



The literacy & policy nexus in SDG 6: A bibliometric mapping of research gaps on water governance and socio-economic disparities in global south megacities

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Received Date: August 19, 2025

Revised Date: January 23, 2026

Accepted Date: February 27, 2026

ABSTRACT

Background: Clean water and sanitation are global goals under SDG 6, but progress is held back by weak governance, socio-economic gaps, and scattered research on water governance and social justice. **Methods:** This research analyzed 260 journal articles (2016–2025) to explore how water governance, socio-economic disparities, and literacy connect, using Excel and VOSviewer. Data were systematically retrieved from the Scopus database to ensure replicability, and analyzed through science mapping techniques using Bibliometrix and VOSviewer to visualize the intellectual and conceptual structure of the field. **Findings:** The analysis identified three key gaps: literacy (knowledge and awareness) is often overlooked; the prevalence of qualitative studies limits the ability to model causal links between literacy and policy; research gaps in the global south hinder mapping of socio-economic disparities. Furthermore, the study reveals that 54.5% of the literature was published between 2022–2025, with research heavily concentrated in India, China, and Bangladesh, while critical megacities like Lagos and Khartoum remain significant research blind spots. **Conclusion:** Our bibliometric analysis reveals that the connection between literacy and policy is weak, primarily due to neglect of literacy, the lack of quantitative analysis, and geographic gaps in the literature. We suggest that future research should prioritize quantitative path analysis (SEM) in understudied megacities. **Novelty/Originality of this article:** This is the first bibliometric mapping to identify the literacy & policy nexus as a critical gap at the intersection of water governance and socio-economic disparities.

KEYWORDS: bibliometric analysis; global south; socio-economic disparities; water governance; water literacy.

1. Introduction

Clean water and proper sanitation are vital and are recognized worldwide through SDG 6, which aims to make clean water and sustainable sanitation available to everyone. Many countries have worked to improve water, sanitation, and hygiene (WASH) following SDG 6. However, progress has fallen short due to weak governance, limited funding, and large regional differences (United Nations, 2025). In line with that, the research revealed a shift in focus from water scarcity to less effective governance issues (Bhardwaj & Devi, 2025), policy failures (Chigor et al., 2021), unreliable data and monitoring (Madrado-Ortega & Molinos-Senante, 2023; Wu et al., 2023). Therefore, to overcome obstacles to policy and governance, there is a need to strengthen the governance framework and implement

Cite This Article:

Mardianti, F. (2026). The literacy & policy nexus in SDG 6: A bibliometric mapping of research gaps on water governance and socio-economic disparities in global south megacities. *Spatial Planning & Management Science*, 3(1), 19–41. <https://doi.org/10.61511/spms.v3i1.2026.3115>

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specific regulations for water supply systems in order to improve water management (Mau et al., 2024).

A strong and adequate governance framework cannot be separated from the role of water literacy both by policymakers and the public. As a policymaker, strong water literacy affects the quality of policy-making which includes technical, administrative and ecological. Meanwhile, public literacy affects the success of policy implementation. For example, the government has made a policy of tariffs in the context of infrastructure maintenance. However, due to low water literacy among the public, there was a rejection of the tariff. Even though it is realistic adjusted to the income of the residents (Yu et al., 2021). Water literacy is very broad to include knowledge, awareness and perception. In other literature, literacy is assumed with the level of education. The higher the individual's level of education, it is assumed that the better the WASH. Individuals with higher education levels usually also have high incomes as well. For example, in households in urban areas of Nepal (Behera et al., 2020) and Benin (Dégbey et al., 2025). However, other studies have found that high levels of education and income do not guarantee involvement in water and sanitation management (Mardianti & Purba, 2023). On the other hand, elementary school students with a strong understanding of water and conservation, are more likely to practice sustainability in the future (Jardioui et al., 2025). This indicates that educational institutions play an important role in promoting sustainable water management practices (Rabêlo et al., 2019) both basic, intermediate and high levels. Therefore, water literacy does not only refer to the level of education taken, but emphasizes the ability of individuals to interact with information and knowledge.

Ineffective water governance is common in developing countries (Herrera, 2019). This is exacerbated by the existence of socio-economic disparities, including literacy gaps in urban areas (Ingutia, 2024; Song et al., 2024) which ultimately leads to health disparities (Tebeje et al., 2025). In other words, the complex interaction between ineffective governance and socio-economic disparities in developing countries is leading to severe water crises (Lerner et al., 2018; Matimolane & Mathivha, 2025). This makes it difficult for low-income groups to get clean, safe and adequate water (Zapana-Churata et al., 2023). The literature on water governance continues to improve (Chundong & Xiuping, 2019). The current literature shows fragmentation between the study of water governance and the study of social justice (Ceseracciu et al., 2025; Derman & Hellum, 2018; Hutete et al., 2023; Mundala et al., 2024; Ríos et al., 2023; Santos, 2025a, 2025b; Schulz et al., 2017). To address this fragmentation, bibliometric research is needed to see research gaps. Several researchers have analyzed bibliometrics related to water governance. They reveal that water governance research has evolved significantly since the 1990s, with a focus on interdisciplinary studies covering water resources, environmental science, and socio-economic factors (Chundong & Xiuping, 2019; Durán-Sánchez et al., 2019). Key areas studied include water resource management, water quality assessment, and the impact of climate change on water resources. No study has used bibliometric analysis to map in an integrated manner Water Literacy, Water Governance, and Socio-economic Disparities in the context of SDG 6 (or Megacities in the Global South). This is reinforced by research in Latin America where injustices occur due to government- and private-centered policies in water governance based on market incentives that exacerbate socio-economic disparities (Ramos-Zaga, 2024).

Although SDG 6 emphasizes universal access (equity), its implementation often fails because the literature fails to bridge the gap between public knowledge (Literacy) and policy frameworks (Governance), especially in the Global South where disparities are severe. Literacy is often considered an endogenous variable (consequence), when in fact it should be an exogenous variable (predictor) for the success of equitable governance. Bibliometrics will examine whether the literature has tested literacy as a predictor. Therefore, this study aims to bridge the gap in the understanding of the literature on water governance and socio-economic disparities by bibliometrically mapping the nexus between water literacy and policy in water governance and socio-economic disparities. By conducting scientific mapping, this research will contribute to identifying patterns and

structures of literature in general, mapping concepts bibliometrically through co-word analysis and revealing research gaps. Bibliometric analysis is a form of literature review that focuses on evaluating the structure of specific research domains in contrast to a narrative review by summarizing articles and meta-analysis (Block & Fisch, 2020). The purpose of using bibliometric analysis is to provide a comprehensive overview of the field being researched by utilizing statistical methods to test bibliographic data (such as articles, year of publication, authors, institutions, countries, journals, keywords, and abstracts) and citation metrics.

