International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Water-Positive Housing Design Strategies in Africa: A Bibliometric Analysis

Frank Frimpong Opoku[1], Otie Pokua Yankyera[2], David Oppong Asare[3], Alexander Boakye Marful[4], Titus Ebenezer Kwofie[5]

[1]Department of Architecture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana / Department of Built Environment, University of Environment and Sustainable Development, Somanya, Ghana
[2,3,4,5]Department of Architecture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract
Water-positive housing design strategies play a significant role in promoting water security and resilience in Africa. Literature asserts that water scarcity in Africa is increasing due to rapid urbanization, climate change, and population growth. It is crucial to understand the extent to which research has progressed in addressing the research gaps and identifying knowledge areas that require further exploration in Africa. This study examines these research areas, identifies knowledge gaps in the literature, and outlines the direction for further research. The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) protocol was adopted in this study. Articles used were limited to English. One hundred fifty-two (152) articles were obtained from the SCOPUS database. The study employed Bibilometrix and VOSviewer software to generate the outcomes, and a qualitative study was conducted. The study's conclusions offer a comprehensive overview of water-positive housing design strategies in Africa, providing valuable insights for both academics and non-academics.

Keywords: Water-Positive, Sustainable-Water, Housing, Water Management, Green Building, Africa

1. Introduction

Water is essential for human survival, economic development, health, and environmental protection. Access to safe water is crucial for well-being. A lack of potable water causes waterborne illnesses like diarrhea, typhoid fever, electrolyte imbalances, cholera, gastrointestinal diseases, and even death (Abanyie et al., 2025) .

There is a need to manage and conserve water because of rapid urban growth, population growth, and climate change, which have resulted in water scarcity, a reduction in water quality, and distribution in Africa (Ismail et al., 2024). There is an increasing need for research on how to efficiently use the limited water supply to meet demand. The housing sector heavily consumes water from municipal or primary sources. (Nnaji et al., 2019). Accordingly, there is a growing emphasis on adapting water-positive housing design strategies.

Water-positive housing design strategies refer to:

1. An integrated and holistic approach that looks at all the components of a building and site, as well as

water management systems (Eberhard and Quick, 1995; Ismail et al., 2024).
2. Maximization of water demand through the use of efficient fixtures, landscaping, and behavioural solutions (Ismail et al., 2024; Worku, 2017).
3. Optimizing on-site water collection and reuse systems, including greywater recycling and rainwater harvesting. (Worku, 2017).
4. Net-positive water balance that looks at houses producing more than their water consumption levels (Eberhard and Quick, 1995).
5. Environmental sustainability that emphases the reduction of over extraction and treatment of groundwater, hence protecting the ecosystem (Worku, 2017; Zaręba et al., 2022).
6. Promoting water resilience and security, as well as water affordability in housing (Belmeziti et al., 2025; Worku, 2017).

Over the years, research on aspects of water-positive housing design strategies has increased. Critical issues on water governance, water management, sustainability in housing design, water quality, health risks in housing, water supply, and urban housing have been examined in the literature (Belmeziti et al., 2025; Frimpong et al., 2021; Nhongo and Dinka, 2025; Zaręba et al., 2022). The data used for the study were obtained from SCOPUS.

The period under review was from 1995 to July 2025. The research questions for this study are as follows:

1. What are the research domains in water-positive housing design strategies in Africa, looking at the dominant authors, co-authors, dominant countries, average citations, co-authorship Network, universities with more publications, and corresponding authors' country?
2. What are the dominant keywords and themes in research on water-positive housing design strategies in Africa?
3. What are the future research directions and knowledge gaps in the study of water-positive housing design strategies in Africa?

By answering these questions, the study offers a systematic overview of the field. This study is critical because it guides future research and highlights knowledge gaps in water-positive housing design strategies that can be adopted by academics, designers, non-academics, and policymakers in the effort to improve the availability and sustainable management of water and sanitation for all (Sustainable Development Goal 6). The subsequent part of the study is organized into subsections. Section 2 outlines the research methodology employed. Section 3 presents the results from the bibliometric analysis related to the first two research questions. Section 4 presents a discussion that analyses the findings, identifies knowledge gaps, and suggests future research directions in water-positive housing design strategies. The final section, Section 5, concludes the study and reviews its limitations.

2. Materials and Methods

2.1 Research approach

A bibliometric analysis was employed in this study. To achieve the set objectives, a sequential exploratory design was used. Both quantitative and qualitative methods, as employed by Agyei et al. (2024) was employed. This was intended to help clarify the various domains of research and to deepen appreciation of themes and knowledge gaps in the field. To ascertain a systematic structure for the study, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to retrieve scholarly articles (Donthu et al., 2021). According to Page et al. (2021), the PRISMA approach is a more rigorous, structured, and preferred way for structured reviews. Scopus was chosen for this study because it offers a

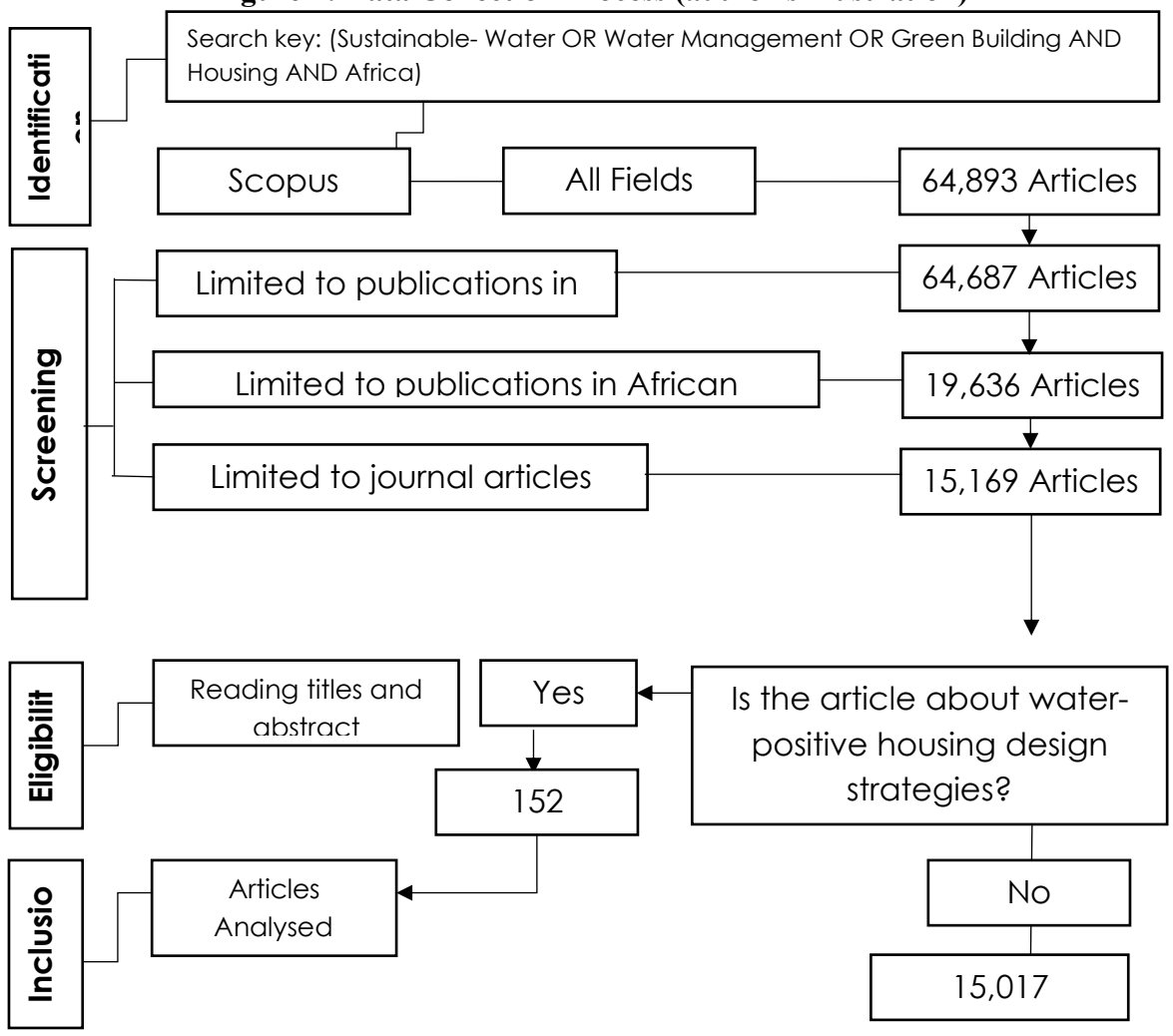
high level of coverage, high-quality content, and the most extensive scientific database for bibliometric research (Donthu et al., 2021). Examining water-positive housing strategies, which encompass a wide range of aspects, Scopus provides a more comprehensive literature assessment.

2.2 Data collection

To obtain the required documents for the study, the PRISMA approach was used, following the keywords. Water-positive housing strategies look at ways to reduce water consumption and promote sustainable water conservation and management (Fakere et al., 2018; Thakur et al., 2022). The data for this study were gathered on July 14, 2025. The Boolean strings were used in conjunction with the keywords (sustainable water architecture OR sustainable housing OR water management strategies OR green building design AND Africa) for the search.

There was no limit to the period of publication. A total of 64,893 Articles were obtained from all fields in Scopus. The articles were screened to be in the English language only. To further ensure the rigor and quality of analysis, an exclusion criterion (limited to publications in African countries and journal articles) was applied. Lastly, for eligibility, the articles were further screened by using titles and abstracts, and a total of 152 articles were included in this study. These processes are similar to those described in studies by Agyei et al. (2024). They are illustrated in Figure 1. The analysis of 152 articles was conducted using VOSviewer and the R software package (Bibliometrix).

