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Bibliometric Analysis of Risk Management of Water Distribution System

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Abstract: *This study aims to provide valuable insights that can contribute to future research directions, policy formulation, and management of water distribution systems to avoid potential risks. This research was conducted using bibliometric analysis of articles related to the topic under study. This research methodology is designed to carry out bibliometric analysis of literature related to water distribution systems, using the VOSviewer and Publish or Perish 8 applications. Research findings show that passenger transportation, satisfaction, and development are the three main keywords and additional keywords related to the research topic. Based on data from the Public Transportation Satisfaction Study, it can be concluded that the number of studies continues to increase from 2000 to 2023, with the highest number in 2021. The research trend regarding public transportation satisfaction continues to grow every year and will continue to increase in the coming years.*

Keywords: *Water Distribution Network, Drainage, Water Resource, Risk management.*

INTRODUCTION

Water is an indispensable element in daily life, used for everything from domestic activity to agriculture production. Despite covering approximately 70% of the Earth's surface, only 3% of the Earth's water is freshwater that can be consumed (Stephens et al., 2020). The management of this finite resource is crucial, requiring a robust system for its distribution to those in need. In modern civilizations, these complex infrastructure systems play a vital role in daily routines, facilitating the delivery of essentials such as water. However, over time, these systems can deteriorate due to environmental conditions, leading to reduced functionality and performance. Routine inspection and maintenance are, therefore, essential to ensure optimal infrastructure performance (Mazumder et al., 2019).

Given the likelihood of substantial climate change, sustainable water usage has emerged as a critical concern for the future of our world (Mishra et al., 2021). Current hydroclimatic data validates theories of how climate change (long-lasting droughts and huge floods globally) could affect the availability of water as a resource (Petpongpan et al., 2021). Because of severe weather, floods are frequently regarded as a natural occurrence. As a result of several environmental changes brought about by human activities, there is actually more flooding. Water management involves a complicated web of factors that make it difficult to make decisions that will minimize the negative effects of future water use scenarios and guarantee the long-term sustainable use of water resources (Mishra et al., 2021).

Water providers need detailed knowledge of the infrastructure shaping their water distribution system to assess its actual condition and establish repair plans (Assad et al., 2019). Water companies are concerned about the aging hydraulic infrastructure, with many pipes, valves, or pumps surpassing or approaching their end of life and requiring renovation. Repairing these systems will enable the sustainable use of water and energy, especially in scenarios of rising energy prices and sustainable greenhouse gas emission reduction (Pérez-Padillo et al., 2021).

Risk management in water distribution networks is essential in maintaining our smooth access to clean and safe water. With a profound understanding of vulnerabilities, conducting comprehensive risk assessments, implementing preventive measures, utilizing monitoring technologies, and enhancing communication with the public, water companies can ensure that their networks remain robust amidst the ongoing global changes (Barraza de la Paz et al., 2023). In an era where water resources are increasingly threatened, effective risk management is critical to ensuring the sustainability of this invaluable resource for future generations.

The purpose of this paper is to conduct a comprehensive bibliometric analysis to gain a deeper understanding of the existing literature and research trends in the field of risk management within water distribution systems. Bibliometrics is a reliable approach to assess quantitative and qualitative changes in research activities over time (Lv & Chang, 2021). The bibliometric analysis is performed using VOSviewer software. By using VOSviewer, we can analyze scientific outputs and identify main research themes and contributors. This study aims to provide valuable insights that can contribute to future research directions, policy formulation, and the management of water distribution systems to avoid potential risks.

In studying the risks of water distribution system management, it discusses the complex infrastructure that provides clean water supply. The water distribution system consists of a network of pipes involving water transportation from the source to the consumer, as well as various supporting elements such as pumps and storage tanks (Kurian et al., 2018). This research will discuss the essential role of management in maintaining water availability and overcoming threats such as equipment failure, infrastructure damage, or operational events that can hinder the flow of clean water to the community (Bello et al., 2019). This analysis guides our understanding of the complexity and significance of water distribution management systems.

In this context, the water distribution management system is key to ensuring operational efficiency and safety. This management includes planning, maintaining, and monitoring infrastructure, as well as responding to challenges that may arise, such as leaks, equipment failure, or other emergency events. Successful distribution management requires a deep understanding of system dynamics, effective policies, and innovative technology integration. Moreover, proactive measures like regular maintenance schedules and predictive analytics play a pivotal role in preventing potential issues before they escalate (Harrison et al., 2019). By embracing a holistic approach that combines vigilant monitoring with strategic planning, water distribution management systems can not only address immediate challenges but also foster long-term sustainability and resilience in the face of dynamic environmental and operational conditions.

