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# Developing an Adaptive Resilience Index for Flood-Resistant Urban Drainage Systems

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***Abstract***

Most urban drainage systems worldwide are under unprecedented stress due to extreme weather driven by climate change and rapid urbanization. This creates severe challenges for traditional static design paradigms. While the different resilience indices proposed to date provide useful performance benchmarks, they reflect the system state at a single point in time and do not capture the system's dynamic capacity to adapt and learn under evolving climatic pressures and urban growth. This paper helps fill this research gap by introducing a new conceptual framework, the Adaptive Resilience Index (ARI). ARI integrates three core dimensions: System Capacity, Climatic Sensitivity, and Adaptive Capacity, offering a potential framework for assessing adaptive resilience in urban drainage systems. The tripartite structure provides a dynamic lens to evaluate system robustness, vulnerability to climatic shifts, and proactive capacity for learning and reorganization. Although the ARI has not yet been empirically tested, its proposed indicators could be operationalized in future studies through surveys, modeling, and institutional assessments, thereby guiding the development of more resilient, adaptive, and sustainable urban drainage infrastructure in a climate-uncertain world.

## I. INTRODUCTION

Urban flooding is one of the most pressing environmental challenges facing cities today, affecting public safety, economic stability, and critical infrastructure (Kala & Balboni, 2023). The interaction of global warming and rapid urbanization acts as compounded stressors on already overloaded drainage systems, as historical design capacities are exceeded and impervious surfaces increase, reducing infiltration and accelerating runoff (Ogie et al., 2019). These dynamics highlight the need for adaptive infrastructure and climate-resilient management, as emphasized in recent global discussions (Magnan et al., 2022; Manzoor et al., 2022; Pambudi et al., 2023). Traditional gray infrastructure, designed under stationary climate assumptions, often lacks the flexibility to absorb shocks, leaving systems rigid and ill-equipped to handle contemporary environmental pressures.

The socio-economic consequences of urban flooding are profound, disproportionately affecting vulnerable populations and raising issues of climate justice (Boston & Jeffrey Thomas Malloy, 2021; Brousseau et al., 2024; Foster et al., 2024). Linking adaptive capacity to social and institutional frameworks is therefore essential, as it ensures that urban drainage systems respond equitably and effectively to flooding events. Recent studies emphasize that smart and eco-friendly

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infrastructure must integrate digital intelligence and adaptive mechanisms to cope with non-stationary environmental dynamics (Harrow et al., 2021; Natarajan et al., 2023; Setyadi Tommy & Putra Jaya, 2025; Wang et al., 2023). Without such integration, socio-economic risks cascade, from property damage to disruption of livelihoods, demonstrating the urgency of adaptive planning.

While previous resilience indices have provided useful performance benchmarks (Guptha et al., 2022; Mohanty et al., 2020), they primarily capture static system states and fail to account for dynamic adaptive capacities the potential for systems to learn, reorganize, and adapt over time (Conz & Magnani, 2020). This limitation is critical, given the documented importance of adaptive capabilities in organizational resilience, supply chains, and ecological systems (Adobor, 2020; Bastiaansen et al., 2020; Nyaupane et al., 2020). Addressing this gap requires a framework that explicitly integrates adaptive capacity with system performance, climatic sensitivity, and social-ecological considerations.

To address this gap, this study develops a conceptual framework for an Adaptive Resilience Index (ARI), integrating system capacity, climatic sensitivity, and adaptive capacity in a time-varying manner (Harrow et al., 2021; Setyadi Tommy & Putra Jaya, 2025). ARI explicitly incorporates social and organizational dimensions, linking engineering robustness with learning and flexibility to promote equitable flood management outcomes. This framework provides the basis for the future operationalization of indicators, guides empirical research, and supports climate-resilient urban planning. The paper is structured as follows: Section 2 reviews adaptive resilience theory and its application to urban drainage; Section 3 describes the constructive conceptual synthesis methodology; Section 4 presents the ARI structure and indicators; and Section 5 concludes with implications, limitations, and future research directions.