Figure 1: Data Collection Process (author's illustration)



2.3 Data analysis

In this study, we used BiblioShiny, an open-source tool for comprehensive scientific mapping, and VOSviewer, a Java-based application for analysis. BiblioShiny (Bibliometrix) was chosen because it supports co-author network analysis, tracking annual scientific output, analyzing authors' keywords, visualizing keyword occurrence networks, creating thematic maps, and more.

Also, the VOSviewer was used for visual citation network analysis (Aria and Cuccurullo, 2017). After obtaining the data from the software, a detailed thematic analysis was conducted to identify gaps in the literature and propose future research paths.

3. Results

This section is divided into two main parts. The first part provides a comprehensive overview of water-positive housing design strategies in Africa, encompassing annual production, citations, authorship, co-authorship, university publications, and the countries of the corresponding authors. The second part examines authors' keywords, the keyword occurrence network, and the thematic areas in the literature. The dataset for the study is found in Table 1.

Overall, 152 documents were reviewed, and 602 authors have published. The period is from 1995 to 2025 (July). This suggests that ongoing research in this area is still ongoing, with a growth rate of 8.32 percent. Over the 30-year period, this indicates an increase in the rate of publications in this subject area. With an average age of 4.89 percent, the study area appears current, indicating related knowledge gaps. The average citation per document stands at 15.12 percent, which means that, on average, most articles in the study have been cited by others 15 times. It emphasizes the increasing interest among researchers in this field. With 1,237 keywords (generated from the articles and titles) and 568 authors' keywords, it suggests that the various authors are focused on specific aspects of the research area. The co-authorship per document (4.29), 53.95 percent international co-authorship, and seven single-authored documents suggest a high level of collaborative and international research on water-positive housing strategies in Africa.

Table 1: Sample Statistics (author's illustration)

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1995 to July 2025
Documents	152
Annual Growth Rate %	8.32
Document Average Age	4.89
Average citations per document	15.12
DOCUMENT CONTENTS	
Keywords Plus (ID)	1237
Author's Keywords (DE)	568
AUTHORS	
Authors	602
Authors of single-authored docs	7
AUTHORS COLLABORATION	
Single-authored Documents	7

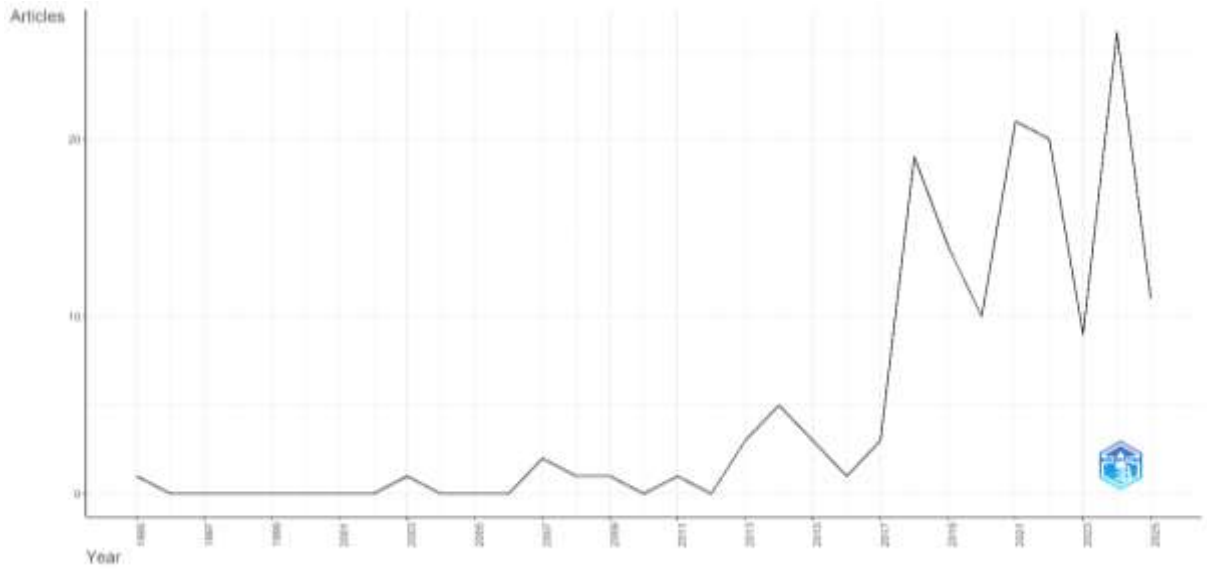
Co-Authors per Documents	4.29
International co-authorships %	53.95
DOCUMENT TYPES	
Article	152

3.1 Water-Positive Housing Strategies in Africa Research Field

This subsection provides a general overview of the research area, focusing on annual scientific production, authors' productivity, co-authors' citations, universities that have made significant contributions to water-positive housing strategies in Africa, and the countries of corresponding authors.

Figure 2 provides a general overview of publications from 1995 to 2025 (as of July 14th). Annual scientific production must be examined to understand whether the study area is gaining attention and inform researchers on the extent of work done (Lima and Carlos Filho, 2019). It is observed that the first publication on water supply and sanitation in urban South Africa was "Getting it right during the transition and beyond" (Eberhard and Quick, 1995). The period from 1996 to 2006 recorded no publications on the subject area, except for 2003, which had one publication. The period between 2007 and 2017 recorded very low publication numbers, with an average of 1 to 2 publications per year. The years 2018 to 2022 saw an increase in publications, totalling 84, which represents 55.26 percent (more than half) of the publications used in this study. Nine publications were seen in 2023, and a sharp increase in 2024, which recorded 26 publications. By the end of 2025, there will have been a record 11 publications. From the analysis, it is observed that there is a gradual increase in interest in the subject area, and several discoveries have been unearthed, adding to the body of knowledge.

Figure 2: Annual Scientific Production from 1995 to July 2025



According to Donthu et al. (2021), it is essential to examine the average citations within the study period to comprehend the significance of various constituents in the research domain. Figure 3 shows the total number of citations over the period. It is observed that very low citations were recorded between 1995 and 2017, suggesting a lesser impact in the study area. The years 2018 to 2023 saw a rise in citations, indicating an increase in interest among researchers in the field of study. Twenty-six citations were recorded in 2024,

indicating a significant increase in the research area. Research in the area of water-positive housing strategies has improved and increased over the years. The last five years have seen a rise in impact and research interest in this field. Figure 4, on the other hand, highlights the 10 most cited authors in the field of water-positive housing strategies. Water Governance and Justice (Enqvist and Ziervogel, 2019), accessing water services (Nganyanyuka et al., 2014), and quality assessment and primary use of water (Dobrowksy et al., 2014), recording 151, 157, and 99 citations over the period. This emphasizes the fact that water governance, water justice, access to water, and water quality focus are the primary areas of research.

Figure 3: Average Citations from 1995 to July 2025

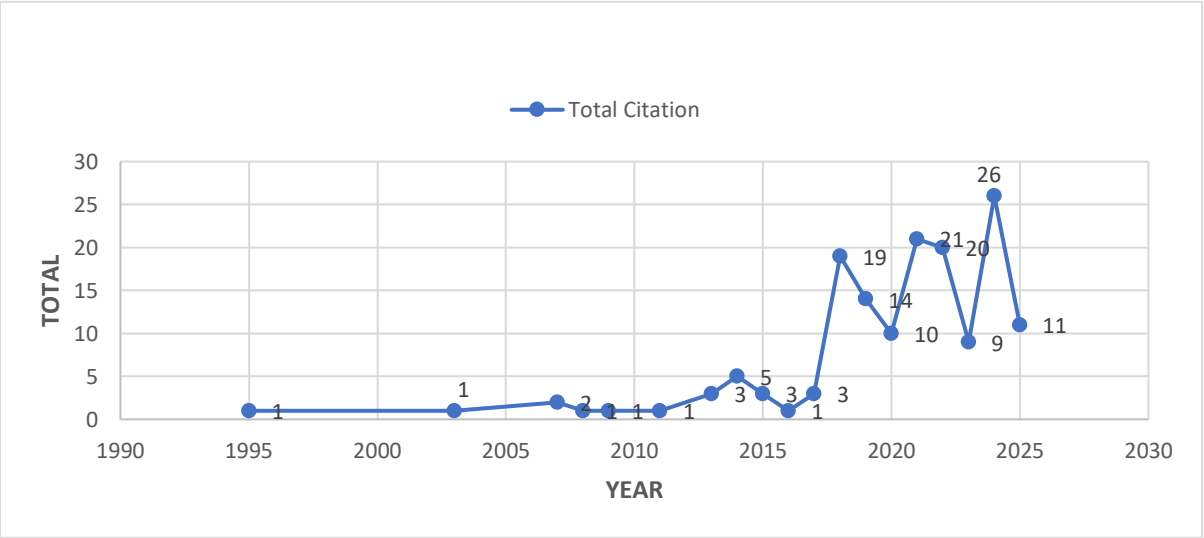
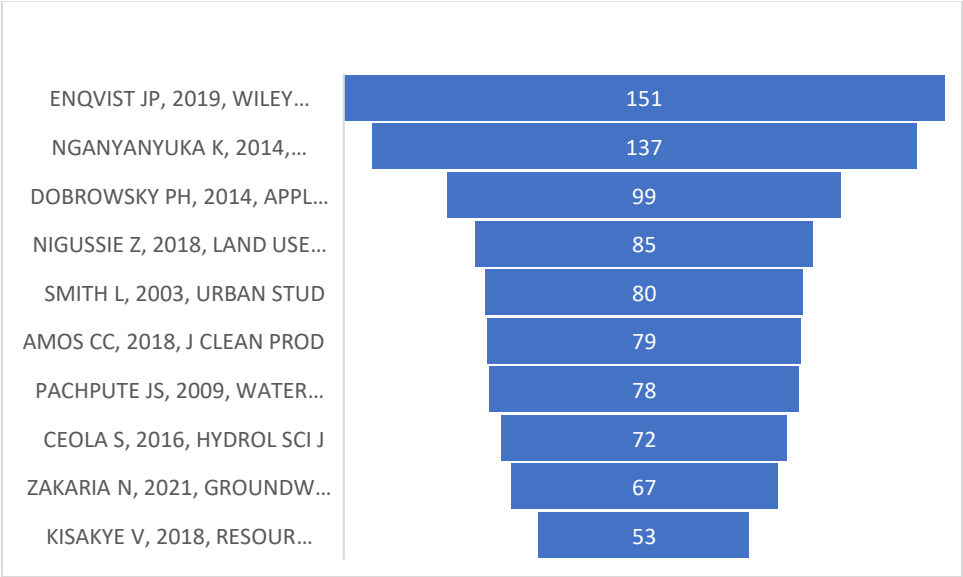


