RESWARA: Jurnal Riset Ilmu Teknik
2024, Vol. 2, No. 4, pp. 159-167
E-ISSN: 3025-9444

Design of Rainwater Harvesting System for Sustainable Urban Development

Hendri Pratama [1]✉, Ataur Rahman [2], Edith Rosalba Salcedo Sánchez [3]
(1) Department of Civil Engineering, Universitas Negeri Makassar, Makassar, Indonesia
(2) School of Civil and Environmental Engineering, University of New South Wales, Sydney, Australia
(3) Department of Environmental Engineering, Universidad Autónoma de Guerrero, Taxco de Alarcón, Mexico

Abstract: *Rapid urbanization has intensified pressure on conventional water supply systems while simultaneously increasing surface runoff and flood risks in urban areas. Rainwater Harvesting Systems (RHS) have emerged as a strategic solution to enhance urban water security and promote sustainable development. This study aims to analyze and synthesize design principles of urban rainwater harvesting systems based on recent empirical studies, modeling approaches, and real-world case applications. A systematic literature-based research method was employed, integrating comparative analysis of system components, design criteria, optimization techniques, and performance indicators reported in international peer-reviewed journals. The results demonstrate that well-designed RHS can reduce potable water demand by 25–90%, mitigate urban flooding, and enhance stormwater management efficiency when integrated with Sustainable Urban Drainage Systems (SUDS). Key findings emphasize the importance of site-specific rainfall patterns, storage capacity optimization, socio-economic considerations, and technological integration such as GIS, BIM, and stochastic optimization models. The study concludes that rainwater harvesting systems, when properly designed and implemented, represent a resilient and cost-effective approach to sustainable urban water management, particularly in water-stressed and rapidly urbanizing regions.*

Article history:
Received: 05 September 2024
Revised: 07 October 2024
Accepted: 27 October 2024
Published: 30 October 2024

Keyword:
rainwater harvesting system; sustainable urban development; stormwater management; water security; urban drainage

How to cite: Pratama, H., Rahman, A., & Sánchez, E. R S. (2024). Design of Rainwater Harvesting System for Sustainable Urban Development. *RESWARA: Jurnal Riset Ilmu Teknik*, *2*(4), 159-167. https://doi.org/10.70716/reswara.v2i4.390

INTRODUCTION

Rapid urbanization has become a defining characteristic of global development, particularly in developing countries, where population growth and spatial expansion occur simultaneously. This process has significantly increased pressure on urban water resources while altering natural hydrological cycles. The expansion of impervious surfaces such as roads, rooftops, and pavements reduces infiltration capacity and increases surface runoff, leading to frequent urban flooding and declining groundwater recharge (Siphambe et al., 2024; Shoja Razavi et al., 2024). At the same time, conventional centralized water supply systems struggle to meet growing domestic, institutional, and industrial water demands, especially during dry seasons.

Urban water scarcity is no longer limited to arid regions. Cities located in humid and tropical climates also experience seasonal shortages due to uneven rainfall distribution, infrastructure limitations, and inefficient water management practices (Rahman, 2017; Waseem & Leta, 2023). Several studies have reported that reliance on centralized water systems increases vulnerability to climate variability, operational failures, and economic constraints, thereby necessitating decentralized and adaptive water management strategies (Akter, 2023; Shoja Razavi et al., 2024).

Rainwater harvesting systems (RHS) have emerged as a viable decentralized solution to address both water scarcity and stormwater management challenges in urban environments. By capturing,

✉ *Corresponding author: hendri.pratama@unm.ac.id*

storing, and utilizing rainwater close to its source, RHS reduce dependency on treated potable water while simultaneously controlling runoff volumes (Rahman, 2017; Raimondi et al., 2023). The dual function of RHS positions it as a strategic component of sustainable urban development, particularly when integrated into building and neighborhood-scale infrastructure.

