific community. Authors such as Simon C. Beecham, Ashley Mark Broadbent, Andrew M. Coutts, and Matthias Demuzere were among the most prolific contributors, indicating their substantial influ-

ence in shaping the discourse on this topic.

Also, the geographical distribution of research activity revealed a concentration of efforts in specific regions, with Australia, China, and the United States being the most productive countries. This pattern may be attributed to the heightened awareness and urgency surrounding urban climate challenges in these regions, as well as the availability of research funding and institutional support. However, it also highlights the need for more widespread global collaboration and knowledge sharing to address the universal challenges posed by urbanisation and climate change.

The content analysis of the most cited articles provided valuable insights into the current state of knowledge regarding the correlation between WSUD and urban climate. The reviewed studies consistently highlighted the significant cooling effects of WSUD strategies, such as green roofs, water bodies, and irrigation. These techniques were found to lower surface and air temperatures through evapotranspiration and shading, thereby mitigating the urban heat island effect and improving outdoor thermal comfort. Additionally, the articles emphasised the multifaceted benefits of WSUD, including improved stormwater management, reduced energy consumption, and enhanced urban resilience.

The keyword analysis further reinforced the prominence of topics such as "low impact development," "urban heat island," "green roofs," and "water sensitive urban design" within this research domain. These keywords reflect the core concepts and strategies being explored to address the interplay between urban water management and climate regulation.

Further, this bibliometric analysis presents a comprehensive overview of the research landscape while simultaneously highlighting lacunae and areas that warrant further investigation. Specifically, a notable absence of literature is observed in the examination of the specific mechanisms and pathways through which Water Sensitive Urban Design (WSUD) influences urban climate at varying spatial and temporal scales. Furthermore, there is a pressing need for additional research endeavours to quantify the long-term effects of WSUD strategies on urban temperatures, energy consumption, and human health, particularly in the context of climate change.

Moreover, the analysis highlighted a lack of diversity in the geographical distribution of research, with certain regions being underrepresented. This gap underscores the need for more collaborative efforts and knowledge exchange among researchers from different parts of the world, as urban climate challenges and solutions may vary across different geographical and cultural contexts.

In summary, this bibliometric analysis provides a comprehensive overview of the research landscape surrounding the correlation between WSUD and urban climate. While the findings underscore the potential of WSUD strategies in mitigating urban heat island effects and improving thermal comfort, they also reveal opportunities for further exploration and knowledge advancement in this critical area.

CONCLUSION

The rapid urbanisation witnessed in the 21st century has posed significant challenges for urban environments, particularly in terms of water management and climate regulation. Traditional urban landscapes, characterised by extensive impervious surfaces, have disrupted the natural hydrological cycle, exacerbating issues such as increased surface runoff, flooding risks, and the urban heat island effect. In response to these challenges, Water Sensitive Urban Design (WSUD) has emerged as a comprehensive approach that integrates water management principles with urban design and landscape planning.

This bibliometric analysis aimed to provide a comprehensive understanding of the research landscape surrounding the correlation between WSUD and urban climate. By systematically reviewing and analysing the relevant literature, this study sought to identify the most prominent research themes, temporal trends, geographic distribution of research activity, key authors and institutions, and the relationships between different research areas within this domain.

The findings revealed a growing interest in investigating the relationship between WSUD and urban climate, as evidenced by the increasing number of publications in recent years. However, the overall number of publications remained relatively low, highlighting the need for further research to advance our understanding of this critical topic. The analysis identified several prominent journals and authors contributing to this field, including the Journal of Hydrology, Urban Climate, and Ecological Engineering, as well as researchers such as Simon C. Beecham, Ashley Mark Broadbent, Andrew M. Coutts, and Matthias Demuzere.

Moreover, analysis of the geographical distribution of research activity indicated a spatial clustering of research efforts, with Australia, China, and the United States exhibiting the highest levels of productivity. This pattern can be attributed to a confluence of factors, including the heightened salience of urban climate challenges within these regions and the availability of robust research funding and institutional infrastructure. Nevertheless, the observed disparity in research output underscores the imperative for enhanced global collaboration and knowledge dissemination to effectively address the pervasive challenges stemming from urbanisation and climate change, which transcend geographical boundaries.