Figure 4: Most Citations Authors



Figures 5 and 6 show that Jacobs H. E. is the lead contributor over the period, with five articles published in 2014, 2017, 2018, 2021, and 2022. Carden K, Frimpong L.K., Winter K., and Khan W., published 4,3,3,3, respectively. This implies that fewer than 1% of authors over the period have published three or

more documents. Notably, the increase in publications from Table 2 suggests a rise in publications from 2018.

Figure 5: Top 10 Most Production Authors

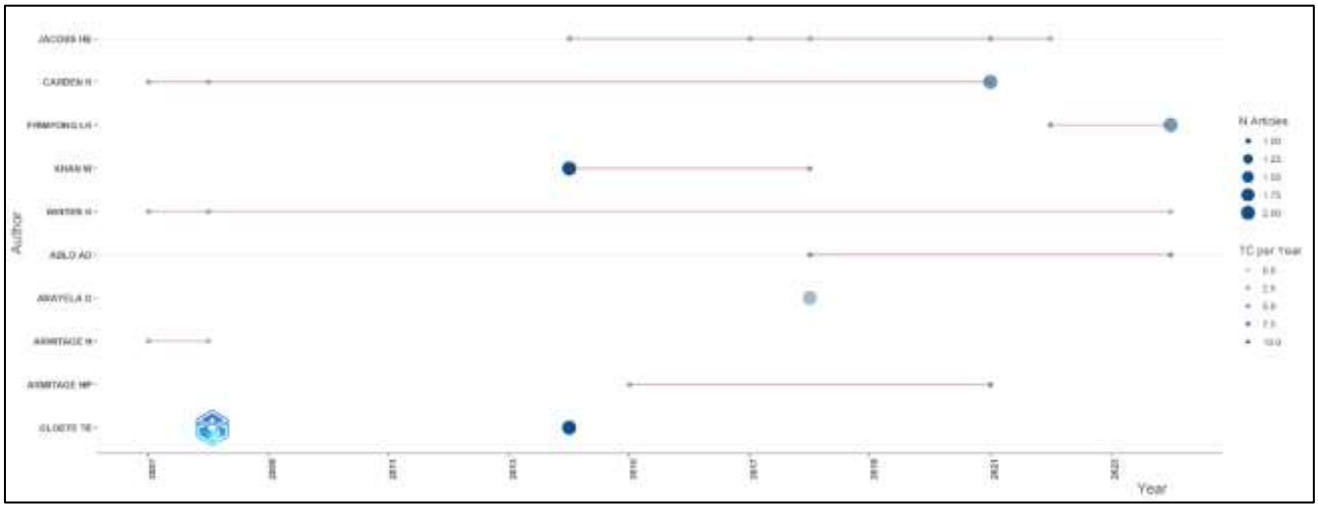
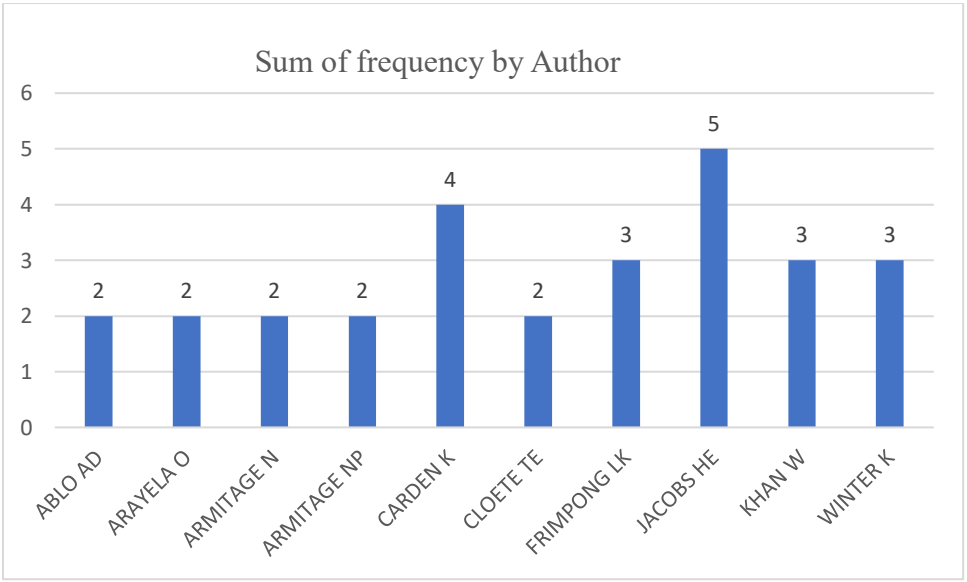


Figure 6: Top 10 Most Productive Authors (frequency)



Several collaborations on articles have occurred during the review period. Figure 7 illustrates the co-authorship network, which is divided into 11 clusters. It is observed that Carden K., Khan W., Jacobs H. E., and Winter K. have the most collaborations in the study in Africa. The collaboration between Carden, Armitage, Winter, Sichone, and Armitage is the strongest among the study's participants. They look at how to dispose of and manage grey water from households. It examines the importance of using grey water and provides planning and management guidelines for managing grey water. They conclude on how policies on greywater management can be implemented for sustainable water management (Carden et al., 2007). The second strongest collaboration is between Khan, Dobrowsky, and De Kwaadsteniet. They looked at how rainwater harvesting can be the solution to global water deficiency (Dobrowksy et al., 2014).

Figure 7: Co-authorship Network

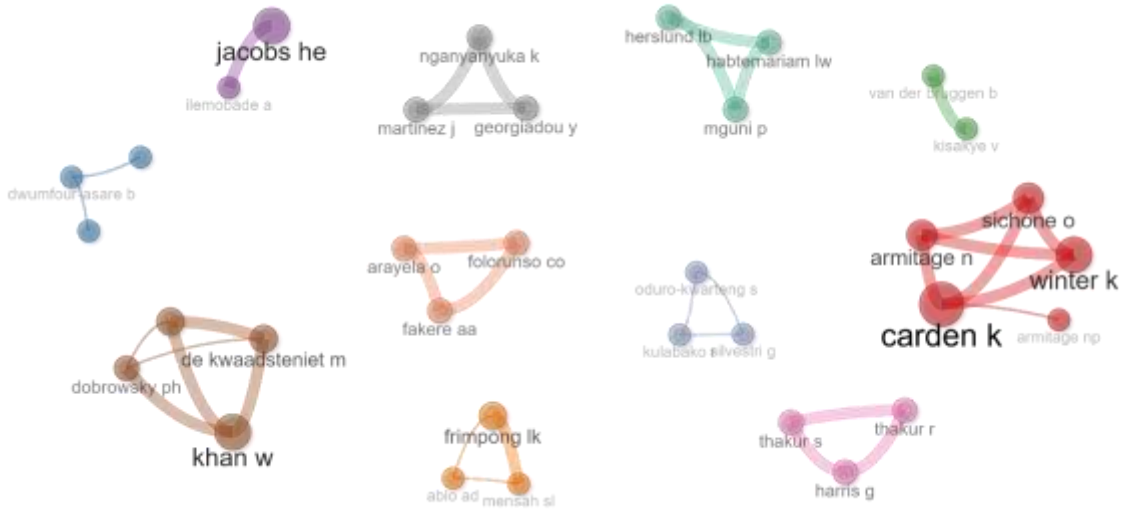


Figure 8 examines the top 10 universities with the most publications on water-positive housing strategies in Africa. The University of Cape Town and the University of Ghana are the top universities with 18 publications each. The University of Johannesburg has published 17 articles. Figure 9, on the other hand, examines the top 10 countries with the highest corresponding authors and illustrates the balance between their Single-Country Publications (SCP) and Multiple-Country Publications (MCP). South Africa, Ghana, and Ethiopia have 33, 21, and 13 articles, respectively. They are the countries of the highest corresponding authors. Moreover, the countries with the highest MCP, which suggests a 100% international correspondence, are Canada, Australia, Algeria, the Netherlands, and the USA. It is evident from Figures 8 and 9 that the top two countries and universities with the highest number of publications and correspondence are still from South Africa and Ghana. This suggests that African countries are not only seeking single-author publications but also strive for a balance of international collaborations.