However, the increasing complexity of modern demands and environmental pressures pose new challenges for water distribution systems. From climate change to water resource ecosystems, these systems must be able to adapt and evolve over time (O'Connell, 2017). Therefore, this introduction will explain the complexity and significance of water distribution systems in a changing global context, underscoring the importance of risk management assessments to maintain the continuity of these systems and ensure the availability of clean water for all (Bartram, 2009).

In addition to the challenges, population growth exacerbates the pressures on water distribution systems, intensifying the need for sustainable management practices. Rapid urbanization and expanding communities further strain existing infrastructures, demanding not only the expansion of current systems but also the incorporation of advanced technologies for optimal performance (Susantono & Li, 2021). Furthermore, the interdependence of water distribution with energy resources introduces an additional layer of complexity, as energy-efficient solutions become crucial for both economic and environmental sustainability. The integration of smart technologies, such as sensor networks and data analytics, emerges as a promising avenue for real-time monitoring, early detection of issues, and informed decision-making in the face of evolving conditions. Ultimately, this evolving landscape underscores the vital role of adaptive and forward-thinking management strategies to navigate the intricate challenges and ensure the resilience and longevity of water distribution systems worldwide (Martínez-Peláez et al., 2023).

As the second layer, this literature will direct its focus to the identification of risk factors that may hinder the effective performance of water distribution systems. Starting from leaks in pipe networks to instability in electricity supplies that can affect pump operations, this literature explores the factors that can cause disruptions and threats (Korlapati et al., 2022). Through careful analysis, readers will understand the dynamics of risks that must be addressed by water distribution management so that the clean water supply remains reliable and dependable.

Water distribution management needs to always face various risk factors that can affect overall

system performance. First, one of the main risk factors that must be identified is leaks in the pipeline network. Leaks can cause waste of valuable water resources and harm overall system efficiency (Mesalie et al., 2021). Identifying potential leak locations and implementing an effective monitoring program is key to minimizing these negative impacts. In addition, instability in electricity supply is a significant risk factor that can hinder the operation of pumps and water treatment stations. Identification of areas that are vulnerable to electricity disruptions and the development of backup systems or renewable energy technology are crucial steps in water distribution risk management (Uddin et al., 2023). Rapid response to power outages through emergency systems can reduce negative impacts on water supplies.

Other risk factors include threats to the cybersecurity of water distribution systems. With increased connectivity through information technology, these systems have become vulnerable to cyber-attacks that can damage operations and result in loss of critical data (Taormina et al., 2018). Therefore, identifying and protecting against potential vulnerabilities is necessary to maintain the security and integrity of water distribution systems. Other risk such as uncertainty in climate conditions is a significant risk factor. Changes in extreme rainfall patterns, long droughts, or sudden floods can change the dynamics of water distribution. Identifying and understanding the potential impacts of climate change is the first step in developing responsive and adaptive risk management strategies. By carefully identifying these risk factors, water distribution management can build a solid foundation to meet challenges, improve operational efficiency, and ensure a reliable water supply for communities.

Turning to the third aspect, this literature highlights various risk evaluation methods that can be applied in the context of water distribution management. From a probabilistic approach that considers the probability of a risk event occurring, to the use of simulation models to forecast the impact of various scenarios, this analysis provides an in-depth look at how to measure and assess risk with precision (Ziya & Safaie, 2023). This knowledge equips practitioners and researchers with essential tools to develop risk management strategies that are appropriate and responsive to changes in the operational environment of water distribution systems.

Climate change plays a crucial role in changing the landscape of water distribution management worldwide. Rising global temperatures, changing rainfall patterns, and extreme events such as floods and droughts are increasingly posing serious challenges to water distribution systems. First, increasing temperatures can accelerate evaporation and increase water demand, causing additional pressure on water resources (Vahmani et al., 2022). In this context, water distribution management must be able to predict and adjust water supplies according to fluctuating needs, considering the intensification of longer and warmer summers. Changes in rainfall patterns are also an important aspect that influences water distribution management. Uneven distribution of rainfall can result in flooding in one area and drought in another area.

Water distribution systems must be prepared to manage and distribute water more efficiently under this uncertainty. Additionally, extreme events such as tropical storms can damage water distribution infrastructure, demanding rapid reactions from management teams to restore normal operations and ensure water supplies during and after the event. Climate change can also present public health risks through impacts on water quality (Ahmed et al., 2020). Changes in water temperature can influence the development of pathogenic microorganisms, while changes in rainfall patterns can accelerate water pollution.

Therefore, water distribution management needs to strengthen water quality monitoring and control systems, as well as develop adaptation strategies to protect public health from risks associated with climate change. Overall, an in-depth understanding of the influence of climate change on water distribution management is essential for developing strategies effective adaptive, involving close monitoring, careful risk planning, and technological innovation to ensure the continuity of water distribution systems in this increasingly changing era.