The content analysis of the most frequently cited scholarly articles yielded valuable insights into the current state of knowledge concerning the relationship between WSUD implementation and urban climate regulation. The reviewed literature consistently demonstrated the substantial cooling effects associated with various WSUD strategies, including green roofs, water bodies, and irrigation systems. These strategies were found to effectively decrease both surface and air temperatures through the processes of evapotranspiration and shading, thus mitigating the urban heat island effect and promoting enhanced outdoor thermal comfort. Furthermore, the analysed articles underscored the multifacet-

ed benefits of WSUD, encompassing improved stormwater management, reduced energy consumption, and increased urban resilience to environmental stressors.

The keyword analysis revealed the prominence of topics such as "low impact development", "urban heat island", "green roofs", and "water sensitive urban design" in this research domain. These keywords reflect the core concepts and strategies being explored to address the interplay between urban water management and climate regulation.

While the findings of this bibliometric analysis contribute to a better understanding of the research landscape, they also reveal potential gaps and areas for future investigation. For instance, there appears to be a dearth of literature examining the specific mechanisms and pathways through which WSUD influences urban climate at different spatial and temporal scales. Additionally, more research is needed to quantify the long-term impacts of WSUD strategies on urban temperatures, energy consumption, and human health, particularly in the context of climate change.

Furthermore, the analysis revealed a notable disparity in the geographical distribution of research output, with certain regions under-represented. This disparity highlights the imperative for enhanced collaborative endeavours and the facilitated exchange of knowledge among researchers from diverse geographical locations. Urban climate challenges and their corresponding solutions are demonstrably heterogeneous across varying geographical and cultural contexts, underscoring the need for a more globally representative research landscape.

Ultimately, this bibliometric analysis has provided a comprehensive overview of the research landscape surrounding the correlation between WSUD and urban climate. The findings underscore the potential of WSUD strategies in mitigating urban heat island effects, improving thermal comfort, and promoting sustainable urban development. However, the study also reveals opportunities for further exploration and knowledge advancement in this critical area.

As cities continue to grow and urbanisation accelerates, the implementation of WSUD principles will become increasingly crucial in creating resilient, liveable, and climate-adaptive urban environments. By integrating water management, urban design, and landscape planning, WSUD offers a holistic approach to addressing the complex challenges posed by urbanisation and climate change.

Moving forward, it is essential for researchers, policymakers, and urban planners to collaborate and leverage the existing knowledge base to develop and implement effective WSUD strategies. This may involve interdisciplinary research efforts, knowledge exchange platforms, and the development of comprehensive policy frameworks that encourage the widespread adoption of WSUD principles in urban planning and development.

Additionally, continued research is needed to address the identified knowledge gaps and deepen our understanding of the specific mechanisms and long-term impacts of WSUD on urban climate, energy consumption, and human health. Such research efforts should encompass a diverse range of geographical and cultural contexts, ensuring that WSUD strategies are tailored to local conditions and needs.

In conclusion, the successful implementation of WSUD will require a paradigm shift in how we perceive and design urban environments. By embracing a water-sensitive approach and incorporating natural processes into the built environment, we can create cities that are not only resilient to the challenges of urbanisation and climate change but also liveable, sustainable, and in harmony with the natural environments.

KEY FINDINGS

1.The study conducted a comprehensive bibliometric analysis of research on the correlation between Water Sensitive Urban Design (WSUD) and urban climate from 2014 to 2023.

2.A total of 38 relevant publications were identified and analysed from the Scopus database.

3.The year 2022 saw the highest number of publications (8) on this topic, indicating growing interest in recent years.

4.The Journal of Hydrology emerged as the most productive journal in this field, with 4 publications and the highest number of citations.

5.Simon C. Beecham was identified as the most prolific author, with 4 publications specifically on WSUD and urban climate.