Figure 8: Top 10 Universities with more Publications

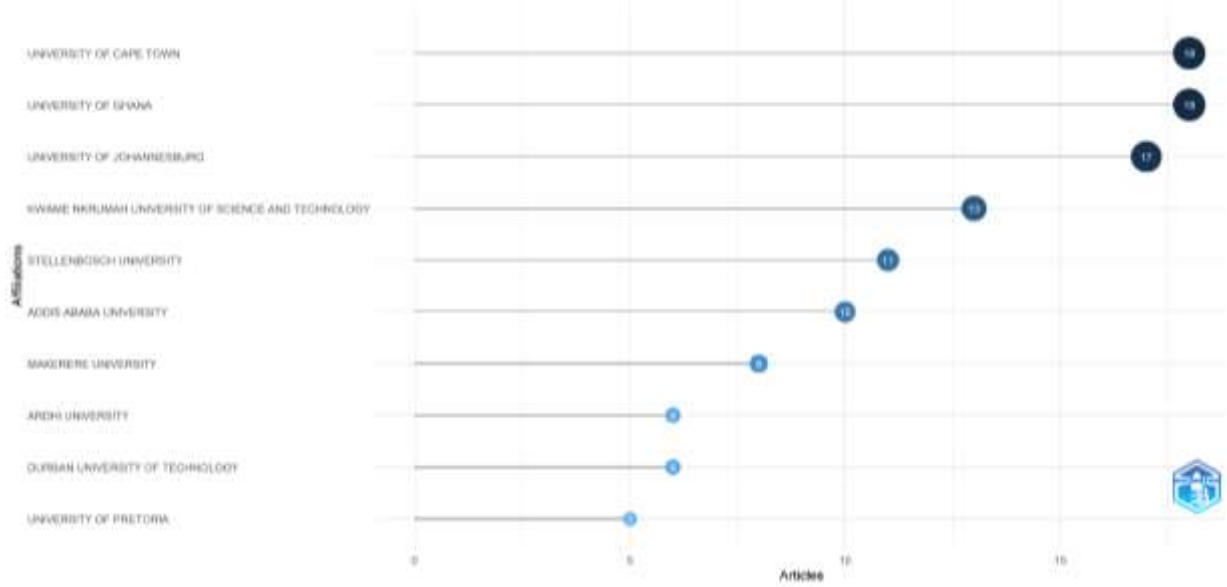
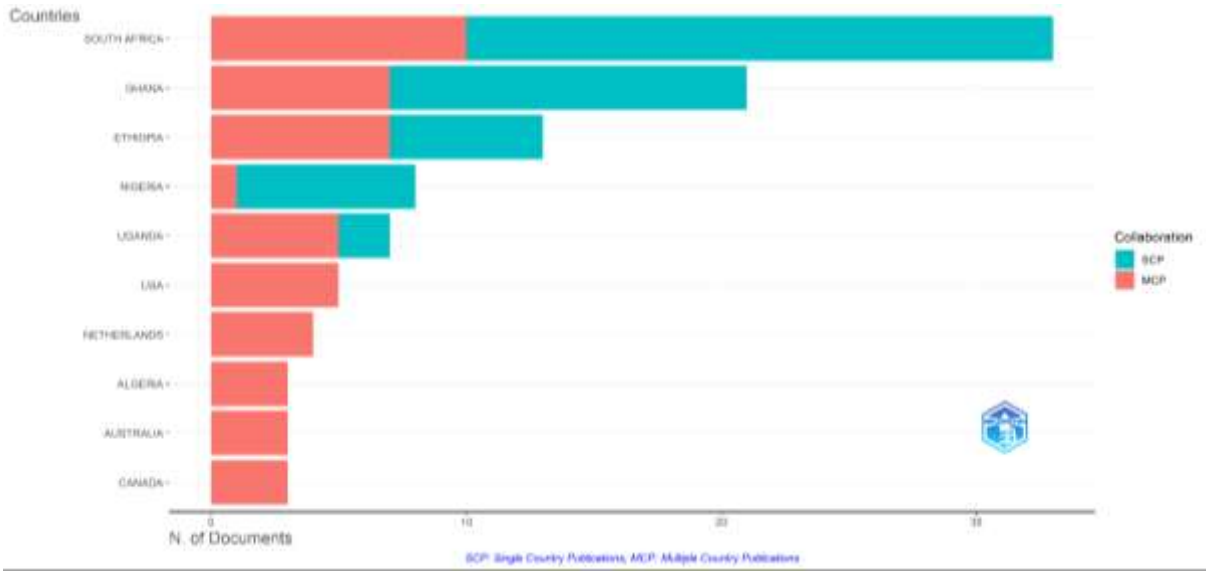


Figure 9: 10 Corresponding Authors Country



This first section provides a general overview of the water-positive housing design Strategies literature in Africa, highlighting key authors, correspondence, citations, and universities with the highest number of publications. The ensuing section expands on the thematic areas in literature to help appreciate and understand the dominant regions of literature, as well as the emerging themes and research directions.

3.2 Thematic Analysis

In this section, the dominant thematic areas in research on water-positive housing design strategies are examined. The keywords used by authors in literature are examined, as well as the co-occurrence network of these keywords. This aids in determining the thematic areas within the field of study (Naeem et al., 2023).

Figure 10 shows the 50 most common dominant keywords. The bigger the size of the word, the more predominant the keyword. It is seen that water supply, water management, and water quality are the three most dominant keywords, looking at their sizes. In addition, the top 10 keywords with their corresponding occurrences are, water supply (59), water management (46), water quality (32), South Africa (28), drinking water (26), Ghana (24), sanitation (24), potable water (23), water source (18) and articles (17). These keywords identify the dominant research areas, serve as the basis for thematic analysis, reveal trends, and indicate areas to focus on in the data reviewed for water-positive housing strategies.

Figure 11 shows the 10 most frequent authors' keywords. It shows a higher rate of growth in keyword frequency from 2015 compared to previous years. Research has increased from 2015 to date, and the different keywords, such as "water supply" (in magenta) and "water management" (in blue), have shown the highest growth over the period. Others, such as Ghana (in olive green) and South Africa (in cyan), continue to dominate in the keywords, confirming their impact, as seen in Figure 9, which shows the two countries leading the field in research on water-positive housing strategies. Generally, it is observed that all these authors' keywords are increasing in terms of their usage.

Figure 10: Fifty (50) most common authors' keywords

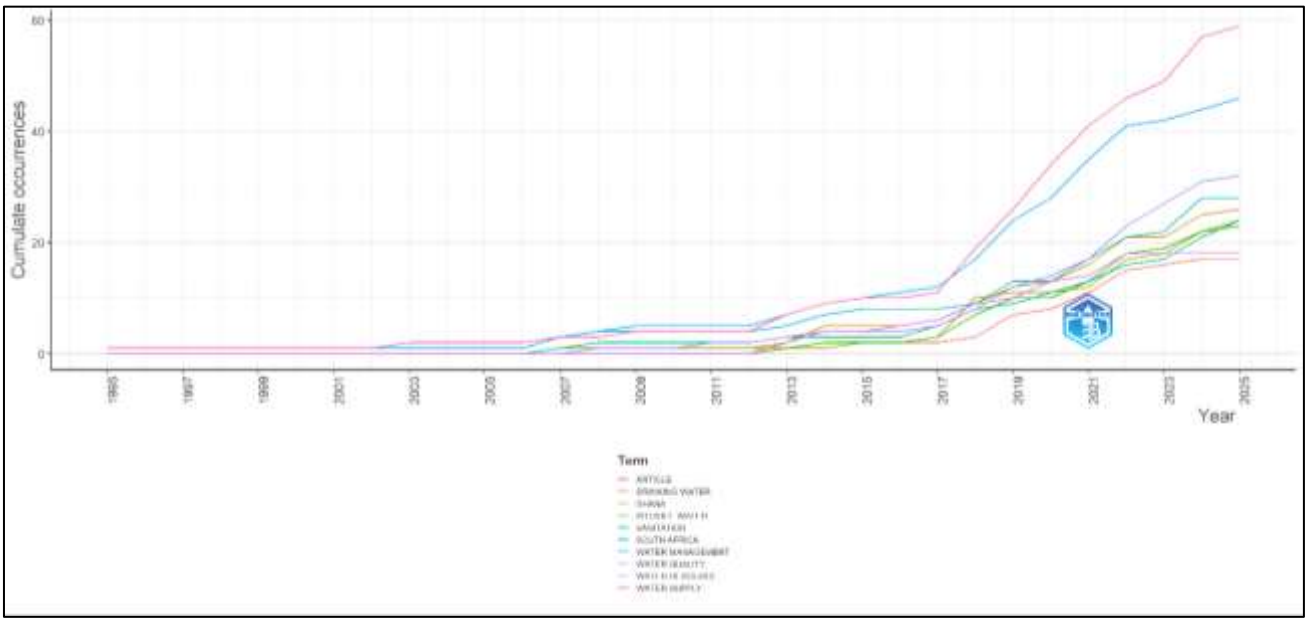


Figure 11: Ten most Frequent Authors' keywords used over time

To further analyse and group the keywords into themes, a VOSviewer software analysis was done. This analysis examined 90 keywords, with the minimum number of occurrences set at 5. The total number of links and total link strengths analysed were 1,897 and 4,453, respectively. The circle sizes, corresponding to the respective keywords, indicate their frequency levels. The bigger the circle, the greater the weight, and the lines connecting the circles are called links. The shorter the line, the stronger the relationship (Cvetkoska et al., 2023).

Three distinct colours group the key words into sub-themes under water-positive housing strategies. The dominant key highlights are water management (red), water quality (green), and water supply (blue), as confirmed in Figure 10. The first cluster (red) encompasses water management, water demand, sustainable development, potable water, housing, water conservation, and rainwater harvesting, as indicated by its keywords. These relate to the sub-theme, water management and sustainability in housing design. Water quality, water pollution, the World Health Organisation, microbiology, wastewater, and health risks are all found under cluster 2 (green). These relate to a sub-theme, water quality and health risks in housing. Lastly, some keywords under cluster 3 (blue) include water supply, urbanization, household survey, water planning, urban areas, and Greater Accra. These are related to the sub-theme of water supply and urban housing.