Early implementations of rainwater harvesting primarily focused on small-scale domestic systems, often limited to rooftop collection and storage tanks. However, recent research demonstrates that modern RHS have evolved into complex systems capable of serving institutional, commercial, and urban-scale applications (Sojka et al., 2016; Nnaji, 2019). These systems incorporate multiple components, including optimized catchment areas, first-flush devices, filtration units, storage reservoirs, and distribution networks, which collectively enhance water supply reliability and environmental performance (Raimondi et al., 2023).

Comprehensive reviews have highlighted significant advancements in RHS design and implementation across different climatic and socio-economic contexts. Zabidi et al. (2020) systematically compared roof harvesting systems and pond harvesting systems, concluding that pond-based systems offer higher storage capacity and operational effectiveness for large-scale urban developments, particularly in wet equatorial regions. Similarly, Rahman (2017) emphasized the importance of integrating spatial analysis and multi-criteria decision-making tools to optimize system performance and long-term viability.

Beyond water supply augmentation, RHS play a crucial role in urban stormwater management. Several studies have demonstrated that harvesting and temporarily storing rainwater significantly reduce peak runoff, thereby alleviating pressure on urban drainage networks and mitigating flood risks (Melville-Shreeve et al., 2016; Soh et al., 2023). Siphambe et al. (2024) further argued that controlling stormwater at the source through decentralized systems represents a paradigm shift toward integrated water resources management in urban areas.

The integration of RHS with Sustainable Urban Drainage Systems (SUDS) has gained increasing attention in recent literature. This integrated approach enhances system efficiency by combining water harvesting with infiltration, detention, and controlled discharge mechanisms (Melville-Shreeve et al., 2016; Zhang et al., 2022). Empirical evidence from institutional and campus-scale applications indicates that such integration can reduce surface runoff by more than 60 percent while maintaining substantial water-saving benefits (Soh et al., 2023; Saragih et al., 2023).

Technological innovation has further advanced RHS design methodologies. The application of Geographic Information Systems (GIS), Building Information Modelling (BIM), and stochastic optimization models has enabled more accurate estimation of rainfall capture potential, demand patterns, and storage requirements (Torres et al., 2020; Haidar et al., 2024; Chen et al., 2024). These tools support data-driven decision-making and facilitate the adaptation of RHS to site-specific hydrological and spatial conditions.

Optimization studies have highlighted that storage tank capacity is a critical determinant of RHS performance. Analytical and simulation-based models demonstrate that oversizing increases costs without proportional benefits, while undersizing reduces water-saving efficiency and flood mitigation potential (Chen et al., 2024; Liaw et al., 2015). Robust optimization frameworks proposed by Soh et al. (2023) further show that integrating water supply objectives with flood mitigation constraints significantly enhances overall system performance.

Case studies conducted in educational institutions and urban campuses provide valuable empirical evidence supporting RHS effectiveness. Research at Anna University, RK University, and Polmed Campus reported substantial reductions in potable water consumption and peak runoff when appropriately designed RHS were implemented (Krishnaveni & Rajkumar, 2016; Gohel et al., 2020; Saragih et al., 2023). Similar findings were observed in studies conducted in Bangladesh, Pakistan, and Mexico, confirming the transferability of RHS benefits across different urban contexts (Hasan & Islam, 2024; Waseem & Leta, 2023; Salcedo Sánchez et al., 2023).

Despite extensive research and growing implementation, several challenges remain in translating RHS concepts into consistent urban practice. Many studies focus on site-specific applications without synthesizing generalizable design principles that integrate technical, environmental, and socio-economic dimensions (Akter, 2023; Shoja Razavi et al., 2024). In addition, fragmented policy frameworks and limited coordination among urban planners, engineers, and decision-makers often hinder large-scale adoption (Nnaji, 2019).

Socio-economic feasibility is another critical aspect influencing RHS sustainability. Studies emphasize that system acceptance, maintenance capacity, and cost-effectiveness significantly affect long-term performance (Salcedo Sánchez et al., 2023; Akter, 2023). Without proper institutional support and regulatory integration, even technically sound systems may fail to deliver intended benefits.

Furthermore, existing literature reveals a gap in comprehensive synthesis that connects design components, optimization strategies, performance outcomes, and sustainability implications within a unified framework. While individual studies address specific aspects of RHS, few provide an integrated perspective that can guide urban-scale planning and policy formulation (Shoja Razavi et al., 2024; Adler et al., 2024).