## II. LITERATURE REVIEW

Resilience as a concept has evolved from a narrowly engineered ability to return to equilibrium into an ecological and adaptive perspective, emphasizing persistence, adaptability, and transformation in complex dynamic environments (Magnan et al., 2022). This adaptive resilience thinking stresses the need to integrate system performance with learning, organizational capacity, and temporal flexibility, particularly in urban drainage systems, which function as socio-technical systems interacting with climatic, ecological, and social drivers of change (Brousseau et al., 2024; Dapilah et al., 2020; Simpong et al., 2022). Although originally derived from ecology, these concepts are increasingly applied to other domains, such as supply chain management and smart grids, where adaptive cycles and control mechanisms are critical for maintaining stability under disruption (Azadegan & Dooley, 2021; Lu et al., 2020). This cross-disciplinary perspective underlines the importance of engaging multiple fields when designing and managing resilient urban infrastructure.

The shift from merely conveying rainwater to integrated management represents a paradigm change in urban drainage, moving toward more adaptive and sustainable systems. Traditional systems that focus on water removal are gradually being replaced or complemented by Sustainable Urban Drainage Systems (SuDS), Low Impact Development (LID), and Nature-Based Solutions (NBS), including green roofs, permeable pavements, and bioswales (Bark et al., 2020; D'Ambrosio et al., 2022). While these solutions provide multifunctional benefits, improving storage, infiltration, water quality, and social-ecological outcomes, they are often evaluated solely on static performance. Consequently, these conventional approaches fail to account for the system's capacity to adapt and learn over time, leaving a critical gap in resilience assessment.

**Table 1: Summary of selected past studies on drainage and flood resilience indices.**

| Author (Year) | Focus Area | Method | Key Limitation |
| --- | --- | --- | --- |
| (Mohanty et al., 2020) | Flood risk classification | Bivariate risk model | Static socio-economic and hazard dimensions |
| (Guptha et al., 2022) | SuDS role in resilience enhancement | Case study simulation | Focuses on static capacity, not adaptive learning |
| (Sun et al., 2021) | Climate impacts & flood schemes | Scenario assessment | Evaluates predefined schemes, not system adaptability |
| (Tansar et al., 2022) | LID effectiveness at multiple scales | Hydraulic modelling | Assesses performance, not dynamic adaptive capacity |

Table 1 summarizes selected past studies on drainage and flood resilience indices, highlighting their focus areas, methods, and key limitations. As shown, most conventional indices (Guptha et al., 2022; Mohanty et al., 2020; Sun et al., 2021; Tansar et al., 2022) primarily measure static system properties or predefined interventions and lack mechanisms for adaptive learning, feedback, and temporal flexibility. In contrast, the proposed Adaptive Resilience Index (ARI) explicitly incorporates dynamic adaptive capacity, institutional flexibility, and learning mechanisms, thereby addressing these gaps. This allows ARI to provide a more comprehensive and forward-looking evaluation of resilience potential, surpassing the limitations of static indices.

From this review, it is clear that current indices mainly focus on short-term performance or static properties, omitting indicators that capture how systems learn, self-organize, and respond to uncertain future risks. These limitations directly motivate the development of the ARI framework, which views the Resilience Outcome of an urban drainage system as an emergent property arising from the interplay among System Capacity, exposure, Sensitivity to climatic stressors, and the effectiveness of Adaptive Mechanisms (Figure 1). By integrating temporal flexibility, learning capacity, and adaptive management, ARI overcomes the constraints of conventional performance-only indices. This conceptual approach provides a foundation for future empirical validation and operationalization of adaptive resilience indicators.

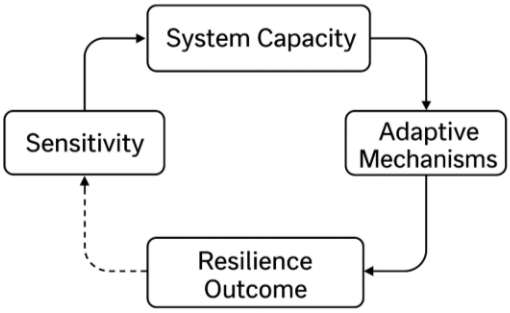


**Figure 1: Conceptual Framework of the Adaptive Resilience Index (ARI).**

## III. RESEARCH METHODOLOGY

### *A. Research Design*

We grounded this study in a qualitative research design employing constructive conceptual synthesis, which is particularly suitable for developing novel theoretical frameworks by integrating concepts from multiple bodies of literature (Singh et al., 2020). This approach enables the systematic abstraction, recombination, and logical alignment of theories drawn from adaptive resilience, socio-technical systems, and urban drainage research. The Adaptive Resilience Index (ARI) is therefore developed through a deductive and integrative reasoning process rather than empirical testing. It is explicitly emphasized that this research remains at a conceptual stage, aiming to establish theoretical coherence and explanatory robustness rather than to validate the framework empirically.