6.Australia was found to be the leading country in terms of research output, with 14 publications (37% of total).

7.Monash University in Australia was the most productive institution, with 5 publications in this field.

8.The most cited article was "Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation" with 164 citations.

LIMITATION

There are several limitations to this study. The Scopus database was the only source used for data collection, which may have resulted in the exclusion of relevant articles from other academic databases such as WoS. Additionally, this analysis did not include the most recent publications from 2024 in Scopus. However, these limitations are unlikely to significantly affect the trends and patterns identified in this research. Furthermore, the data set was limited to articles that specifically mentioned the following terms: 'water sensitive urban design', 'sustainable urban drainage systems', 'low impact development', 'cooling', 'thermal comfort', 'urban climate', and 'urban heat island'. This use of precise search terms may have resulted in a narrower data set.

In light of these limitations, it is important to note that there are still significant gaps in the literature that warrant further investigation. Consequently, future studies might consider

the following research questions:

•How do the performance and effectiveness of different WSUD strategies vary across various climate zones?

•In what ways can the combination of different WSUD strategies enhance the resilience of urban areas to extreme events such as floods, droughts, and heatwaves?

•How does modelling WSUD interventions within GIS improve predictions of local microclimates?

•How can GIS visualisation facilitate the adaptation of WSUD designs to different cultural and environmental contexts?

•In what ways can smart technology be integrated with GIS to enhance the monitoring and optimisation of WSUD systems?

•What are the long-term ecological and urban climate impacts resulting from implemented WSUD projects over time?

•Which research methodologies are most commonly utilised in WSUD literature, and how have they evolved over time?

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

1. United Nations, Department of Economic and Social Affairs, Population Division. "World Urbanization Prospects 2018 Highlights," United Nations, 2019.
2. L. Teang, (2021). " Modelling The Impact of Water Sensitive Urban Design on Pluvial Flood Management in a Tropical Climate (Master's thesis)," THAMMASAT UNIVERSITY.
3. M. Banjara, A. Bhusal, A. B. Ghimire, and A. Kalra, "Impact of Land Use and Land Cover Change on Hydrological Processes in Urban Watersheds: Analysis and Forecasting for Flood Risk Management," Geosciences, Vol. 14(2), pp. 40, 2024.
4. V. R. S. Cheela, M. John, W. Biswas, and P. Sarker, "Combating Urban Heat Island Effect—A Review of Reflective Pavements and Tree Shading Strategies," Buildings, Vol. 11(3), pp. 93, 2021.
5. S. Samouei, and M. Özger, "Evaluating the Performance of Low Impact Development Practices in Urban Runoff Mitigation Through Distributed and Combined Implementation," Journal of Hydroinformatics, Vol. 22(6), pp. 1506–1520, 2020.
6. M. E. Dietz, "Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions," Water, Air, and Soil Pollution, Vol. 186, pp. 351–363, 2007.
7. J. C. Radcliffe, " History of Water Sensitive Urban Design/Low Impact Development Adoption in Australia and Internationally." In A. K. Sharma, T. Gardner, and D. Begbie, (Eds.). Approaches to Water Sensitive Urban Design. Elsevier. pp. 1–24, 2019.
8. W. Peiyao, "Application of Sponge City Concept in Urban Waterfront Landscape Design," Academic Journal of Architecture and Geotechnical Engineering, Vol. 6(3), pp. 1–5, 2024.
9. L. R. N. P. Rentachintala, M. G. M. Reddy, and P. K. Mohapatra, "Urban Stormwater Management for Sustainable and Resilient Measures and Practices: A Review," Water Science and Technology, Vol. 85(4), pp. 1120–1140, 2022.
10. Y. Yuan, Q. Zhang, S. Chen, F. Chen, and M. Zhang, "Design and Spatial Pattern Optimization for a Sponge City Using Factor Analysis and Geographical Statistics to Restore Urban Resilience: A Case Study in a Coastal Area of China," Water Science and Technology, Vol. 88(9), pp. 2246–2263, 2023.
11. C. Zevenbergen, D. Fu, and A. Pathirana, "Transitioning to Sponge Cities: Challenges and Opportunities to Address Urban Water Problems in China," Water, Vol. 10(9), pp. 1230, 2018.
12. F. Ahammed, "A Review of Water-Sensitive Urban Design Technologies and Practices for Sustainable Stormwater Management," Sustainable Water Resources Management, Vol. 3, pp. 269–282, 2017.
13. A. Chao Guerbatin, and F. Ahammed, "Climate Change Impacts on Water Sensitive Urban Design Technologies," Sustainability, Vol. 16(4), pp. 1568, 2024.
14. T. D. Fletcher, W. Shuster, W. F. Hunt, R. Ashley, D. Butler, S. Arthur, S. Trowsdale, S. Barraud, A. Semadeni-Davies, J.-L. Bertrand-Krajewski, P. S. Mikkelsen, G. Rivard, M. Uhl, D. Dagenais, and M. Viklander, "SUDS, LID, BMPs, WSUD and More – The Evolution and Application of Terminology Surrounding Urban Drainage," Urban Water Journal, Vol. 12(7), pp. 525–542, 2015.
15. M. J. Mouritz, (1996). " Sustainable Urban Water Systems: Policy and Professional Praxis (Doctoral dissertation)," Murdoch University.
16. S. S. B. Patil and C. Anbalagan, "A Contemporary Approach on Water Sensitive Urban Design for