Figure 12 shows the various nodes that represent the keywords and terminologies from the dataset. The different node sizes represent the frequency of occurrence. The larger the size, the higher the frequency, and the smaller the circle, the lower the frequency. The network lines represent the co-occurrence relationships between the keywords. Thicker lines indicate stronger co-occurrence links, and the proximity of circles shows how often they appear together in research.

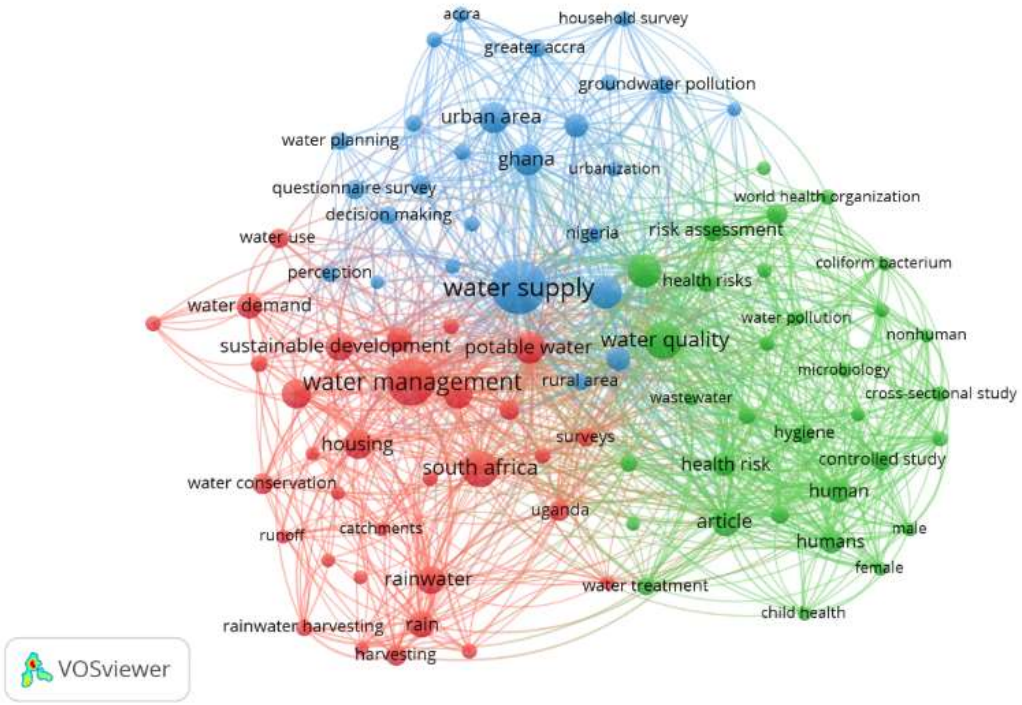


Figure 12: Keyword Occurrence Network

Figure 13 confirms Figure 2, illustrating the periods for the keyword occurrences as 2018 (in dark purple) and 2021 (in yellow). The dominant keywords, as illustrated in Figure 13, between 2018 and 2021 were water management, water supply, and water quality, which confirm the key sub-themes identified in Figure 12. South Africa and Ghana are again seen as leaders in water-positive housing research, according to Figure 13.

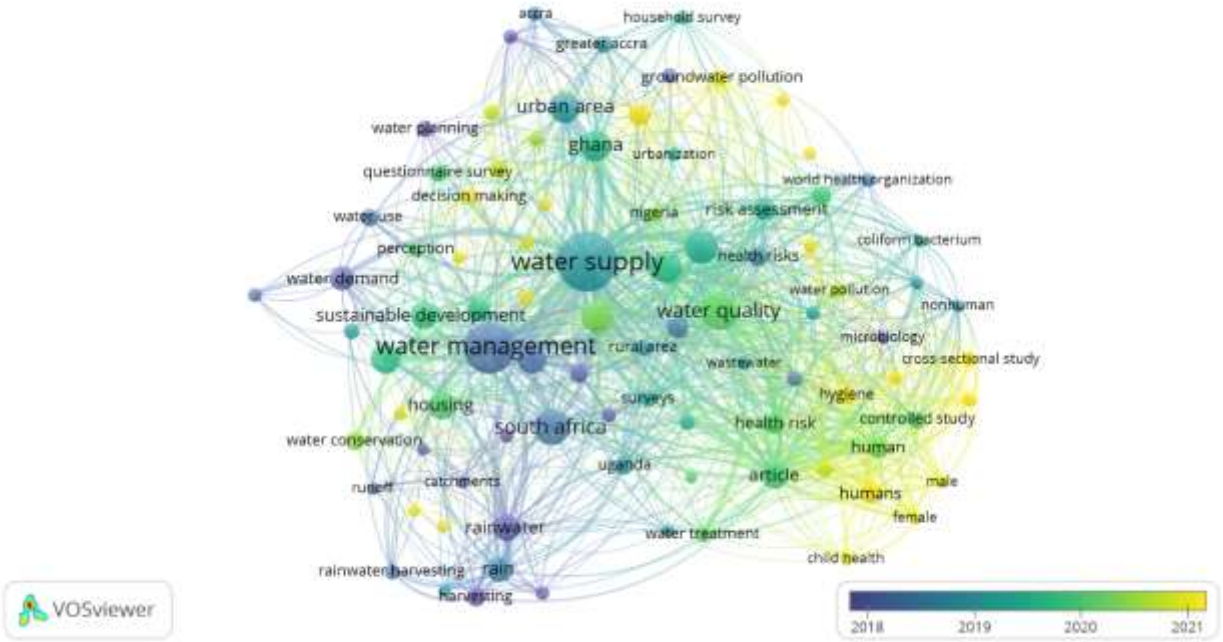


Figure 13: Keyword Occurrence Overlay Visualization

Table 2 provides further support for the cluster (sub-themes) used in the analyses. It shows the keywords and their respective links, occurrences, and total link strengths. Water supply has the highest link (88), occurrence (67), and total link strength (522). This emphasizes that water supply is a significant keyword when it comes to the water-positive housing strategy research field (Cvetkoska et al., 2023).

Table 2: 15 Keywords and their Links (authors' illustration)

Position	Keyword	Cluster Number	Occurrence	Link	Total link strength
1	Water supply	3	67	88	522
2	Water management	1	51	86	361
3	Water quality	2	32	81	321
4	South Africa	1	29	57	157
5	Drinking water	2	26	77	273
6	Sanitation	3	24	64	196
7	Potable water	1	23	72	201
8	Urban area	3	22	54	141
9	Ghana	3	22	63	167
10	Sustainability	1	20	36	112
11	Housing	1	19	52	130
12	Article	2	18	71	256
13	Rainwater	1	18	52	141
14	Water Demand	1	15	39	91
15	Health Risk	2	13	62	165

A thematic map analysis was conducted to gain an understanding of the current state, and a study was performed to inform future research directions in water-positive housing strategies. The thematic map has four quadrants, each highlighting a different theme. These are the Niche, Emerging/ Declining, Motor, and Basic themes (Bagdi et al., 2023). The map features a vertical axis indicating density (development level) and a horizontal axis representing Centrality (Relevance Level). The placement of clusters on these axes determines their density or centrality.

- **Niche Themes and Emerging/ Declining Themes**

Niche themes are well-developed but lack centrality. This means they have fewer links to the core field of study. These are located at the top left of Figure 14. Emerging/ Declining Themes have both low centrality and density. They are either less developed or fading out as subjects (Rahim Thaha et al., 2025). These are located at the bottom left of Figure 14. The key themes that intersect are water demand, climate change, rainwater harvesting, water conservation, water planning, water use, rain, rainwater, and housing. These are both underexplored and have fewer connections to other themes. Water conservation is crucial to help reduce water scarcity (Bigurra-Alzati et al., 2021). To achieve water sustainability in the urban space, there is a need to explore rainwater harvesting as an alternative water source (Ndeketeya and Dundu, 2019). These studies, among others, highlight the need to concentrate research on these themes to promote water-positive strategies in Africa.

- **Niche Themes and Motor Themes**

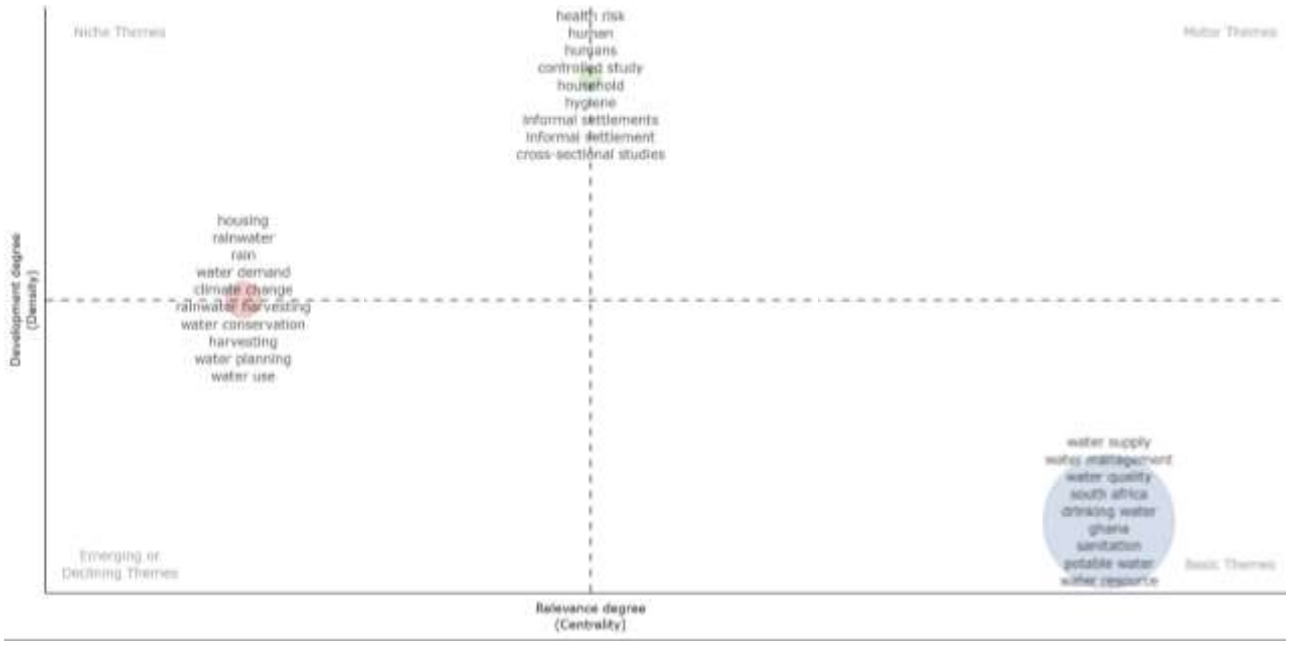
Motor Themes are highly developed with high centrality, indicating strong connections to related topics and playing a significant role in advancing the research area (Rahim Thaha et al., 2025). These are located at the top right of Figure 14. The illustration shows again a centrality (relevant degree) line intersecting both Niche and Motor Themes. This suggests that the themes of health risk, human, household, hygiene, and Informal settlements are significant areas that need to be further explored in research. These are well-researched areas, but since they still fall under the Niche themes, they have not yet reached their full impact; hence, further research is needed to achieve full centrality.