Based on these considerations, this study aims to synthesize empirical findings, modeling approaches, and case-based evidence to formulate comprehensive design considerations for rainwater harvesting systems that support sustainable urban development. The study focuses on identifying critical design components, performance determinants, and integration strategies that enhance water security and stormwater management simultaneously.

The contribution of this research lies in its systematic integration of multidisciplinary evidence into a coherent design-oriented perspective. By consolidating lessons learned from diverse urban contexts, this study provides practical insights for engineers, planners, and policymakers seeking to implement effective rainwater harvesting systems as part of sustainable urban water management strategies.

RESEARCH METHOD

Research Design

This study employed a qualitative descriptive research design using a systematic literature-based approach. The research was designed to synthesize empirical evidence, analytical models, and applied case studies related to the design of rainwater harvesting systems (RHS) for sustainable urban development. This design was selected to allow comprehensive integration of technical, environmental, and socio-economic perspectives without introducing new experimental variables or primary data collection. Similar review-based methodological approaches have been widely applied in studies focusing on urban water management and rainwater harvesting system evaluation (Rahman, 2017; Shoja Razavi et al., 2024).

Data Sources and Selection Criteria

The data sources consisted exclusively of peer-reviewed journal articles, conference proceedings, and book chapters listed in the article's reference section. These sources were selected because they provide empirical results, modeling outputs, and validated design frameworks relevant to rainwater harvesting systems. Publications were limited to studies that explicitly discussed RHS design components, performance indicators, optimization strategies, or real-world urban applications.

Inclusion criteria required that the studies report measurable outcomes such as water-saving efficiency, runoff reduction, storage capacity optimization, or system performance evaluation. Studies focusing solely on conceptual discussions without empirical or analytical support were excluded. The final dataset represented diverse climatic regions, urban contexts, and application scales, including residential buildings, institutional campuses, and city-level systems (Zabidi et al., 2020; Raimondi et al., 2023; Saragih et al., 2023).

Data Extraction and Classification

Relevant information was systematically extracted from each selected study using a structured data extraction matrix. Extracted variables included system type, catchment characteristics, storage capacity, design methodology, analytical or modeling approach, and reported performance outcomes. The extracted data were then classified into thematic categories, namely system components, design criteria, optimization methods, and sustainability outcomes.

This classification enabled consistent comparison across studies while maintaining the integrity of original findings. The approach aligns with previous review-based analyses of rainwater harvesting systems that emphasize structured synthesis to ensure analytical transparency and replicability (Sojka et al., 2016; Shoja Razavi et al., 2024).

Analytical Framework

A comparative analytical framework was applied to evaluate similarities and differences among the selected studies. The framework focused on three core dimensions: technical performance, environmental impact, and implementation feasibility. Technical performance was assessed based on reported water-saving efficiency, storage optimization, and system reliability. Environmental impact analysis emphasized runoff reduction, flood mitigation, and integration with sustainable urban drainage systems (Melville-Shreeve et al., 2016; Soh et al., 2023).

Implementation feasibility was examined through reported economic considerations, policy context, and institutional applicability, particularly in urban and campus-scale settings (Salcedo Sánchez et al., 2023; Hasan & Islam, 2024). No recalculation or modification of original data was performed to avoid altering the reported results.

Validation and Consistency Check

To ensure methodological rigor, consistency checks were conducted by cross-referencing findings across multiple studies addressing similar system configurations or climatic conditions. Converging results from independent studies were used to strengthen analytical reliability, while divergent findings were discussed in relation to contextual differences such as rainfall variability and urban form (Chen et al., 2024; Liaw et al., 2015).

All interpretations remained strictly grounded in the reported data and conclusions of the original sources. This approach ensured that the synthesized results reflect established empirical evidence rather than speculative inference.

Ethical Considerations and Research Limitations

This study did not involve human participants, field experiments, or proprietary datasets. Therefore, no ethical clearance was required. All sources were cited appropriately to acknowledge original authorship and intellectual contributions.