In managing risk in the context of water distribution management, selecting and implementing appropriate risk evaluation methods is a critical step. First, the probabilistic approach emerged as a

commonly used method. By considering the probability of certain risk events, this method allows system administrators to identify and assess the level of possible risks (Vasile & Croitoru, 2012). This analysis includes thorough statistical calculations, helping in identifying areas susceptible to certain risks and designing appropriate mitigation measures.

Simulation model-based approaches have also become an integral part of risk evaluation. Through the use of mathematical models that reflect the complexity of water distribution systems, this research can predict the impact of various risk scenarios. This model allows simulating interactions between system components, helping system administrators understand the impact of risk on overall system performance (Phan et al., 2021). Thus, this method provides better visibility of potential consequences and helps in the development of more targeted mitigation strategies.

Furthermore, risk evaluation can involve in-depth qualitative analysis. This approach involves a deep understanding of the operational dynamics of the system and the potential impact of certain risks. By involving stakeholders and industry experts, qualitative analysis can reveal important insights in identifying risks that other evaluation methods may miss. In water distribution management, where social interactions and policies play an important role, these qualitative aspects can provide the necessary holistic understanding (Dinka, 2018).

Lastly, technology-based approaches are also increasingly developing in risk evaluation. The use of smart sensors and information technology-based monitoring systems enables real-time data collection. By leveraging big data and predictive analysis, this method provides the ability to detect and respond to risks more quickly and effectively, strengthening water distribution management in the face of dynamic risks (Alahi et al., 2023). Through the application of integrated risk evaluation methods, water distribution management can better understand and manage the risks faced, ensure operational continuity, and increase the reliability of clean water supply to the community.

MATERIALS AND METHODS

This study is carried out by using bibliometric analysis of articles related to the researched topic. This research methodology was designed to conduct a bibliometric analysis of literature related to water distribution systems, using VOSviewer and Publish or Perish 8 applications. Inputting keywords relevant to water distribution systems, then with. strict inclusion criteria were applied to select articles that fit the scope of this study. After collecting bibliometric data, we used the VOSviewer application to analyze collaboration patterns among researchers, research topic clusters, and the evolution of key concepts in the literature. Next, we utilized Publish or Perish software to evaluate publication impact, researcher productivity, and citations of relevant articles in the literature. The combined analysis of these two tools provides a comprehensive understanding of research trends in water distribution systems. This method provides a solid foundation for exploring and analyzing the latest research developments in the field of water distribution systems. By utilizing VOSviewer and Publish or Perish 8, this research aims to provide a meaningful contribution to a comprehensive understanding of collaboration dynamics, citation distribution, and the impact of publications in relevant literature.

RESULTS AND DISCUSSION

The following bibliometric analysis engages data processing through a database generated via the utilization of Publish or Perish 8. The journals that are searched are sourced from the semantic scholar. The keywords that are entered in the search include Water Managements, Drainage system management, water distribution system, water resource, water distribution network, with a maximum number of results set at 1000. The data collected in Publish or Perish 8 encompasses a variety of fields, including author, title, year, publisher, and type, in addition to the number of citations.

The data that are collected via Publish or Perish 8 are subsequently processed through the use of Microsoft Excel, where they are transformed into tables and graphs. The utilization of VOSviewer

software has been facilitated to render the data more readable via visualization. The bibliometric analysis conducted herein utilizing VOSviewer software provides a holistic overview of the research landscape in water distribution network. The VOSviewer software enables the identification of the relationship between keywords and density, thereby providing a comprehensive analysis of the subject matter.

Keywords Network Analysis

The keyworks provided by Publish or Perish and processed in the VOSviewer application at are in Publish or Perish and then generate the image below showing the keywords networks connection between others (Figure 1.).

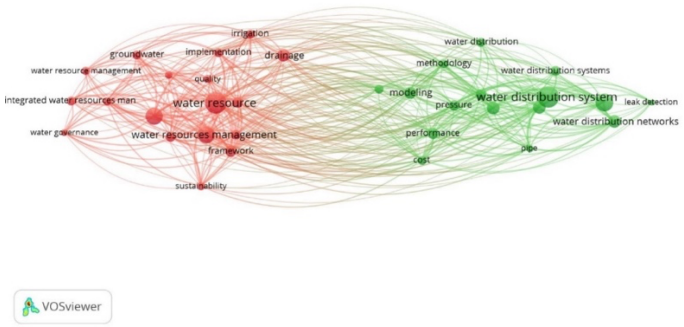

Figure 1. Network Visualization of Keywords

Keywords Density Analysis

The keyworks provided by Publish or Perish and processed in the VOSviewer application at are in Publish or Perish and then generate the image below showing the Density, meaning the keywords occurrence in journals (Figure 2.).