The following questions guide research on the literature. In terms of general structure and profile, this study seeks to understand the annual trend of article publication, identify which journal is the most productive, determine who the most contributing authors are and how the pattern of multi-authorship and collaboration looks, and examine which countries and universities lead in the number of publications. Regarding central issues and research concepts, the study investigates the most dominant issue, specifically whether research focus leans more toward technical aspects such as water infrastructure and water treatment, or social aspects such as water rights, community participation, and water equity. It also explores the concept linkage or nexus by examining to what extent the keywords water governance and socio-economic disparities genuinely appear together within a single study. In terms of temporal development, the study traces how the existing research focus has shifted over time. Finally, in uncovering research gaps, the study addresses three dimensions. The first is thematic gaps, comparing how themes of water management and socio-economic disparities that are frequently cited contrast with those that are rarely cited yet related to water literacy. The second is methodological gaps, assessing whether existing studies are dominated by qualitative case studies or whether quantitative modeling linking governance, disparity, and literacy has begun to emerge. The third is geographic gaps, identifying whether specific megacities in the Global South remain underrepresented in the literature despite facing severe SDG 6 challenges.

2. Methods

Bibliometrix is an open-source tool designed for comprehensive science mapping analysis of literature (Ghorbani, 2024; Ibrahim & Kumar, 2023). It is particularly useful for conducting bibliometric analyses, which involve the quantitative assessment of academic literature to reveal research trends, authorship patterns, and the impact of publications (Ghorbani, 2024). Bibliometrix helps visualize the relationships between published articles, authors, affiliations, and research trends (Ghorbani, 2024). This visualization aids in understanding the intellectual and conceptual structure of research fields. Beside that, Bibliometric analysis using Bibliometrix provides quantitative indicators of impact, productivity, quality, and collaboration (Brown et al., 2018). The research method using bibliometrix analysis refers to the research (Öztürk et al., 2024). Here are the steps of the suggested method, described in the following few points.

2.1 Data collection and database selection

Data collection was conducted systematically, an approach that is fundamental in bibliometric research to ensure a process that is both replicable and transparent to other researchers (Linnenluecke et al., 2020). Systematic data collection minimizes the risk of selection bias and allows future researchers to reproduce or extend the study using the same parameters, thereby strengthening the credibility of the findings. In this study, the author selected the Scopus database as the primary data source. This decision was not arbitrary; rather, it was grounded in three main criteria for database selection as outlined by Öztürk (2021). First, Scopus offers wide journal coverage, including a substantial number of high-impact, peer-reviewed journals across multiple disciplines relevant to water governance, environmental science, and social policy. Second, Scopus provides robust data export compatibility, supporting file formats such as CSV and RIS that are directly

compatible with bibliometric analysis software including VOSviewer and Bibliometrix. Third, the number of exportable records in Scopus, capped at 2,000, was well above the initial sample size of 1,371 documents retrieved, ensuring that no relevant records would be lost due to export limitations.

The deliberate choice to rely on a single database, rather than combining multiple sources such as Web of Science or Google Scholar, was also a methodological consideration. While multi-database searches can increase recall, they simultaneously introduce the risk of overlapping or duplicated publications, which could distort citation counts and co-occurrence patterns and ultimately undermine the integrity of the analysis. By confining the dataset to Scopus alone, this study maintains internal consistency and ensures that all retrieved records are subject to the same indexing standards and quality thresholds.

2.2 Initial search and screening process

The initial search of the Scopus database was conducted on October 18, 2025 at 11:36 PM using search terms and codes designed to perform topic-based searches (*Topic-based search*) (Dong et al., 2023). Use of Boolean operators (OR, AND) and *Wildcard* (*) in the TITLE-ABS-KEY syntax aims to broaden and narrow search results to address potential representation issues in relevant literature (Hahn, 2025; Picalho et al., 2022; Scells et al., 2023; Y. Wang et al., 2025). The following is the syntax of the search performed on the scopus database: (TITLE-ABS-KEY ("water managemen*" OR "sanitat*" OR "WASH") AND TITLE-ABS-KEY ("disparit*" OR "inequalit*" OR "socio-economic" OR "urban poor" OR "slum*") AND TITLE-ABS-KEY ("governance" OR "policy" OR "participa*" OR "literacy") AND TITLE-ABS-KEY ("urban*" OR "megacit*" OR "global south" OR "developing countr*")). These words were chosen because they are contextually identifiable with the intersecting themes of the research; specifically the Socio-Economic Disparities, Water Governance, and the Literacy & Policy Nexus; and are synonymous with core concepts in the fields of urban water management and development studies. The initial search results, before strict criteria screening was applied, yielded 1,371 documents.

Furthermore, the Filtering process must be applied to the initial search results, Specific inclusion and exclusion criteria must be applied and justified to limit the scope of the research and form a final *dataset*. The criteria applied include: Year of Publication (2016-2025), Source Type (Journal), and Subject Area (Environmental Science (316), Social Sciences (304), Economics, Econometrics and Finance (53)). The Document Type Criteria are limited to Article (485) only; this restriction automatically excludes *Review Articles* (which can be biased due to high citations) and *Proceeding Papers* (which have the potential to overlap or duplicate when converted to articles).

The most important screening criteria is content relevance (reading titles and abstracts). Researchers are encouraged to review the titles and abstracts of all documents remaining after the automatic filter (which resulted in 312 documents). The goal is to identify and eliminate papers that are not actually related to the research topic, even if they pass the established criteria. The application of accurate inclusion and exclusion criteria resulted in a final sample of 260 documents to be analyzed. The final sample document must meet 4 criteria which contain (1) Water/Sanitation/WASH, (2) Disparity/Socio-Econ, (3) Governance/Policy/Literacy, (4) Urban context. Once the screening criteria are applied, *the dataset* is downloaded in a file format that can be selected by the researcher during the analysis process (Dong et al., 2023). In this study, the dataset was downloaded using CSV and Excel formats. CSV format for analysis with VOSviewer and Biblioshiny (which is the interface for the Bibliometrix package in R Studio). The Excel format is to be compiled by the author himself.