- **Basic Themes**

These are crucial themes, but they are underdeveloped. They need further development since they have low density but high centrality (Rahim Thaha et al., 2025). These are located at the bottom right of Figure 14. Water supply, water management, water quality, drinking water, sanitation, potable water, and water resources are essential themes, but are underdeveloped. The figure suggests that these themes should be explored in future research on water-positive housing strategies. Dusabe et al. (2019) as mentioned, there is a need to provide basic quality water for human survival. Poor sanitation can be a result of inadequate water supply in households, which can result in diarrhoea among children and in the informal housing settlements (Nguyen et al., 2021). Water management is also crucial since there is a limited potable water supply in households (McClelland et al., 2022). These studies, among others, highlight the importance of further research in this area, especially on these particular topics.

South Africa and Ghana, within the Basic theme, emphasize the significance of country collaboration. There is a need for further research on water–positive housing strategies to enhance the understanding of water management, resources, policy, technology, and potable water supply. Conducting empirical studies in these areas will help bridge the existing knowledge gaps.

Figure 14: Thematic Map



4. Discussion

This section provides a general overview of water-positive housing design strategies in Africa. A qualitative analysis was conducted better to understand the themes, support interpretation of the findings, mitigate potential biases, and meet the research objectives.

4.1 Research Topics

4.1.1 Water Management and Sustainability in Housing Design.

The literature indicates that water-positive housing design strategies address both water management and broader sustainability issues in housing. Efficient water management should be incorporated into housing design, starting from water supply to wastewater treatment. At the household level, decentralizing water management systems is essential. Rainwater harvesting as well as greywater recycling can promote housing water resilience and sustainability (Moghayedi, 2024). Similarly, implementing greywater and rainwater harvesting as a housing design strategy can provide an alternative source of water, supplementing the primary source, which is limited in supply. Zaręba et al. (2022) support the other authors by also highlighting that stormwater can be considered a water-positive housing design within a green infrastructure system strategy. Again, it is argued that incorporating permeable pavements, swales, green roofs, and retention ponds into housing design can help reduce flooding and waste from running water. These alternative water sources can be used for toilet flushing, watering plants, and the like (Angmor et al., 2024; Carden and Fell, 2021; Mukwarami and Fakoya, 2022; Thakur et al., 2022). Another key aspect of water management and sustainability, as mentioned by Abraham et al. (2015), This involves using water-efficient fixtures like low-flow toilets, showerheads, and taps. These design choices in housing help reduce indoor water use. Thakur et al. (2022) agree and add that there is also a need for behavioural change by household water users since people turn to waste water by their actions. Awareness creation, education, and the like can help promote water conservation and efficiency.

The aspects of landscaping as a means of water sustainability are also not left out. Drought-resistant landscaping and proper irrigation design concepts help minimize outdoor water usage. Cost is one of the

main concerns for families when it comes to water-positive housing design strategies. For these above strategies to be economically sustainable, it is essential, according to Belmeziti et al. (2025), to look at a cost-effective water management design solution. This has an impact on equitable accessibility by households (Thakur et al., 2022).

For governance and policy implementation purposes, examining the water supply deficits in Africa as a whole, there must be community engagement and participation. Government policies should be tailored to stress the importance of effective implementation when it comes to water issues (Moghayedi, 2024). There are a series of case studies in the literature showing how water management and sustainable housing design strategies have been implemented and their successes. In South Africa, for example, innovative technologies and studies on water usage behaviours have been employed in affordable housing (Mukwarami and Fakoya, 2022; Thakur et al., 2022). Also, Addis Ababa in Ethiopia is looking at water conservation and stormwater management strategies in housing as a policy (Moghayedi, 2024; Mukwarami and Fakoya, 2022).

The literature indicates that, due to water scarcity, there is a need to manage and employ sustainability design strategies. The use of technology, education, policy, affordability principles, reuse systems, recycling approaches, and decentralization systems in housing design will go a long way to promote water efficiency and conservation in housing in Africa.

4.1.2 Water Quality and Health Risks in Housing

The quality and health risks associated with household water are critical because they directly impact people's health. Key aspects of water-positive housing design strategies are informed by this issue.

According to Gbedemah et al. (2024) and Nhongo and Dinka (2025), there are several unsafe water supply sources, such as surface water and open wells. These expose users to numerous waterborne diseases. Abanyie et al., (2025) supports by adding that some of these waterborne diseases are diarrhoea, cholera, typhoid fever, electrolyte imbalances, gastrointestinal illnesses, and even death, especially for the vulnerable population. There is usually an outbreak of these diseases when water sources are not adequately treated, contaminated, or when there are poor hygiene practices (Nhongo and Dinka, 2025). When there is an outbreak, Abanyie et al., (2025) adds, children, the elderly, and those with a weak immune system usually suffer.

Apart from the issues with water scarcity and unsafe water sources, poor sanitation and waste discharge also pose significant health risks. Poor sewage systems, improper discharge of wastewater, inadequate sanitary facilities, and the like pollute water bodies and affect drinking water quality (Sindane and Modley, 2023).

The primary factors influencing water quality in Africa include the absence of basic services like clean water and sanitation. (Sindane and Modley, 2023). Baddianaah et al. (2024) further adds that inadequate and poorly designed infrastructure for water and sanitation is also a critical factor. Gbedemah et al., (2024) agrees and adds that climate change also impacts water quality and its availability. During these changes, there are droughts, floods, and sometimes concentrated pollution.

It is essential to critically examine these issues and develop strategies to mitigate or eliminate their impact on households. Water treatment methodologies, education on hygiene, provision of improved sanitary facilities, and introduction of water quality control and monitoring systems help reduce health risks and improve water delivery and use quality (Baddianaah et al., 2024; Kihila and Balengayabo, 2020; Tesfay Abraha et al., 2024).

4.1.3 Water Supply and Urban Housing

This section examines the challenges of water supply for housing, including the causes of inequality in water access, governance and management issues, and sustainable solutions and alternative strategies for water-positive housing in Africa.

Belmeziti et al. (2025) and Frimpong et al. (2024) suggest that the primary causes of water supply irregularities in many households stem from inadequate or poorly maintained water infrastructure. These could be leakages, old pipes that need replacement, or poor distribution pipe networks. Rapid urbanization, in contrast to the rate of development in terms of water, has led to water scarcity and access issues. Frimpong et al. again mention that urbanization and informal settlement development against a limited water supply push households to rely on alternative water supply options. These are usually expensive and cannot be relied on.

In addition to the above, low-income households usually face the challenge of low water supply compared to high-income households. This prompts them to purchase water from alternative sources rather than municipal or primary ones (Frimpong et al., 2024).

Several institutional challenges, such as financial constraints, operational problems, and households' inability to pay water levies, can affect water management and governance. Additionally, weak governance frameworks hinder the delivery of water services across Africa (Ablo and Yekple, 2018; Braimah et al., 2018; Frimpong et al., 2024).

It is essential to provide sustainable solutions to the above issues to enhance water efficiency. Frimpong et al. suggest that an integrated Urban Water Management (IUWM), which looks at water supply, stormwater management, and sanitation, be employed. The issue of demand management also needs to be looked at. There should be the implementation of water consumption technologies in design, and water-saving behavioural education (Abraham et al., 2015; Inkani et al., 2021; Moghayedi, 2024). Design strategies, such as incorporating rainwater harvesting techniques, water reuse systems, and recycling, should be integrated into design concepts to provide alternative water sources, thereby reducing pressure on potable water and enhancing water security. (Abraham et al., 2015; Inkani et al., 2021; Lewis et al., 2018; Moghayedi, 2024; Worku, 2017). Ablo and Yekple (2018), further emphasize that to achieve water sustainability and equitable solutions, community or stakeholder engagements should be prioritized.

4.2 Knowledge Gaps and Future Research Directions

After a careful study in the subject area limited to the African context, several knowledge gaps and future research directions have been identified.

Table 3: Knowledge Gaps and Future Research Directions (authors' illustration)

Key Issues Identified	Knowledge Gaps and Future Research Directions
Water Policy and Governance	i. Empirical research on policies and frameworks that can promote water-positive housing in Africa. ii. Empirical research into Low-income governance systems with respect to water infrastructure systems.
Technical, Technological Innovations, and Architectural Design Strategies	i. An integrated design framework for water-positive architecture.