Sustainable Urban Development," Materials Today: Proceedings, [Preprint], 2023.
17. J. Schirmer and F. Dyer, "A Framework to Diagnose Factors Influencing Proenvironmental Behaviors in Water-Sensitive Urban Design," Proceedings of the National Academy of Sciences, Vol. 115(33), pp. E7690–E7699, 2018.
18. M. S. Lariyah, M. D. Mohd Nor, Z. A. Mohamed Roseli, M. Zulkefli, and M. P. Amirah Hanim, (2011, September 10-15). " Application of Water Sensitive Urban Design at Local Scale in Kuala Lumpur " [Paper presentation]. 12nd International Conference on Urban Drainage, Porto Alegre, Brazil.
19. R. Hakimdavar, P. J. Culligan, M. Finazzi, S. Barontini, and R. Ranzi, "Scale Dynamics of Extensive Green Roofs: Quantifying the Effect of Drainage Area and Rainfall Characteristics on Observed and Modeled Green Roof Hydrologic Performance," Ecological Engineering, Vol. 73, pp. 494–508, 2014.
20. M. Razzaghmanesh, S. Beecham, and T. Salemi, "The Role of Green Roofs in Mitigating Urban Heat Island Effects in The Metropolitan Area of Adelaide, South Australia," Urban Forestry & Urban Greening, Vol. 15, pp. 89–102, 2016.
21. H. Abuhassna, F. Awae, K. Bayoumi, D. U. Alzitawi, A. H. Alsharif, and N. Yahaya, "Understanding Online Learning Readiness among University Students: A Bibliometric Analysis," International Journal of Interactive Mobile Technologies (iJIM), Vol. 16(13), pp. 81–94, 2022.
22. A. Hassan, N. Yahaya, M. A. Z. M. Zakaria, N. Abu Samah, and A. H. Alsharif, "A Bibliometric Analysis of Sustainability in Future Education: Trends and Future Agenda," Sains Humanika, Vol. 14(3–2), pp. 167–176, 2022.
23. B.-J. He, J. Zhu, D.-X. Zhao, Z.-H. Gou, J.-D. Qi, and J. Wang, "Co-benefits Approach: Opportunities for Implementing Sponge City and Urban Heat Island Mitigation," Land Use Policy, Vol. 86, pp. 147–157, 2019.
24. A. M. Broadbent, A. M. Coutts, N. J. Tapper, and M. Demuzere, "The Cooling Effect of Irrigation on Urban Microclimate During Heatwave Conditions," Urban Climate, Vol. 23, pp. 309–329, 2018.
25. J. L. Senosiain, "Urban Regreeneration: Green Urban Infrastructure as a Response to Climate Change Mitigation and Adaptation," International Journal of Design & Nature and Ecodynamics, Vol. 15(1), pp. 33–38, 2020.
26. L. Rosenberger, J. Leandro, S. Pauleit, and S. Erlwein, "Sustainable Stormwater Management Under The Impact of Climate Change and Urban Densification," Journal of Hydrology, Vol. 596, pp. 126137, 2021.
27. D. R. Richards and P. J. Edwards, "Using Water Management Infrastructure to Address Both Flood Risk and The Urban Heat Island," International Journal of Water Resources Development, Vol. 34(4), pp. 490–498, 2017.