3. Results and Discussion

This bibliometric analysis of 260 articles aims to classify and test a set of knowledge on Water Governance, Socio-Economic Disparities, and the Literacy & Policy Nexus in the

context of SDG 6 hereinafter referred to as SISTEM ("S" refers to sanitation and water in SDG 6; "I" refers to inclusivity in addressing socio-economic disparities/disparities; 'S' refers to structure/regulation (governance); "T" refers to topography/location; "E" refers to evaluation (improvement and monitoring aspects); "M" refers to management (resource management)). This step is crucial to position these fields under relevant themes, connect them internally based on conceptual foundations, and systematically categorize them (Horvatinovic et al., 2023).

3.1 Overview of basic bibliometric indicators

3.1.1 General structure and profile

3.1.1.1 Annual trend of article publication

A total of 260 final articles published between 2016 and 2025 were analyzed, the results showed that the topic of this SISTEM is growing. The high growth in publication volumes in this time period is an indication of the rapid academic response to global sustainability issues (Sianes et al., 2022).

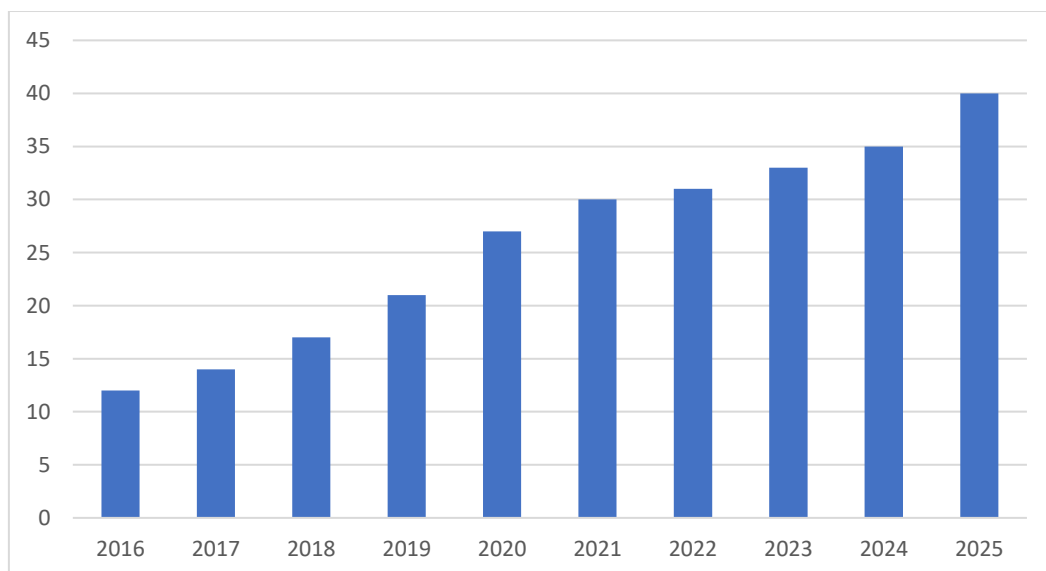


Fig. 1. Publication dynamics of selected articles

Fig.1. shows the growth in the number of articles from 2016 to 2025. Overall, there is an increasing trend in the number of articles published during this time period. In 2016, the number of articles was 12, and this number continues to increase every year until it reaches 40 articles by 2025. Based on the data in fig. 1., it is clear that the last years (2022-2025) accounted for the largest percentage of total publications, which was 55%. The Early Period (2016–2018) accounted for about 17% of the total articles. Meanwhile, the Middle period (2019–2021) accounted for around 31% of the total articles. So it can be concluded that more than half of the sample articles have been published in just the last four years. The increase in the number of articles related to SISTEM indicates that there is an increase in research focus related to this field. The increased focus of this study may be due to a combination of climate change (Majahana et al., 2025; Thommandru et al., 2025) Urbanization (Gondo & Kolawole, 2019; D. Singh et al., 2020), socio-economic and political pressures (Durán-Sánchez et al., 2018; Monyai et al., 2022; Thommandru et al., 2025) awareness (Durán-Sánchez et al., 2018; Gondo & Kolawole, 2019), multidisciplinary approach (Chundong & Xiuping, 2019; Li et al., 2018), focus on social justice (Machado et al., 2025; Seghiri et al., 2025; Thommandru et al., 2025).

3.1.1.2 Prolific journal

Table 1. shows the most productive journals in the field of research related to SISTEM. The journal Sustainability (Switzerland) was the most prolific journal with a total of 12 published articles, followed by Water (Switzerland) with 11 articles, and the International Journal of Environmental Research and Public Health with 10 articles. Meanwhile, Science of the Total Environment published 7 articles, and Cities, PLOS Water, and Environmental Science and Policy published 5 articles each. The CiteScore (CS) metric of a journal shows the average citations received per article and is a benchmark indicator of the quality of the journal (May, 2019). All journals in Table 1. have a relatively high CiteScore value for this field. The journal with the highest CiteScore is in Table 1. It is Science of the Total Environment (CS: 16.4), followed by the Journal of Environmental Management (CS: 14.4) and World Development (CS: 13.1). Therefore, it can be concluded that the journals that publish articles related to SISTEM are high-quality journals.

Table 1. Most prolific journals in SISTEM literature

Journal	Cite score	No. of papers	No. of citations
Sustainability (Switzerland)	7.7	12	106
Water (Switzerland)	6.0	11	350
International Journal of Environmental Research and Public Health	8.5	10	178
Science of the Total Environment	16.4	7	258
Cities	10.9	6	43
PLOS Water	2.8	5	26
Environmental Science and Policy	10.4	5	109
Water Policy	3.6	5	63
Journal of Water, Sanitation and Hygiene for Development	3.1	4	19
Utilities Policy	8.1	4	35
Environmental Management	6.5	4	139
Journal of Environmental Management	14.4	4	69
Journal of Urban Management	9.1	3	132
GeoJournal	6.0	3	34
Discover Sustainability	2.6	3	20
Sustainable Water Resources Management	3.8	3	47
World Development	13.1	3	35

Table 1. also shows the total citations received by articles published through the most productive journals above. Articles published in the journal Water (Switzerland) had the highest total citations (350), followed by articles in Science of the Total Environment (258), and the International Journal of Environmental Research and Public Health (178). When the total citations and CiteScore values of the journals in Table 1. Considered, Water (Switzerland), the International Journal of Environmental Research and Public Health, and Science of the Total Environment can be considered the most prestigious and productive journals for the field of SISTEM.