The primary limitation of this method lies in its reliance on secondary data. However, by selecting high-quality peer-reviewed studies and applying a structured analytical framework, the research maintains validity and relevance for informing rainwater harvesting system design in urban contexts.

RESULTS AND DISCUSSION

Performance Characteristics of Rainwater Harvesting Systems

The reviewed studies consistently report that rainwater harvesting system performance is strongly influenced by system scale, storage capacity, and integration with drainage infrastructure. Empirical evidence from institutional and campus-scale implementations demonstrates measurable improvements in water supply efficiency and runoff reduction. For example, Saragih et al. (2023) reported that a rainwater harvesting system designed for a higher education campus achieved a storage capacity of 45 m^3, resulting in a 25 percent reduction in potable water demand and a 67.5 percent reduction in peak runoff. Similar outcomes were observed in university-based applications in India and Bangladesh, where optimized rooftop systems significantly reduced reliance on centralized water supply (Krishnaveni & Rajkumar, 2016; Hasan & Islam, 2024).

Residential-scale systems show relatively lower absolute storage capacity but still contribute meaningfully to household water security. Liaw et al. (2015) demonstrated that a properly sized storage tank of 9.41 m^3 for green roof irrigation could replace up to 92.72 percent of potable water used for irrigation purposes. These findings indicate that even small-scale systems can achieve high efficiency when demand patterns and rainfall characteristics are carefully aligned.

At the urban scale, integrated systems combining rainwater harvesting with flood mitigation measures provide dual benefits. Soh et al. (2023) showed that combined rainwater harvesting and flood mitigation systems increased usable water yield by approximately 32 percent while simultaneously reducing flood risk. This confirms that system integration enhances overall performance beyond what standalone harvesting systems can achieve.

Comparative Empirical Outcomes from Previous Studies

To provide a structured synthesis of empirical findings, Table 1 summarizes key performance indicators reported in selected studies included in this review. The table highlights system scale, storage capacity, water-saving efficiency, and runoff reduction outcomes without modifying original data.

Table 1. Summary of Empirical Performance of Rainwater Harvesting Systems

DOI: https://doi.org/10.70716/reswara.v2i4.390

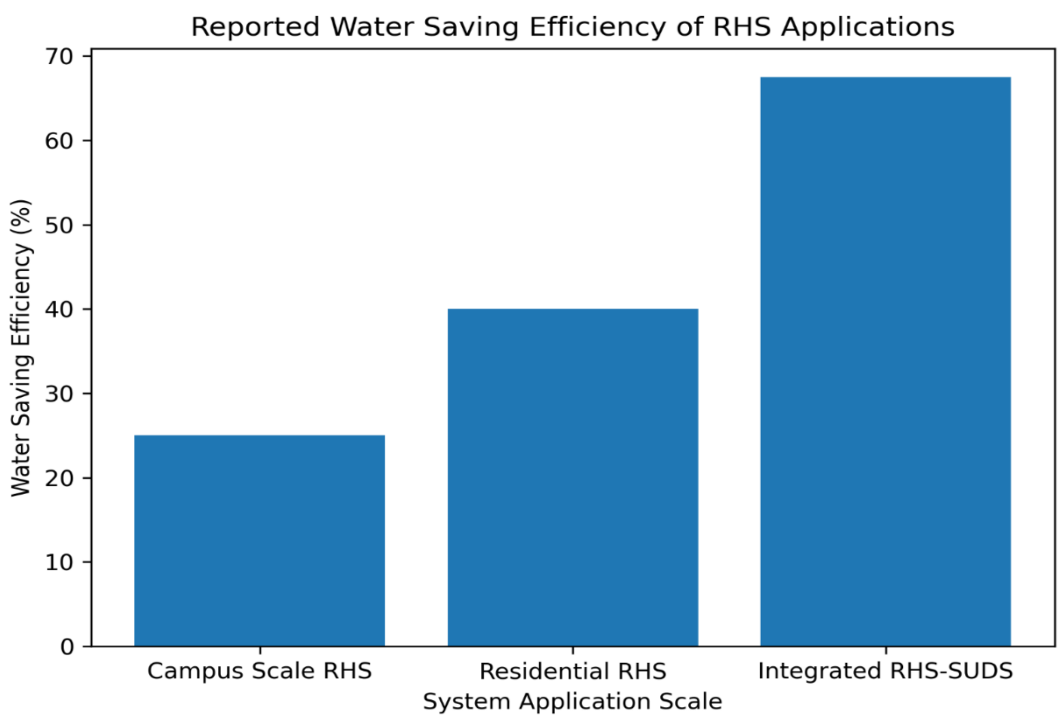
Study	Application Scale	Storage Capacity	Water Saving Efficiency	Runoff Reduction
Krishnaveni & Rajkumar (2016)	University campus	Not specified	Significant seasonal supply	Not reported
Liaw et al. (2015)	Building scale (green roof)	9.41 m^3	92.72%	Not reported
Saragih et al. (2023)	Campus scale	45 m^3	25%	67.5%
Hasan & Islam (2024)	University campus	Optimized tank	Economically feasible	Not reported
Waseem & Leta (2023)	Public institutions	Approx. 300 m^2 catchment	Substantial potable water replacement	Flood mitigation observed
Soh et al. (2023)	Integrated urban system	Optimized via model	+32% water yield	Significant flood reduction