### *B. Research Stages*

The development of the ARI followed a structured, multi-stage process, as illustrated in Figure 2, to ensure transparency and theoretical rigor. The first stage involved identifying key theories and candidate indicators related to adaptive capacity, resilience, and system performance across ecology, organizational science, and infrastructure management literature. In the second stage, these concepts were critically classified, synthesized, and mapped onto the functional and performance characteristics of urban drainage systems. The final stage consisted of conceptual validation through cross-literature comparison, ensuring that the proposed dimensions and indicators were logically consistent, theoretically grounded, and clearly differentiated, while acknowledging that empirical calibration is deferred to future research.

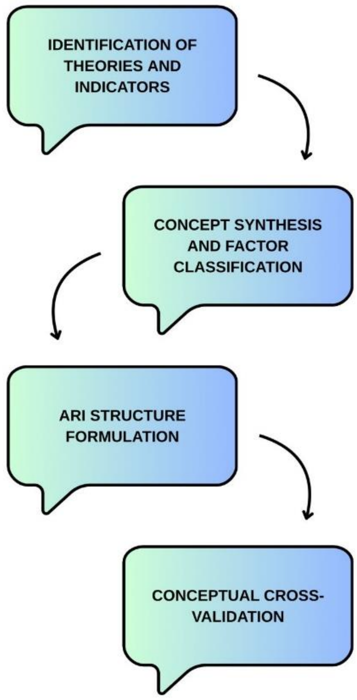


**Figure 2: Flowchart of research procedure.**

*C. Analysis Technique*

The primary analytical method employed was deductive–comparative analysis across multiple theoretical domains. General principles of adaptive systems were first derived from established resilience theory and then systematically compared with documented characteristics of urban drainage systems reported in the literature. This process emphasized conceptual alignment between theoretical indicators and practical system attributes, rather than quantitative validation. The analysis was iterative, enabling continuous refinement of ARI components to ensure internal consistency, conceptual clarity, and completeness within the theoretical framework's defined scope.

*D. Potential Operationalization of the ARI*

Although the ARI is developed as a conceptual framework, each indicator is explicitly defined with a clear pathway toward future operationalization. Potential empirical implementation may involve hydrological modeling to quantify system capacity and climatic sensitivity, survey-based instruments to assess organizational learning and institutional adaptability, and performance metrics derived from infrastructure management records. This staged development allows the ARI to maintain theoretical rigor while remaining flexible for empirical testing in diverse urban contexts. By clearly distinguishing conceptual formulation from future measurement strategies, this study addresses reviewer concerns regarding operational clarity without prematurely engaging in empirical validation.

## IV. FINDINGS AND DUSCUSSION

### *A. Result*

This study resulted in the development of the Adaptive Resilience Index (ARI) as a conceptual analytical framework, which represents the primary outcome of this research. Rather than offering an empirically validated performance score, ARI is intended to provide a structured diagnostic lens for understanding the multidimensional and dynamic nature of resilience in urban drainage systems. The proposed indicators highlight how resilience extends beyond physical robustness to include sensitivity to climatic stressors and the capacity for adaptation over time. In this sense, ARI offers potential improvement over static resilience metrics by enabling planners and managers to assess relative strengths and weaknesses across different resilience dimensions qualitatively.

The ARI framework is structured around three primary dimensions Capacity, Sensitivity, and Adaptability each represented by a set of conceptually defined indicators. Table 2 explicitly presents these dimensions and their associated indicators, serving as the core output of the conceptual synthesis conducted in this study. The indicators are not intended to be exhaustive or final, but rather to provide a theoretically grounded foundation for future refinement and empirical operationalization. By organizing resilience attributes into a coherent structure, Table 2 illustrates how technical, environmental, and institutional factors are jointly considered within the ARI framework.