Journals listed in Table 1 generally focus on environmental and policy issues, as evidenced by the presence of outlets such as Water Policy, Environmental Science and Policy, and Environmental Management. This pattern suggests that research on SDG 6 tends to be directed toward the interconnected concerns of clean water access, adequate sanitation, and the governance frameworks that underpin them. The concentration of publications in these domain-specific journals reflects a field that is still largely anchored in applied environmental and policy sciences, where practical outcomes and regulatory implications take precedence over purely theoretical inquiry.

At the same time, the presence of general and multidisciplinary journals such as Sustainability and World Development signals that SDG 6 research is not confined to a single discipline. These outlets attract contributions from economics, sociology, urban planning,

and public health, among others, indicating that water governance and socio-economic disparities are increasingly recognized as cross-cutting issues that cannot be addressed through any single lens. The fact that Sustainability ranks highest by number of articles in this sample further reinforces this point: it suggests that researchers in this field are actively seeking broader, more integrative platforms through which to communicate their findings to diverse academic audiences.

3.1.1.3 Prolific author

A total of 967 authors contributed to the articles in this sample. Table 2. Indicates the authors who contributed to two or more articles. Contributions and Impact of citations Mberu, B. is the most prolific author in terms of the number of articles receiving a total of 419 citations. This author is also among the most cited authors, followed by Corburn, J., and Weru, J., who each contributed to two articles with a total of 434 citations (note: 434 citations for Corburn and 434 citations for Weru). Although Mberu, B. has the highest number of articles, Corburn, J. and Weru, J., are the authors with the highest total citations among the most prolific authors in Table 2. The most cited papers from these top authors include conceptual articles that have great potential to contribute to the evolution and development of the field of research. For example, the article written by Corburn, J. is an analysis of the problem followed by proposals for solutions and concrete actions.

Table 2. Most prolific authors in SISTEM literature

Author	No. of papers	No. of citations
Mberu, B.	3	419
van Dijk, M.P.	2	7
Rahmasary, A.N.	2	70
Mishra, P.K.	2	9
Truffer, B.	2	66
Corburn, J.	2	434
Wolf, J.	2	434
van Welie, M.J.	2	66
Wu, J.	2	108
Mukiga, A.K.	2	1
Adams, E.A.	2	203
Souza, A.	2	1
Chumo, I.	2	10
ElZein, Z.	2	7
Ribbe, L.	2	156
Shrestha, S.	2	25
Koop, S.H.A.	2	70
Singh, A.	2	6
Bisung, E.	2	52
Devkota, K.	2	17
by Almeida Souza, M.A.	2	1
Ahmed, T.	2	14
Bartram, J.	2	70

Taking into account the single- or multi-author authorship status of the articles in this sample (260 articles), it was found that only about 13% of the articles (34 out of 260 articles) were written by a single author. In this case, more than 85% of the articles are written by many (two or more) authors. This ratio can be interpreted as a tendency to cooperate among authors in this field. However, it can also be seen as a necessity rather

than a choice. Given the interdisciplinary nature of SISTEM, which comes from various disciplines (engineering and social). The need to have a theoretical background and proficiency in methodological diversity may make it difficult for a single researcher to conduct a comprehensive study. When it is difficult to access the required data, especially social and geographical data, this problem is compounded, and researchers will tend to work with partners naturally. Collaboration from authors tends to result in higher productivity and improved research results. This is evidenced by the positive correlation between author collaboration and the number of citations received (Alamah et al., 2023; De Jager et al., 2020; Kohus et al., 2022), for example, in authors Corburn, J., and Weru, J. They both collaborated on a single study. Not only the two of them, but there are also other authors who are members of the study. The results showed that their citations were the highest citations from the sample of articles selected in this study. High-impact articles are not exclusively produced by high-impact authors, but rather, collaboration itself can improve the quality and impact of research (Brito et al., 2023).

3.1.1.4 Prolific affiliations

Table 3. Most prolific affiliation in the SISTEM field

Affiliate	No. of papers	No. of citations
Swiss Federal Institute of Aquatic Science and Technology	4	104
The University of Manchester	4	3
Oswaldo Cruz Foundation	3	8
University of Chinese Academy of Sciences	3	164
Khulna University	3	33

A total of 682 institutions contributed to the sample of this study. Table 3 lists the top institutions that contribute to this field of research with three or more SISTEM-related articles. The Swiss Federal Institute of Aquatic Science and Technology and the University of Manchester are the institutions that contribute the most to this field, with 4 published articles each. It was followed by Fundacao Oswaldo Cruz, the University of Chinese Academy of Sciences, and Khulna University, which each contributed with 3 articles. The Swiss Federal Institute of Aquatic Science and Technology is not only the most productive but also the institution whose articles receive a high total of citations (104 citations). However, the University of Chinese Academy of Sciences also showed a very high citation impact with 164 citations from its 3 articles, making the institution the top contributor in terms of total citation impact, although the number of articles was the same as Fundacao Oswaldo Cruz and Khulna University. Considering that many universities contribute to only one study, these findings underscore the Swiss Federal Institute of Aquatic Science and Technology and the University of Chinese Academy of Sciences as major centers of expertise and ongoing research in the field of SISTEM.

3.1.1.5 Prolific country

Researchers from 67 countries contributed to these sample articles. Table 4. indicates the most productive country in the field of SISTEM, based on the number of articles and total citations received. Table 4 lists the top countries that contribute to this field. The most active and productive country is India with 85 articles, followed very closely by the United States with 84 articles, and the United Kingdom with 41 articles. It is followed by China (40 articles) and Bangladesh (37 articles). Although India leads in the total number of published articles, its dominance in the literature of this field cannot be seen only from the number of articles. The total number of articles in this sample is 260 articles, India's contribution (85 articles) accounts for about 33% of the articles in this field. Comparison of citations gives a different picture of the impact of the study.