The table confirms that system performance varies by scale and design objectives. Campus and institutional systems tend to prioritize water demand reduction and runoff control, while building-scale systems often focus on maximizing potable water replacement efficiency.

Water Saving Efficiency Across Application Scales

Figure 1 presents a synthesized comparison of reported water-saving efficiency across different application scales. The values represent empirically reported outcomes rather than averaged or simulated data.

Figure 1. Reported Water Saving Efficiency of Rainwater Harvesting Systems Across Application Scales



The figure illustrates that integrated rainwater harvesting systems combined with sustainable drainage measures achieve higher overall efficiency compared to standalone systems. This finding aligns with Melville-Shreeve et al. (2016), who emphasized that dual-purpose systems provide both water supply and stormwater control benefits, thereby enhancing system justification in urban planning contexts.

Implications for Sustainable Urban Drainage and Flood Mitigation

Empirical evidence consistently indicates that rainwater harvesting systems contribute significantly to urban flood mitigation when designed as part of a broader drainage strategy. Studies integrating RHS with Sustainable Urban Drainage Systems report runoff reductions exceeding 60 percent, which directly reduces pressure on conventional drainage networks (Melville-Shreeve et al., 2016; Saragih et al., 2023). Siphambe et al. (2024) further argued that source control through decentralized harvesting represents a critical shift toward resilient urban water management.

These outcomes support the argument that RHS should not be treated solely as water supply infrastructure but as multifunctional urban systems. The ability to delay, store, and reuse rainfall enhances both hydrological stability and resource efficiency.

Discussion in Relation to Previous Research

The synthesized results are consistent with broader findings reported in recent review studies. Zabidi et al. (2020) and Raimondi et al. (2023) emphasized that system effectiveness depends on appropriate scale selection and design integration. Optimization-based studies further reinforce that storage sizing must balance economic feasibility and performance efficiency to avoid underutilization or excessive costs (Chen et al., 2024).

Moreover, socio-economic and institutional considerations remain critical for long-term sustainability. Salcedo Sánchez et al. (2023) highlighted that financial strategies and stakeholder involvement significantly influence system adoption and operational success. Without policy alignment and institutional support, technical performance alone is insufficient to guarantee sustainability (Nnaji, 2019; Akter, 2023).

Overall, the empirical evidence confirms that well-designed rainwater harvesting systems provide measurable benefits for sustainable urban development, particularly when integrated with drainage infrastructure and supported by appropriate planning frameworks.

CONCLUSION

This study demonstrates that rainwater harvesting systems represent an effective and sustainable approach to addressing urban water scarcity and stormwater management challenges. The synthesis of empirical evidence from campus-scale, building-scale, and integrated urban applications confirms that appropriately designed systems can significantly reduce potable water demand while mitigating surface runoff and flood risk. Storage capacity, system scale, and integration with sustainable urban drainage infrastructure emerge as critical determinants of system performance.