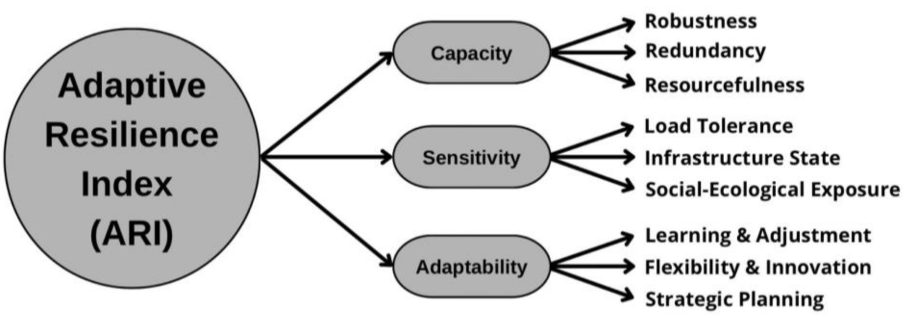


**Figure 3: ARI Structure Diagram.**

As illustrated in Figure 3, the three ARI dimensions are interconnected dynamically, with Capacity and Sensitivity establishing the baseline system condition. At the same time, Adaptability serves as a key modulating factor over time. This visualization supports the conceptual argument that resilience is not a fixed property but an evolving outcome shaped by continuous interaction between system components and external stressors. Figure 3 clarifies how changes in adaptive mechanisms can alter resilience trajectories even when physical capacity remains constant. Consequently, the figure reinforces the time-dependent logic underpinning the ARI structure.

**Table 2: Proposed Dimensions and Indicators of the Adaptive Resilience Index (ARI)**

| Dimension | Indicator | Description |
|---|---|---|
| Capacity | Robustness | The ability of system components (e.g., pipes, pumps) to withstand hydraulic loads without significant degradation of function. |
| | Redundancy | The availability of alternative flow paths or backup systems to maintain functionality if primary elements fail. |
| | Resourcefulness | The ability to mobilize material, financial, and human resources to respond to and manage flood events effectively. |
| Sensitivity | Load Tolerance | The system's performance threshold and its ability to handle precipitation and runoff volumes exceeding design standards. |
| | Infrastructure State | The physical condition and degradation level of assets, influencing their susceptibility to failure under stress. |
| | Social-Ecological Exposure | The degree to which the surrounding population and natural environment are vulnerable to system failure. |
| Adaptability | Learning & Adjustment | The institutional capacity to monitor performance, learn from past flood events, and adjust operational rules and maintenance protocols. |
| | Flexibility & Innovation | The ability to integrate new technologies (e.g., real-time control and AI-driven forecasting) and implement innovative solutions such as SuDS. |
| | Strategic Planning | The existence of long-term plans, policies, and funding mechanisms for proactive system upgrades and climate adaptation. |

Figure 1 further elaborates the conceptual logic of the ARI by depicting how systems respond to flooding shocks through different resilience pathways. Immediate system responses are primarily governed by Capacity and Sensitivity, determining the extent to which infrastructure can absorb and manage hydraulic stress. However, the long-term resilience outcome is largely shaped by Adaptive Mechanisms, including learning, innovation, and strategic planning. Systems with high adaptive capacity may not only recover but also reconfigure themselves to reduce future vulnerability, whereas systems with limited adaptability may remain brittle despite strong initial capacity. ARI is therefore designed to capture this dynamic interplay conceptually, rather than to quantify resilience outcomes empirically at this stage.

### ***B. Discussion***

The ARI framework offers a conceptual shift in resilience thinking by framing urban drainage systems as adaptive socio-technical systems rather than static engineering assets. By treating Adaptability as a core dimension rather than a secondary or external factor, the framework aligns with contemporary resilience theory, which emphasizes learning, flexibility, and transformation. Rather than claiming superiority over existing indices, ARI offers potential improvement by explicitly addressing temporal dynamics and adaptive processes. This perspective supports a more holistic understanding of infrastructure sustainability under conditions of deep uncertainty.