Table 4. Most prolific country in SISTEM field

Country	No. of papers	No. of cited
India	85	1324
United States	84	3507
United Kingdom	41	1463
China	40	1397
Bangladesh	37	936
Australia	34	604
South Africa	28	987
Brazil	25	985
Mexico	20	140
Canada	20	470
Netherlands	19	354
Sweden	19	336
Germany	18	608
Indonesia	15	162
Thailand	14	307

The United States is the country whose articles receive the highest total citations (3507 citations), far surpassing other countries. This shows that although the number of articles is slightly below that of India, research originating from the United States has a much greater impact and influence among academics. After the United States, the countries with the highest total citations are the United Kingdom (1463 citations), China (1397 citations), and India (1324 citations). When the total number of citations and the number of articles are considered, the United States can be considered the most impactful and prestigious contributor to SISTEM's research, followed by India and the United Kingdom as the most active and highly prestigious contributors. Important points in Table 4 are the visible significant contributions of countries that directly address SDG 6 issues and social/governance disparities, such as India, Bangladesh, South Africa, and Brazil, which are developing countries. This suggests that research in this area is driven by the practical challenges faced in countries with critical water resources and governance needs.

3.2 Central issues and research concepts

Co-word analysis based on the frequency of co-occurrence to identify the most frequently occurring keywords (or sub-topics) and measure the strength of the relationship between those keywords (Župič & Cater, 2015). Furthermore, the network of themes or clusters that are helped can help identify potential themes to be researched in the future (De Bakker et al., 2005). I took this analysis using keywords, rather than titles and abstracts. This is because keywords symbolize the entire content of the research. There are two keywords, namely the author keyword and the keyword of papers. I take the keywords of papers because this method identifies the most researched concepts or subtopics related to the literature SISTEM.

I analyzed the keywords of these papers using VOSviewer. Here are the steps: (1) I downloaded the Scopus data in CSV format; (2) I downloaded 260 papers and uploaded them into the VOSviewer software; (3) I use co-occurrence analysis; (4) I set a minimum threshold at five appearances; This indicates that the keyword to be analyzed appears at least 5 times; (5) A total of 145 of 2318 keywords out of 260 articles to be analyzed; (6) I removed the keyword "article, humans, humans, controlled study" because the keyword was not included in the topic to be analyzed so that the total keyword was 141.

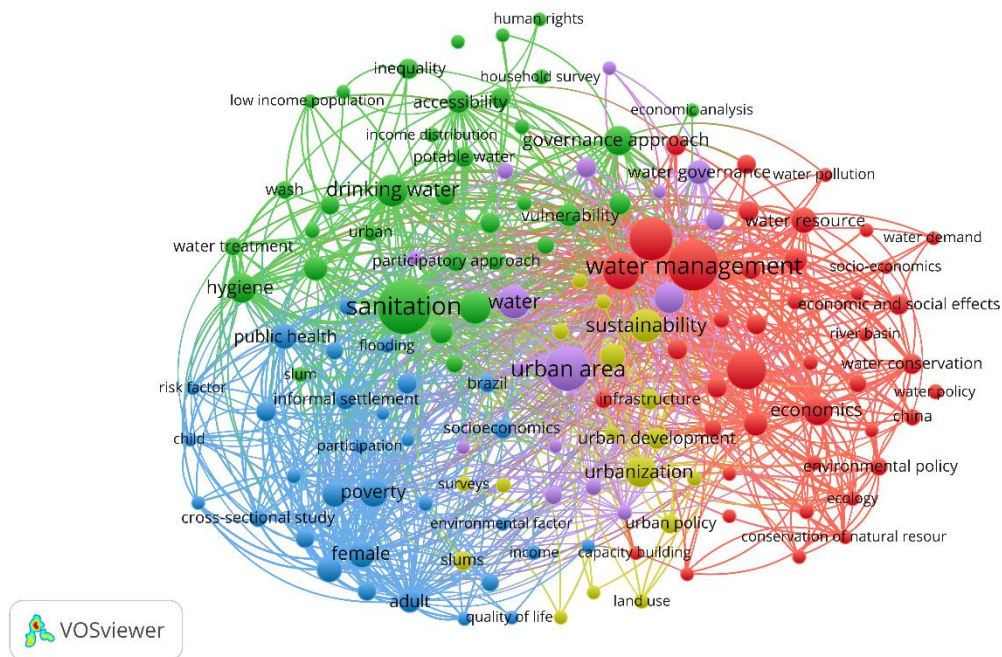


Fig. 2. Co-occurrence network visualization (VOSviewer Visualization)

Fig. 2. above shows the Co-occurrence results of the VOSviewer. This VOSviewer network map groups 141 keywords into five main thematic clusters (represented by different colors), where the *size of the nodes* (circles) indicates the frequency of keyword occurrences. The first cluster is water management (red cluster) with 42 items covering it, including economic and policy items. The second cluster is WASH (green cluster) with 35 items covering it, including governance and social justice items. The third cluster is poverty (blue cluster) with 31 items, including social, population, and informal settlement factors. The fourth cluster is institutional strengthening (yellow cluster) with 17 items, including urban policy and infrastructure. The fifth cluster is governance and policy (purple cluster) with 16 items, including perception.

3.2.1 The most dominant issue

Based on the *size of the nodes* (frequency) and cluster distribution, it can be seen that the focus of the research is very multidisciplinary, with a balanced dominance between technical/economic management aspects and social/sanitary aspects.

Table 5. Dominant issue of co-occurrence

Aspects	Related Clusters	Dominant Keywords (Largest Nodes)	Dominance Conclusion
Technical & Economics	Red (Water Management/Economy) & Purple (Location/Geography) & Yellow (Sustainability)	Water management (Very Large), economics (large), urban area (large)	Issues related to resource management, economy, water policy and infrastructure are prominent and form the red core of the network and
Social & Sanitation	Light Blue (Poverty/Social) & Green (Sanitation/Access)	Poverty (Large), Sanitation (Very Large), Drinking Water (Large),	Issues related to basic access, public health, and social disparities are also very prominent and form the core of the green/blue network.