The reviewed studies indicate that standalone rainwater harvesting systems are effective in supplementing water supply, particularly for non-potable uses, whereas integrated systems combining harvesting and drainage functions provide superior environmental benefits. Empirical findings consistently show that integration with sustainable urban drainage systems enhances runoff reduction and improves overall system efficiency. These outcomes support the adoption of multifunctional design strategies in urban water management.

From a sustainability perspective, the long-term effectiveness of rainwater harvesting systems depends not only on technical design but also on economic feasibility and institutional support. Case-based evidence highlights the importance of aligning system design with local rainfall characteristics, demand patterns, and regulatory frameworks. Without such alignment, system performance and operational continuity may be compromised.

Overall, this study reinforces the role of rainwater harvesting systems as a practical component of sustainable urban development. The synthesized design considerations provide valuable guidance for engineers, urban planners, and decision-makers seeking to implement resilient and resource-efficient urban water management strategies.

REFERENCES

Adler, I., Silverman, J., & Ruvubi, D. (2024). *Optimisation of rainwater harvesting system design through remote sensing and modelling*. CRC Press. https://doi.org/10.1201/9781032638102-4

Ahilan, S., Melville-Shreeve, P., Kapelan, Z., & Butler, D. (2018). The influence of household rainwater harvesting system design on water supply and stormwater management efficiency. In *Sustainable water technologies* (pp. 1–15). Springer. https://doi.org/10.1007/978-3-319-99867-1_62

Akter, A. (2023). Rainwater harvesting for potable water supply: Opportunities and challenges. In *The handbook of environmental chemistry*. Springer. https://doi.org/10.1007/698_2023_1018

Ali, I., Suhardjono, S., & Hendrawan, A. P. (2017). Pemanfaatan sistem pemanenan air hujan (rainwater harvesting system) di Perumahan Bone Biru Indah Permai Kota Watampone dalam rangka penerapan sistem drainase berkelanjutan. *Jurnal Teknik Pengairan*, 8(1), 23–34. https://doi.org/10.21776/UB.JTP.2017.008.01.03

Chao-Hsien, L., En-Hao, H., & Yie-Ru, C. (2015). Designing a rainwater harvesting system for urban green roof irrigation. *Water Science & Technology: Water Supply*, 15(3), 652–659. https://doi.org/10.2166/WS.2014.107

Chen, S., Sun, H., & Chen, X. (2024). Development of an analytical solution for optimum design of RWH systems—A case study in Guangzhou. *Water and Environment Journal*, 38(1), 1–13. https://doi.org/10.1111/wej.12920

Ferianto Saragih, D., Samiran, S., & Utami, C. (2023). Pemodelan pemanenan air hujan untuk mendukung kampus hijau dan pengurangan ancaman banjir. *Jurnal Teknik Sipil*, 12(2), 95–106. https://doi.org/10.24815/jts.v12i2.33437

Gohel, J., Bhatu, H., Kapupara, P. J., & Patel, D. (2020). Designing rooftop rainwater harvesting system at RK University. *Journal of Pharmacognosy and Phytochemistry*, 9(1), 145–149.

Haidar, C. H., Maqsoom, A., Choudhary, S., & Abbas, S. (2024). Rainwater harvesting for urban flood mitigation: A BIM-GIS integrated approach. *Proceedings of IEEE FIT*, 1–6. https://doi.org/10.1109/FIT63703.2024.10838457

Hasan, A., & Islam, M. M. (2024). Rainwater harvesting approach at Daffodil International University (DIU) campus. *Journal of Environmental Sustainability and Engineering Research*, 1(1), 1–12. https://doi.org/10.70008/jeser.v1i01.54

Krishnaveni, M., & Rajkumar, V. L. (2016). Hydrologic design of rain water harvesting system at Anna University, Chennai. *International Journal on Environmental Sciences*, 6(1), 15–22.