Community-level Dynamics	i.	Comparative analysis of water management in various housing typologies and their impact on housing.
Socio-Economic and Behavioural Aspects	i.	An empirical study on individuals' behavioural patterns, cultural practices, and socio-economic traits related to water supply and usage.

This is illustrated in Table 3 and discussed below:

4.2.1 Water Policy and Governance

Belmeziti et al. (2025) have pointed out that there have been some policies governing water conservation, supply, and the like. What is missing in current research is a comprehensive water-positive housing design policy and governance framework that actively involves local communities in decision-making processes related to water management. Again, governance systems and policies that look at water infrastructure and its design in the low-income communities should be examined (Frimpong et al., 2024).

4.2.2 Technical, Technological Innovations, and Architectural Design Strategies

The research has resulted in various new technologies and innovations, such as Internet of Things (IoT) strategies that enable monitoring and management of water supply and usage (Abraham et al., 2015; Dickson-Gomez et al., 2023). Again, there have been several design strategies, such as rainwater harvesting, stormwater management, the use of bioswales, building materials selection, both indoor and outdoor water connection systems, water-efficient technology specifications, the sponge city concept, water-sensitive urban design, and green infrastructure strategies, among others. (du Toit and Wagner, 2022; Inkani et al., 2021; Moghayedi, 2024; Worku, 2017; Zaręba et al., 2022). There is a need to evaluate and establish a comprehensive integrated design framework for water-positive architecture that encourages water efficiency and conservation across Africa (Dolman, 2023).

4.2.3 Community-level Dynamics

Studies have highlighted specific typologies, such as the informal sector, and its water-related issues, including a lack of access to potable water. (Frimpong et al., 2024). There is a need for a comparative study on the design strategies, supply systems, water usage, water management systems, and sanitation for the different housing typologies in the communities.

4.2.4 Socio-Economic and Behavioural Aspects

Literature has highlighted some key behavioral attitudes related to water conservation and management. These include wasteful water consumption practices, failure to pay water levies, over-reliance on the government for water supply, and misconceptions about using greywater and rainwater. (Baddianaah et al., 2024; Carden et al., 2008; Nganyanyuka et al., 2018; Thakur et al., 2019). To advance research, an empirical study on the behavioural patterns of individuals, the cultural practices, and the socio-economic characteristics of the supply and usage of water should be conducted.

5. Conclusion

Water is essential for human survival. It is a basic human need. Water promotes human hygiene, helps prevent diseases, regulates the human temperature, and sustains the ecology (Ahmed et al., 2022; Baddianaah et al., 2024; Tesfay Abraha et al., 2024). “The provision of clean water is regarded as the heart of all the Sustainable Development Goals” (Mukwarami and Van der Poll, 2023). There is therefore a need to look at water-positive design strategies in housing to be able to adequately design, supply, use, manage, and conserve water. There have been several studies in this field, but there is a need to assess the level of

research done to determine the knowledge gap as well as the future research directions, especially in Africa. This study looked at water-positive housing design strategies, focusing on articles produced over time, authors and co-authors who have contributed to the advancement of water-positive knowledge, as well as institutions, various dominant keywords, and a thematic analysis that helped to identify the knowledge gap and direction for future research.

The study was limited to the SCOPUS database, and a total of 152 articles were collected. Enqvist and Ziervogel (2019) with water governance and justice, Nganyanyuka et al. (2014) with accessing water services, and Dobrowksy et al. (2014) with quality assessment and primary use of water were the most cited authors. The number of citations recorded was 151, 157, and 99, respectively, over the period. These authors also doubled as the most influential authors in Africa when it comes to water-positive housing design strategies publications. South Africa and Ghana lead the ranking of African countries with the most publications. There were several keywords, but the three dominating ones in the study were water supply, water management, and water quality, which showed the direction of the study so far. From the analysis of the keywords and cluster themes, three sub-themes were qualitatively analyzed. These were Water Management and Sustainability in Housing design, Water Quality and Health Risks in Housing, and Water Supply and Urban Housing Design. Through the analysis, five research topics and four knowledge gaps were identified for further study.

An integrated study of policies and governance related to water-positive housing design strategies is crucial to strengthening and implementing current policies and governance systems. This approach will help address water scarcity challenges and promote community involvement in decision-making (Belmeziti et al., 2025). The literature emphasizes various technical, technological, and architectural design strategies that support water conservation and efficiency (Moghayedi, 2024; Worku, 2017; Zaręba et al., 2022). Conducting empirical research in this area can identify practical solutions and frameworks to aid their implementation. Given the variety of housing types, an empirical study comparing design features like water supply systems, quality, usage, management, and sanitation can guide policy and decision-making. Additionally, future research should explore the socio-economic and behavioral factors influencing water use.

This study examined published journal articles exclusively from the SCOPUS database, limited to English-language publications. Other sources, such as different databases, languages, conference papers, and books, were excluded, despite potentially containing relevant and significant articles. Nonetheless, the SCOPUS database offers a high-quality resource within underexplored research areas. The study also makes a notable contribution to knowledge by providing a comprehensive overview of water-positive housing design strategies in Africa. Its findings are valuable to academics, non-academics, designers, practitioners, and policymakers, offering insights into prior research, highlighting future research directions, and identifying existing knowledge gaps in water-positive housing design strategies across Africa.

References

1. Abanyie S. K., Amuah, E. E. Y., Nang, D. B. (2025). Water scarcity and its implications on sanitation: A perspective study in an emerging city in Northern Ghana. *Green Technologies and Sustainability, 3,* 100138. https://doi.org/10.1016/j.grets.2024.100138

2. Ablo, A. D., & Yekple, E. E. (2018). Urban water stress and poor sanitation in Ghana: Perception and experiences of residents in the Ashaiman Municipality. *GeoJournal.* https://doi.org/10.1007/s10708-017-9787-6
3. Abraham, E. M., Martin, A. M., Cofie, O., & Raschid-Sally, L. (2015). Urban households' access to water for livelihoods enhancement in Accra, Ghana. *Waterlines.* https://doi.org/10.3362/1756-3488.2015.014
4. Agyei, V., Adom-Asamoah, G., & Poku-Boansi, M. (2024). Sustainable transportation in Africa: A bibliometric, visualisation and thematic analysis. *Journal of Cleaner Production, 462,* 142727. https://doi.org/10.1016/j.jclepro.2024.142727
5. Ahmed, H., Zolfo, M., Williams, A., Ashubwe-Jalemba, J., Tweya, H., Adeapena, W., Labi, A.-K., Adomako, L. A., Addico, G. N., & Banu, R. A. (2022). Antibiotic-resistant bacteria in drinking water from the Greater Accra Region, Ghana: A cross-sectional study, December 2021–March 2022. *International Journal of Environmental Research and Public Health, 19,* 12300. https://doi.org/10.3390/ijerph191912300
6. Angmor, E., Frimpong, L. K., Mensah, S. L., & Okyere, S. A. (2024). Exploring the institutional barriers to rural water management in Ghana. *Water Policy, 26,* 921–940. https://doi.org/10.2166/wp.2024.130
7. Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11,* 959–975. https://doi.org/10.1016/j.joi.2017.08.007
8. Baddianaah, I., Dongzagla, A., & Salifu, S. N. (2024). Navigating access to safe water by rural households in sub-Saharan Africa: Insights from north-western Ghana. *Sustainable Environment, 10,* 2303803. https://doi.org/10.1080/27658511.2024.2303803
9. Bagdi, T., Ghosh, S., Sarkar, A., Hazra, A. K., Balachandran, S., & Chaudhury, S. (2023). Evaluation of research progress and trends on gender and renewable energy: A bibliometric analysis. *Journal of Cleaner Production, 423,* 138654. https://doi.org/10.1016/j.jclepro.2023.138654
10. Belmeziti, A., M'hammedi Bouzina, A., & De Gouvello, B. (2025). Emergence of a new paradigm of water supply through adaptation strategies of the intermittent system in Algerian residential buildings. *Cities.* https://doi.org/10.1016/j.cities.2024.105657
11. Bigurra-Alzati, C. A., Ortiz-Gómez, R., Vázquez-Rodríguez, G. A., López-León, L. D., & Lizárraga-Mendiola, L. (2021). Water conservation and green infrastructure adaptations to reduce water scarcity for residential areas with semi-arid climate: Mineral de la reforma, Mexico. *Water.* https://doi.org/10.3390/w13010045
12. Braimah, I., Obeng Nti, K., & Amponsah, O. (2018). Poverty penalty in urban water market in Ghana. *Urban Forum.* https://doi.org/10.1007/s12132-017-9328-x
13. Carden, K., Armitage, N., Sichone, O., & Winter, K. (2007). The use and disposal of greywater in the non-sewered areas of South Africa: Part 2 - Greywater management options. *Water SA.*
14. Carden, K., Armitage, N., Winter, K., Sichone, O., & Rivett, U. (2008). The management of greywater in the non-sewered areas of South Africa. *Urban Water Journal.* https://doi.org/10.1080/15730620801972316
15. Carden, K., & Fell, J. (2021). A community of practice approach to planning water sensitive cities in South Africa. *Urban Planning.* https://doi.org/10.17645/up.v6i4.4575