Based on table 5 and fig.2, water management is the central topic in this study. Meanwhile, sanitation with drinking water is a basic service in clean and safe waste disposal. The predominance of urban areas suggests that most of the research is in urban environments that face major challenges in water and sanitation management. Sustainability shows the purpose of holding water and sanitation management, namely for sustainability. Therefore, it can be seen that water management as a technical aspect is considered the most dominant conceptual issue bridging aspects of governance, socio-economics and its disparities, policies, and sustainability in urban environments.

3.2.2 Nexus linkage: (Water governance) and (socio-economic disparities)

To assess the relationship between these two concepts, it can be seen based on the distance between the nodes and the thickness of the link between them. Water governance is in the purple cluster, strongly connected to the governance approach (green), water management (red) and urban areas (purple). Socio-economic in the red cluster has strong links to urban areas (Purple) and water management (red). The concept of disparity represented by inequality and low income population (Green Cluster) has strong links to developing countries (green), water management (red) and urban areas. These two issues are connected in a larger network, water management and urban areas. Although these two issues do not have a direct link, the distance between the nodes is very close. The themes or concepts represented by the two nodes are highly conceptually related in the literature, but the direct co-occurrence (co-occurrence in the same document) of the two specific terms does not meet the minimum threshold set by the researcher through VOSviewer which is five times to be described as a link. These two issues are often researched in the same literature and have to do with the same third-party node. These issues are interacted and discussed extensively, but the authors rarely use these two terms explicitly and simultaneously in a single study.

3.2.3 Temporal shift

The temporal dimension of the co-occurrence network is visualized through the overlay map in VOSviewer, where node color indicates the average year of keyword co-occurrence ranging from purple for older concepts to yellow for more recent ones. In addition to color, the spatial positioning of nodes also carries interpretive significance: more mature and stable concepts tend to cluster toward the center of the network, while newer and niche concepts are located on the periphery. Together, these two visual cues color and position allow for a nuanced reading of how the research agenda in this field has evolved over time. Figure 3 below presents this overlay visualization, which forms the basis for the temporal analysis discussed in this section.

As shown in Figure 3, the center of the network is occupied by core and fundamental concepts such as water management, sanitation, drinking water, and urban areas, representing a stable and enduring focus on water supply and infrastructure. Some social concepts and WASH-related terms — including human rights, inequality, urban water, spatiotemporal analysis, environmental factors, sustainable development goals, water and sanitation, China, and education — tend to be positioned on the periphery, indicating their relatively more recent emergence in the literature. There are indications of a gradual shift away from a purely supply-oriented focus toward newer issues centered on water justice and sustainable governance in urban environments. The large clusters remain anchored in water management, sanitation, and urban areas, but show growing linkages to social concerns such as poverty, economics, and low-income populations, as well as to environmental policy dimensions including environmental policy, public policy, and water policy. Overall, the temporal shift visible in Figure 3 reflects a transition in research emphasis from early social and economic framings (purple/blue) toward environmental, governance, and geographically specific policy topics (green/yellow).

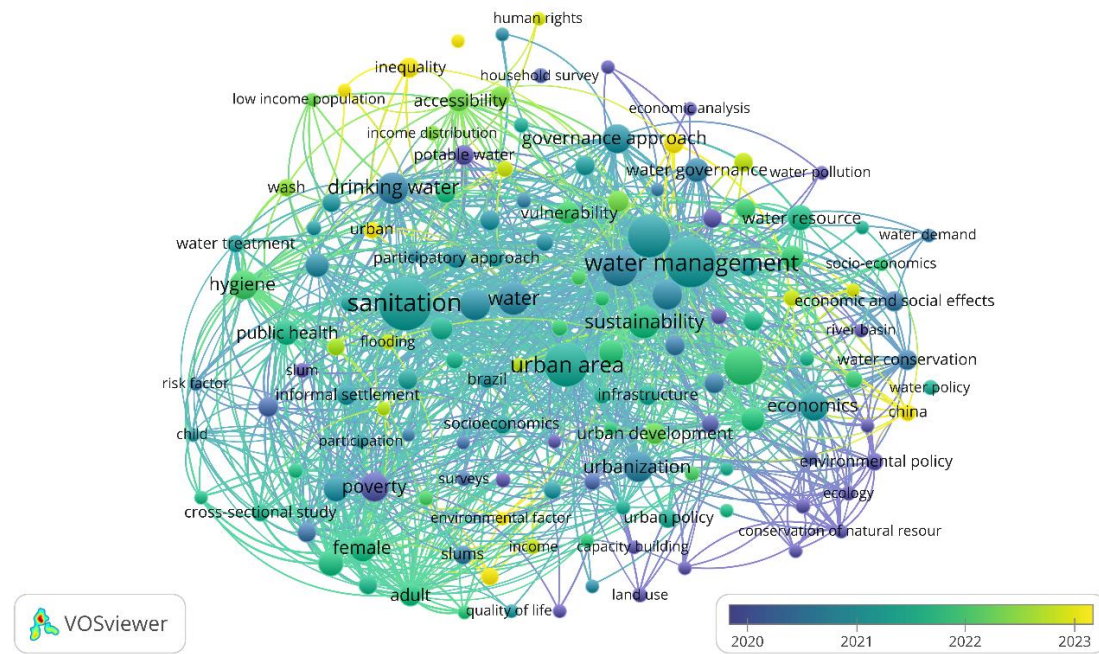


Fig. 3. Co-occurrence overlay visualization
(VOSviewer Visualization)

3.3 Research Gaps

3.3.1 Thematic Gaps

By comparing frequently cited themes with rarely cited but important themes (especially those related to literacy). If the keyword "Literacy" is the most cited theme, this means that many high-citation articles will have those words in the title, abstract, or keyword. This theme is mature and saturated, so it is no longer an original research gap. Here's the data that has been filtered to find articles with high citations and check the titles:

Table 6. The most cited topics and their relevance to "literacy"