28. M. Shafique and R. Kim, "Application of Green Blue Roof to Mitigate Heat Island Phenomena and Resilient to Climate Change in Urban Areas: A Case Study from Seoul, Korea," Journal of Water and Land Development, Vol. 33, pp. 165–170, 2017.
29. K. N. Irvine, H. H. Loc, C. Sovann, A. Suwanarit, F. Likitswat, R. Jindal, T. Koottatep, J. Gaut, L. H. C. Chua, L. W. Qi, and K. De Wandeler, "Bridging the Form and Function Gap in Urban Green Space Design through Environmental Systems Modeling," Journal of Water Management Modeling, Vol. 29, pp. C476-1-19, 2021.
30. P. Fensterseifer, E. Gabriel, R. Tassi, D. G. A. Piccilli, and B. Minetto, "A Year-Assessment of The Suitability of a Green Façade to Improve Thermal Performance of an Affordable Housing," Ecological Engineering, Vol. 185, pp. 106810, 2022.
31. A. M. Broadbent, A. M. Coutts, N. J. Tapper, M. Demuzere, and J. Beringer, "The Microscale Cooling Effects of Water Sensitive Urban Design and Irrigation in a Suburban Environment," Theoretical and Applied Climatology, Vol. 134, pp. 1–23, 2018.
32. C. Rey-Mahía, L. A. Sañudo-Fontaneda, V. C. Andrés-Valeri, F. P. Álvarez-Rabanal, S. J. Coupe, and J. Roces-García, "Evaluating the Thermal Performance of Wet Swales Housing Ground Source Heat Pump Elements through Laboratory Modelling," Sustainability, Vol. 11(11), pp. 3118, 2019.
33. Y. Zhang, H. Qin, J. Zhang, and Y. Hu, "An In-situ Measurement Method of Evapotranspiration from Typical Lid Facilities Based on The Three-Temperature Model," Journal of Hydrology, Vol. 588, pp. 125105, 2020.
34. M. Razzaghmanesh and S. Beecham, "The Hydrological Behaviour of Extensive and Intensive Green Roofs in a Dry Climate," Science of the Total Environment, Vol. 499, pp. 284–296, 2014.
35. P. J. Alexander, R. Fealy, and G. M. Mills, "Simulating The Impact of Urban Development Pathways on The Local Climate: A Scenario-Based Analysis in The Greater Dublin Region, Ireland," Landscape and Urban Planning, Vol. 152, pp. 72–89, 2016.
36. D. A. Brent, L. Gangadharan, A. Lassiter, A. Leroux, and P. A. Raschky, "Valuing Environmental Services Provided by Local Stormwater Management," Water Resources Research, Vol. 53, pp. 4907–4921, 2017.
37. A. H. Alsharif, N. Z. Md Salleh, R. Baharun, Y. H. Alsharif, and H. Abuhassna, "A Bibliometric Analysis of Neuromarketing: Current Status, Development and Future Directions," International Journal of Academic Research in Accounting Finance and Management Sciences, Vol. 11(3), pp. 828–847, 2021.
38. A. Broadbent, (2016). " The Effect of Water Sensitive Urban Design and Outdoor Water-Use Practices on Urban Microclimate (Doctoral dissertation)," Monash University.