16. Cvetkoska, V., Eftimov, L., & Kitanovikj, B. (2023). Enchanting performance measurement and management with data envelopment analysis: Insights from bibliometric data visualization and analysis. *Decision Analytics Journal, 9,* 100367. https://doi.org/10.1016/j.dajour.2023.100367
17. Dickson-Gomez, J., Nyabigambo, A., Rudd, A., Ssentongo, J., Kiconco, A., & Mayega, R. W. (2023). Water, sanitation, and hygiene challenges in informal settlements in Kampala, Uganda: A qualitative study. *International Journal of Environmental Research and Public Health, 20,* 6181. https://doi.org/10.3390/ijerph20126181
18. Dobrowksy, P. H., Mannel, D., De Kwaadsteniet, M., Prozesky, H., Khan, W., & Cloete, T. E. (2014). Quality assessment and primary uses of harvested rainwater in Kleinmond, South Africa. *Water SA, 40,* 401–409. https://doi.org/10.4314/wsa.v40i3.2
19. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133,* 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070
20. du Toit, J., & Wagner, C. (2022). Property owners' uptake of stormwater source controls: A case study of a low-density upmarket residential estate in Pretoria, South Africa. *Urban Water Journal.* https://doi.org/10.1080/1573062X.2022.2035410
21. Dusabe, M.-C., Wronski, T., Gomes-Silva, G., Plath, M., Albrecht, C., & Apio, A. (2019). Biological water quality assessment in the degraded Mutara rangelands, northeastern Rwanda. *Environmental Monitoring and Assessment.* https://doi.org/10.1007/s10661-019-7226-5
22. Eberhard, R., & Quick, A. J. R. (1995). Water supply and sanitation in urban South Africa: Getting it right during the transition and beyond. *Development Southern Africa, 12,* 1–19. https://doi.org/10.1080/03768359508439864
23. Enqvist, J. P., & Ziervogel, G. (2019). Water governance and justice in Cape Town: An overview. *WIREs Water, 6,* e1354. https://doi.org/10.1002/wat2.1354
24. Fakere, A. A., Folorunso, C. O., Arayela, O., & Adedeji, Y. M. (2018). Participatory predictors of users' satisfaction with housing infrastructure in Akure, Nigeria. *Facilities.* https://doi.org/10.1108/F-10-2017-0103
25. Frimpong, J., Adamtey, R., Pedersen, A. B., Wahaga, E., Jensen, A., Obuobie, E., & Ampomah, B. (2021). A review of the design and implementation of Ghana's National Water Policy (2007). *Water Policy, 23,* 1170–1188. https://doi.org/10.2166/wp.2021.042
26. Frimpong, L. K., Mensah, S. L., & Ablo, A. D. (2024). Households' access and expenditure on water services: Examining intra-urban differences in the Accra metropolis, Ghana. *Urban Governance, 4,* 222–231.
27. Gbedemah, S. F., Gbeasor, A. A., Hosu-Porbley, G. S., Frimpong, L. K., Amfo-Otu, R., Adanu, S. K., & Doe, E. K. (2024). Analysis of heavy metals and pathogen levels in vegetables cultivated using selected water bodies in urban areas of the Greater Accra Metropolis of Ghana. *Heliyon, 10,* e12345.
28. Inkani, A.I., Saleh, H., Rumah, M.M., 2021. Toward tackling urban water scarcity: linking risk, vulnerability adaptive capacity and adaptation at household level. J. Environ. Plan. Manag. 64, 536–558. https://doi.org/10.1080/09640568.2020.1776228
29. Ismail, A., Shalaby, A.-F., Khedr, A., 2024. Residential Water Consumption Patterns: A Theoretical Review. Environ. Res. Eng. Manag. https://doi.org/10.5755/j01.erem.80.3.36870

30. Kihila, J.M., Balengayabo, J.G., 2020. Adaptable improved onsite wastewater treatment systems for urban settlements in developing countries. Cogent Environ. Sci. https://doi.org/10.1080/23311843.2020.1823633
31. Lewis, E.W., Siyambango, N., Lendelvo, S., 2018. Assessment of accessibility of safe drinking water: A case study of the goreangab informal settlement, Windhoek, Namibia. Water Pract. Technol. 13, 871–878. https://doi.org/10.2166/wpt.2018.096
32. Lima, S., Carlos Filho, F.D.A., 2019. Bibliometric analysis of scientific production on sharing economy. Rev. Gest. 26, 237–255. https://doi.org/10.1108/rege-01-2019-0018
33. McClelland, P.H., Kenney, C.T., Palacardo, F., Roberts, N.L.S., Luhende, N., Chua, J., Huang, J., Patel, P., Sanchez, L.A., Kim, W.J., Kwon, J., Christos, P.J., Finkel, M.L., 2022. Improved Water and Waste Management Practices Reduce Diarrhea Risk in Children under Age Five in Rural Tanzania: A Community-Based, Cross-Sectional Analysis. Int. J. Environ. Res. Public. Health. https://doi.org/10.3390/ijerph19074218
34. Moghayedi, A., 2024. Enhancing water recycling adoption in South African residential properties: a multi-dimensional analysis for sustainable water management. Discov. Sustain. 5. https://doi.org/10.1007/s43621-024-00469-y
35. Mukwarami, S., Fakoya, M.B., 2022. CAUSALITY RELATIONSHIP BETWEEN SUSTAINABILITY FACTORS AND WATER MANAGEMENT: THE EMERGING MARKET STUDY. J. Gov. Regul. https://doi.org/10.22495/jgrv11i2art13
36. Mukwarami, S., van der Poll, H.M., 2023. ANALYSIS OF THE RELATIONSHIP BETWEEN SOCIAL FACTORS AND WATER SERVICES DELIVERY IN THE PUBLIC SECTOR: A CASE OF AN EMERGING ECONOMY. J. Gov. Regul. https://doi.org/10.22495/jgrv12i2art11
37. Naeem, M., Ozuem, W., Howell, K., Ranfagni, S., 2023. A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research. Int. J. Qual. Methods 22. https://doi.org/10.1177/16094069231205789
38. Nanco Dolman, 2023. Water-Positive Architecture. https://doi.org/10.13140/RG.2.2.16161.58729
39. Ndeketeya, A., Dundu, M., 2019. Maximising the benefits of rainwater harvesting technology towards sustainability in urban areas of South Africa: a case study. Urban Water J. 16, 163–169. https://doi.org/10.1080/1573062X.2019.1637907
40. Nganyanyuka, K., Martinez, J., Lungo, J., Georgiadou, Y., 2018. If citizens protest, do water providers listen? Water woes in a Tanzanian town. Environ. Urban. https://doi.org/10.1177/0956247817744942
41. Nganyanyuka, K., Martinez, J., Wesselink, A., Lungo, J.H., Georgiadou, Y., 2014. Accessing water services in Dar es Salaam: Are we counting what counts? Habitat Int. https://doi.org/10.1016/j.habitatint.2014.07.003
42. Nguyen, T. Y. C., Fagbayigbo, B. O., Cissé, G., Redi, N., Fuhrimann, S., Okedi, J., Schindler, C., Röösli, M., Armitage, N. P., Carden, K., & Dalvie, M. A. (2021). Diarrhoea among children aged under five years and risk factors in informal settlements: A cross-sectional study in Cape Town, South Africa. *International Journal of Environmental Research and Public Health, 18,* 6043. https://doi.org/10.3390/ijerph18116043
43. Nhongo, K., & Dinka, M. O. (2025). Assessing the vulnerability of districts to waterborne diseases in Harare, Zimbabwe. *Journal of Water, Sanitation and Hygiene for Development.* https://doi.org/10.2166/washdev.2025.009

44. Nnaji, C. C., Tenebe, I. T., & Emenike, P. G. C. (2019). Optimal sizing of roof gutters and hopper for rainwater harvesting. *Environmental Monitoring and Assessment, 191,* 7434. https://doi.org/10.1007/s10661-019-7434-z
45. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372,* n71. https://doi.org/10.1136/bmj.n71
46. Rahim Thaha, A., Riau, D. P., Antoro, A. F. S., & Aziz, F. (2025). Digital economy and SME research landscape: A bibliometric analysis of emerging themes and trends. *Journal of Scientometric Research, 14,* 272–282. https://doi.org/10.5530/jscires.20251711
47. Sindane, J. T., & Modley, L.-A. S. (2023). The impacts of poor water quality on the residential areas of Emfuleni local municipality: A case study of perceptions in the Rietspruit River catchment in South Africa. *Urban Water Journal, 20,* 203–213. https://doi.org/10.1080/1573062X.2022.2030763
48. Tesfay Abraha, A., Assefa Woldeamanuel, T., & Gebremariam Beyene, E. (2024). Tracking and tracing water consumption for informed water sensitive intervention through machine learning approach. *npj Clean Water, 7,* 309. https://doi.org/10.1038/s41545-024-00309-6
49. Thakur, R., Harris, G., Thakur, S., & Onwubu, S. (2019). Factors contributing towards high water usage within poor communities in KwaZulu-Natal, South Africa. *WIT Transactions on Ecology and the Environment, 239,* 1–10. https://doi.org/10.2495/WS190011
50. Thakur, R., Onwubu, S. C., Harris, G., & Thakur, S. (2022). Examining the factors influencing water conservation intentions amongst peri-urban communities of Ethekwini Municipality, South Africa. *Water Conservation and Management, 6,* 81–88. https://doi.org/10.26480/wcm.02.2022.81.88
51. Worku, H. (2017). Rethinking urban water management in Addis Ababa in the face of climate change: An urgent need to transform from traditional to sustainable system. *Environmental Quality Management, 27,* 103–119. https://doi.org/10.1002/tqem.21512
52. Zaręba, A., Krzemińska, A., Adynkiewicz-Piragas, M., Widawski, K., van der Horst, D., Grijalva, F., & Monreal, R. (2022). Water oriented city—A '5 Scales' system of blue and green infrastructure in sponge cities supporting the retention of the urban fabric. *Water, 14,* 4070. https://doi.org/10.3390/w14244070