Title	Year	No. of citation	Contains "Literacy"
"Slum Health: Arresting COVID-19 and Improving Well-Being in Urban Informal Settlements" (Corburn et al., 2020)	2020	409	No
"The study of slums as social and physical constructs: Challenges and emerging research opportunities" (Mahabir et al., 2016)	2016	204	No
"Socioeconomic and Demographic Predictors of Potable Water and Sanitation Access in Ghana" (Adams et al., 2016)	2016	121	No
"Evaluation of groundwater sustainability in the arid Hexi Corridor of Northwestern China, using GRACE, GLDAS and measured groundwater data products" (S. Wang et al., 2020)	2020	89	No
"Day Zero and The Infrastructures of Climate Change: Water Governance, Inequality, and Infrastructural Politics in Cape Town's Water Crisis" (Millington & Scheba, 2021)	2021	82	No
"'Spaces of Exclusion' in community water governance: A Feminist Political Ecology of gender and participation in Malawi's Urban Water User Associations" (Adams et al., 2018)	2018	82	No
"Analysis of current and future water demands in the Upper Indus Basin under IPCC climate and socio-economic scenarios using a hydro-economic WEAP Model" (Amin et al., 2018)	2018	80	No
"Urban water security: Definition and assessment framework" (Aboelnga et al., 2019)	2019	76	No

Title	Year	No. of citation	Contains "Literacy"
"Urbanization impacts on greenhouse gas (GHG) emissions of the water infrastructure in China: Trade-offs among sustainable development goals (SDGs)" (Zhang et al., 2019)	2019	75	No
"Rural-urban spatial inequality in water and sanitation facilities in India: A cross-sectional study from household to national level" (Chaudhuri & Roy, 2017)	2017	72	No

The most cited themes (Citation > 70) in table 6. tend to focus on: (1) Macro Issues: Urbanization impacts, Water Security Framework, Water Governance Contribution. (2) Descriptive Problems: Rural-urban inequality, Slum studies. None of these dominant articles use "Literacy" as the primary focus or even as a prominent keyword. These results conclusively support that the Literacy & Policy Nexus is a theme that: (1) Rarely Cited: Barely appears in the title/abstract, even on high-cited articles (Citation >70), This proves that it is a neglected variable. (2) Important: This variable is critical because it bridges policy implementation failures (which are discussed by the high-citation article) and the realities of disparity/exploitation at the grassroots level (which are discussed by the low-cited article).

Although the literature on Water Governance and Socio-Economic Disparities in the Global South is mature, as shown by the high citations on macro themes (Urban Water Security), there is a substantial gap at the micro level: the role of policy and water literacy as a mediating factor between formal policies and the real impact on poor households has never been systematically tested. Themes other than those in Table 6. The above is then assessed qualitatively with the help of an Excel filter using the "Contains" text filter in the "Title" column using the following words: Knowledge, Awareness (Kraljević et al., 2019; Liu et al., 2022; Manolitsis, 2017), perception (Ferah-Ozcan & Yildiz, 2022) The result is as shown in Table 7. Next.

Table 7. Rarely cited topics (<5) and their relevance to "literacy."

Title	Year	No. of citations	Text filter "contains."	Niche
"Awareness on usage of contaminated groundwater around Perungudi dumpsite, Tamil Nadu, India" (Parameswari et al., 2016)	2016	4	Awareness	Very High
"Building knowledge, negotiating expertise: Participatory water supply advocacy and service in globalizing Jakarta" (Padawangi, 2017)	2017	1	Knowledge	Very High
"Stakeholders' perceptions on water resources management in the Okavango Delta, Botswana" (Gondo et al., 2019)	2019	3	Perception	Very High
"A tale of two communities: Comparing user perceptions of condominium and conventional sewer systems in Salvador, Brazil" (Palma et al., 2023)	2023	1	Perception	High
"Assessment of public awareness on antimicrobial resistance and practices for antimicrobial use in Dodoma region of Tanzania" (Mramba et al., 2025)	2025	2	Awareness	High

Niche Criteria: Very high [old](<2023); High[new] (last three years)≥ 2023. Niche Score indicates the variables that are least frequently associated or tested (isolated), Table 7. The above explains that literacy has historically been neglected (high niche score). The very high niche score for years <2023 is due to the fact that this research has been around for a long time, but still has low citations. This indicates that the literacy component for these years has been neglected, especially in concepts such as those stated in the title. Lower

citations in the new years still allow for more citations in the future, because this research is still "warm," so the niche is not as high as in old years. This validates that the literature does not consider it as an important predictor.

3.3.2 Methodological Gaps

This section addresses the following methodological question: Are existing studies dominated by qualitative case studies, or have quantitative models been sufficiently developed to link literacy with other variables? To answer this question, Table 8 presents the distribution of methodological approaches and their relevance to literacy-related terms.

Table 8. Trends in the methodology used and its relevance to "literacy"

Types of methodology	Keywords	Number of articles that appeared	Total	Number of articles mentioning the word Literacy/Perception/Awareness
Quantitative / Modelling	Type	62	170	2+5+1=8
	Framework	56		2+3+3=8
	MCDM	1		0+0+1=1
	GIS	21		2+3+3=8
	Statistics	10		3+0+1=4
	Quantify	10		0+0+1=1
	Predictors	5		1+0+0=1
	Decoupling	2		0
	WEAP	3		0
Qualitative/ Case Study	Case Study	13	219	
	Ethnographic	2		
	Qualitative	28		
	Perception	17		
	Perspective	24		
	Experience	41		
	Challenges	81	389 (129 overleap)	
	Barriers	13		
Total				

Based on the data in Table 8, a very strong methodological gap has been identified. Studies related to SISTEM are dominated by qualitative studies that focus on Challenges/Perceptions and are severely lacking in quantitative modeling that relates to Literacy. This gap is shown through two main points: (1) Dominance of Qualitative Methods (challenges). More than half of the studies focused only on what happened (Challenges, experience) rather than strictly examining the cause-and-effect relationship (Model, Framework). (2) Gap in Quantitative Modeling with Literacy. Although there are 8 articles that use a quantitative approach (Model, Framework) and are directly related to literacy, this number is still very minimal. Literacy (knowledge, awareness, perception) is recognized qualitatively as a problem, but it is still very minimally integrated and quantitatively measured as a determinant of governance success and disparity reduction. Therefore, the next researcher is expected to be able to fill this gap by taking variables that are still very minimal (Knowledge/Awareness/Perception) and applying quantitative methods/modeling (e.g., Structural Equation Modeling or advanced regression) to test the Literacy & Policy Nexus, something that has not been done by 8 existing modeling studies. This demonstrates that the research methodology used was inadequate to test the causal relationship (literacy and equitable governance). This reinforces the thematic conclusion that the literature does not yet consider literacy to be a significant predictor.