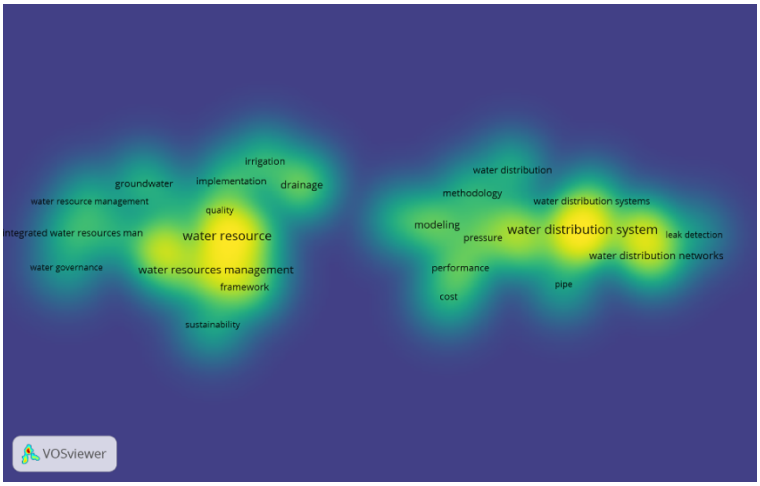

Figure 2. Density Visualization of Keywords

Yearly Analysis of Publications

This data is gathered from Publish or Perish 8 software. The data that are used is the research year from 2003 – 2023 with 1000 maximum searches using semantic scholar search. The conducted research includes the generation of a graph to illustrate the status of the quantity of relevant articles spanning from 2003 to 2023 (see Figure 3.)

In Figure 3, the publication year distribution shows an increasing trend. Since 2009, the number of publications has been increasing steadily. Based on Figure 3, the highest number of articles was in 2018

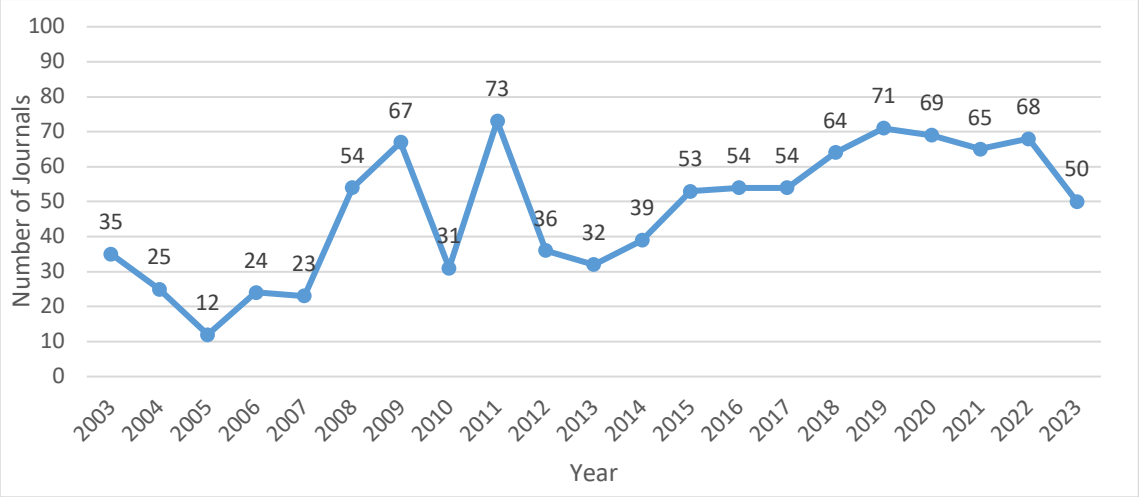

Figure 3. Distribution of Published Article from 2003 - 2023

CONCLUSION

This This research uses bibliometric analysis to identify research topic networks, evaluate the relevance of literature sources, and update research on public transport passenger satisfaction to maintain sustainable Transport. Publish or Perish application generated 1000 articles about the influence of passenger satisfaction on sustainable transportation between 2000 and 2023 consisting of 486 journal articles, 311 books, 54 reviews, 39 compositions, 34 report series, 16 datasets, 13 reference items, five texts, five monographs, two peer-reviewed, and 35 others. The study's findings indicate that passenger transport, satisfaction, and development are the three primary keywords and additional keywords related to the research topic. Based on data from the Public Transportation Satisfaction Study, it can be concluded that the number of studies continues to increase from 2000 to 2023, with the highest number in 2021. Research trends regarding public transportation satisfaction continue to grow every year and will continue to increase in the years to come.of.

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