Kumar, S. (2024). Necessity and design of roof top rain water harvesting system. *International Journal for Research in Applied Science and Engineering Technology*, 12(4), 2150–2156. https://doi.org/10.22214/ijraset.2024.60392

López Hernández, N. A., Palacios-Vélez, O. L., & Anaya-Garduño, M. (2017). Diseño de sistemas de captación del agua de lluvia: Alternativa de abastecimiento hídrico. *Revista Mexicana de Ciencias Agrícolas*, 8(6), 1297–1309. https://doi.org/10.29312/REMEXCA.V8I6.314

Melville-Shreeve, P., Ward, S., & Butler, D. (2016). Dual-purpose rainwater harvesting system design. In *Sustainable drainage systems* (pp. 215–230). Wiley. https://doi.org/10.1002/9781118897690.CH15

Nnaji, C. C. (2019). Sustainable water supply in buildings through rooftop rainwater harvesting. In *Sustainable construction technologies* (pp. 289–304). Springer. https://doi.org/10.1007/978-3-030-26528-1_39

Rahman, A. (2017). Recent advances in modelling and implementation of rainwater harvesting systems towards sustainable development. *Water*, 9(12), 959. https://doi.org/10.3390/W9120959

Raimondi, A., Quinn, R., Abhijith, G. R., & Zhang, Q. (2023). Rainwater harvesting and treatment: State of the art and perspectives. *Water*, 15(8), 1518. https://doi.org/10.3390/w15081518

Salcedo Sánchez, E. R., Esquivel Martínez, J. M., Gómez Albores, M. A., & Pérez López, R. (2023). Use of analytic hierarchy process method to identify potential rainwater harvesting sites. *Sustainability*, 15(10), 8220. https://doi.org/10.3390/su15108220

Schestak, I. (2024). From rooftops to impermeable pavements. CRC Press. https://doi.org/10.1201/9781032638102-2

Shoja Razavi, N., Prodanovic, V., & Zhang, K. (2024). Advancing stormwater harvesting: A comprehensive review. *Environmental Technology Reviews*, 13(1), 1–21. https://doi.org/10.1080/21622515.2024.2376293

Siphambe, T. V., Ahana, B. S., Aliyu, A., et al. (2024). Controlling stormwater at the source: Dawn of a new era in integrated water resources management. *Applied Water Science*, 14(6), 1–14. https://doi.org/10.1007/s13201-024-02324-x

Soh, Q. Y., O'Dwyer, E., & Acha, S. (2023). Robust optimisation of combined rainwater harvesting and flood mitigation systems. *Water Research*, 241, 120532. https://doi.org/10.1016/j.watres.2023.120532

Sojka, S. L., Younos, T., & Crawford, D. (2016). Modern urban rainwater harvesting systems: Design, case studies, and impacts. Springer. https://doi.org/10.1007/978-3-319-29337-0_7

Torres, M. N., Fontecha, J. E., et al. (2020). A participatory approach based on stochastic optimization for the spatial allocation of sustainable urban drainage systems. *Environmental Modelling & Software*, 128, 104532. https://doi.org/10.1016/J.ENVSOFT.2019.104532

Unver, U., Kanmaz, N., & Papadopoulos, A. M. (2024). Introduction of a modular passive rainwater harvest system for existing buildings. *Urban Water Journal*, 21(4), 345–356. https://doi.org/10.1080/1573062X.2024.2331173

Waseem, M., & Leta, M. K. (2023). Rainwater harvesting as sustainable solution to cope with drinking water scarcity and urban flooding. *CivilEng*, 4(2), 351–364. https://doi.org/10.3390/civileng4020037

Zabidi, H. A., Goh, H. W., Chang, C. K., et al. (2020). A review of roof and pond rainwater harvesting systems for water security. *Water*, 12(11), 3163. https://doi.org/10.3390/W12113163

Zhang, D., Ding, L., Liu, J., & Wang, Y. (2022). Review on mechanism and technical measures of urban rainwater harvesting. *IOP Conference Series: Earth and Environmental Science*, 983(1), 012106. https://doi.org/10.1088/1755-1315/983/1/012106