3.3.3 Geographic Gaps

This section addresses the following question: are there specific megacities in the Global South that have not been widely studied, despite facing severe SDG 6 challenges? Geographic representation in bibliometric research is not merely a matter of academic diversity it carries substantive implications for policy relevance. When certain cities or regions are systematically underrepresented in the literature, the knowledge base available to policymakers, development agencies, and international organizations becomes skewed toward contexts that may not reflect the most acute or complex manifestations of the problem. In the case of SDG 6, this skew is particularly consequential, as the cities facing the most severe water and sanitation crises are often precisely those that receive the least scholarly attention. To explore this issue, data on countries experiencing SDG 6 crises were examined by comparing the volume of publications against the severity of water and sanitation challenges, with particular attention to vulnerable regions such as Sub-Saharan Africa. This comparison was necessary because publication volume alone does not indicate whether the literature is adequately addressing the most critical geographic contexts. A city may be absent from the literature not because its situation is unremarkable, but because structural barriers including limited research infrastructure, restricted data access, and underfunding of local academic institutions, prevent its challenges from reaching international journals. Identifying these blind spots is therefore an important step toward redirecting future research efforts to where they are most needed. The results are summarized in Table 9.

Table 9. Geographical gaps in the global south

Country	Number of articles	SDG 6 Conditions (Severity of Problems)	Gap status
Lagos (Nigeria)	8	'Very severe'. One of the megacities with the fastest growth rate. The level of access to safe water and sanitation is among the worst in Sub-Saharan Africa, exacerbated by widespread informal settlements (Ayanlola et al., 2025; Kugbayi & Adegbam, 2023)	Strong Gap.
Kinshasa (DR Congo)	4	'Extreme'. DR Congo has one of the lowest levels of water access in the world. Governance issues, conflicts, and humanitarian crises make the fulfillment of SDG 6 in Kinshasa very complex (Gaiffe et al., 2023; Quattrochi et al., 2021)	Strong Gap.
Khartoum (Sudan)	0	'Very severe'. Facing severe scarcity and pollution of surface water and groundwater (Shakak, 2022)	Critical Gaps.
Mogadishu (Somalia)	1	'Severe', water scarcity especially in the Juba and Shabelle river valleys, exacerbated by dependence on upstream flows from Ethiopia, frequent droughts, poor infrastructure and weak governance systems (Ali et al., 2025) and poor sanitation (Werku & Woldeamanuel, 2025)	Critical Gaps.
Casablanca (Morocco)	2	'Severe'. Morocco faces significant difficulties in accessing adequate clean water due to ineffective national governance (Ikram & Boudraa, 2025)	Critical Gaps.

Note: the number of articles featured are articles by authors from that country, not articles that discuss SDG 6 in the country's megacities. The list of countries is reinforced by the study (S. Singh & Jayaram, 2022) which states that Africa faces great difficulties in

achieving clean water and sanitation targets. Based on the data above, it can be concluded that study locations in the global south are still uneven. This adds to the evidence that the problem of socio-economic disparities has not been evenly mapped where it is needed most. The lack of quantitative research examining Literacy prevents the identification of valid causal mechanisms in the locations where it is most needed.

4. Conclusions

This study maps the research architecture in the field of SISTEM (SDG 6, Inclusivity/Disparity, Structure/Governance, Topography/Location, Evaluation, and Management) and finds that this field shows very high and structured research activities with more than half of the articles (54,5%) published in the last four years (2022–2025). The most prolific and impactful journals (such as *Water*, *International Journal of Environmental Research and Public Health* and *Science of the Total Environment*) confirm the interdisciplinary nature of this field, driven by the urgent need in the countries of the Global South that are actively publishing (especially India, China, and Bangladesh). The co-keyword analysis shows that the research focus is evenly divided between Technical/Economic (Water Management) and Social/Sanitation (Sanitation, Poverty) aspects. However, the direct conceptual link between Water Governance (regulation) and Socio-economic Disparities (poverty/inequality) is still moderate to weak, validating early hypotheses about literature fragmentation. However, the node spacing of the concepts is close to each other. This indicates that these concepts are often researched in the same literature and have links to the same third-party nodes.

Empirical bibliometric analysis demonstrates that the Literacy & Policy Nexus remains a pressing disconnect in the macro literature. This is identified through three fundamental gaps. First, Literacy is a neglected variable, as evidenced by the absence of a single highly cited article focusing on "Literacy" as a primary variable. This finding confirms that the mediating role of Literacy between formal policies and their real impacts at the household level has never been systematically tested. Second, quantitative approaches to examining this nexus are still very limited. Existing studies are dominated by qualitative approaches, while quantitative modeling focused on technical and economic metrics is still very limited in integrating and measuring Literacy (knowledge/perception/awareness) variables as predictors of governance success. Third, there are geographically uneven problem areas, characterized by extreme Research Blind Spots in megacities facing Severe SDG 6 challenges (such as Lagos and Khartoum), where the volume is very low (0–8 articles), in contrast to research-saturated cities. To address this disjuncture, future researchers should focus on quantitative path modeling (path analysis/SEM) in these neglected megacities, where the water literacy variable is established as a structural predictor for the success of Water Governance (policy).

Acknowledgement

The author extends sincere gratitude to the Sekolah Ilmu Lingkungan (SIL) Universitas Indonesia Research Cluster for the institutional support and invaluable opportunity provided, which made the conception and publication of this research possible.

Author Contribution

In this study, F. M. is expected to make substantial contributions to the design of the work, data acquisition, analysis or interpretation, drafting or revising the manuscript, and approving the final version. For multi-authored articles, individual contributions must be clearly stated on the Title Page using the standardized CRediT taxonomy, which defines roles such as conceptualization, methodology, writing, and supervision.

Funding

This research received no external funding.

Ethical Review Board Statement

Not available.

Informed Consent Statement

Not available.

Data Availability Statement

The data used in this study consist of secondary bibliometric data collected from online databases. No new primary data were created. Data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The author declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the author used ChatGPT to assist in drafting and refining the manuscript. After using this tool, the author reviewed and edited the content as needed and took full responsibility for the final content of the publication.

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