The ARI framework builds upon prior resilience indices that emphasize static capacity and vulnerability metrics (Guptha et al., 2022; Mohanty et al., 2020), while also addressing their documented limitations. Conventional indices primarily evaluate predefined scenarios and fixed performance thresholds, whereas ARI conceptually integrates feedback loops and learning processes characteristic of adaptive systems. In doing so, ARI provides a theoretical bridge between traditional engineering resilience and ecological resilience paradigms. This integrative approach allows institutional learning, strategic planning, and innovation to be considered alongside physical infrastructure within a single analytical structure.

From a practical perspective, ARI should be interpreted as a diagnostic and guiding framework rather than a decision-support tool with immediate quantitative outputs. The framework helps urban water managers identify which dimensions of resilience such as physical robustness, exposure management, or institutional adaptability may require greater attention. For instance, a system may demonstrate strong physical capacity but weak strategic planning, suggesting that governance reforms may be as critical as infrastructure upgrades. In this way, ARI offers conceptual insight to support adaptive flood management strategies, without asserting empirically proven performance advantages.

**Limitations**

As a conceptual study, this research has several inherent limitations that must be acknowledged. The most significant limitation is the absence of empirical validation, as the ARI has not yet been applied to real-world case studies or supported by quantitative data. In addition, the proposed indicators remain at a theoretical level and require further operationalization into measurable parameters, which may reveal practical challenges not apparent during conceptual development. This study also intentionally refrains from proposing indicator weighting schemes or aggregation methods, as such decisions involve normative judgments and context-specific priorities. Future research could address these limitations by operationalizing ARI indicators through hydrological simulations, field measurements, surveys, or institutional performance metrics to evaluate applicability and robustness across diverse urban contexts.

## V. CONCLUSION AND RECOMMENDATION

This study presents the Adaptive Resilience Index (ARI) as a conceptual framework for assessing adaptive capacities in urban drainage systems under climate uncertainty. By integrating System Capacity, Climatic Sensitivity, and Adaptive Capacity, ARI addresses a key limitation of existing resilience indices that predominantly rely on static performance and vulnerability metrics. Rather than providing an empirical score, ARI offers a structured conceptual lens to diagnose strengths and weaknesses across physical, climatic, and institutional dimensions. In this way, the framework bridges engineering-based assessments with socio-ecological perspectives, contributing a coherent theoretical basis for understanding resilience as a dynamic and evolving system property.

Despite its conceptual contributions, this study is subject to several limitations that should be acknowledged. Most notably, ARI has not yet been empirically validated, nor have weighting schemes for aggregating indicators been developed. Future research should focus on operationalizing the proposed indicators using hydrological modeling outputs, infrastructure condition data, institutional surveys, and policy metrics, and then apply them in case-study cities to test robustness and contextual relevance. Further work may also explore integrating ARI with GIS-based analyses, hydrodynamic simulations, and emerging tools such as AI and digital twins to enable the dynamic updating of resilience diagnostics (Diana & Angga Mukti, 2025; Iqbal et al., 2021). Such developments would support the transition from a static conceptual framework to a practical tool for adaptive, forward-looking urban flood management.

### AI-Assisted Language Editing Disclosure

The authors acknowledge that AI tools, such as ChatGPT, were used exclusively for improving language and editorial quality. All intellectual and scientific components of the study, including conceptualization, data acquisition, analysis, interpretation, and conclusion formulation, were conducted independently by the authors. The authors remain fully accountable for the content, accuracy, and authenticity of the manuscript.

## REFERENCES

Adobor, H. (2020). Supply chain resilience: an adaptive cycle approach. *International Journal of Logistics Management*, *31*(3), 443–463. https://doi.org/10.1108/IJLM-01-2020-0019

Azadegan, A., & Dooley, K. (2021). *A Typology Of Supply Network Resilience Strategies: Complex Collaborations In A Complex World*.

Bark, R. H., Martin-Ortega, J., & Waylen, K. A. (2020). *Stakeholders' views on natural flood management: Implications for the nature-based solutions paradigm shift?* https://www.iucn.org/theme/nature-based-solutions

Bastiaansen, R., Doelman, A., Eppinga, M. B., & Rietkerk, M. (2020). The effect of climate change on the resilience of ecosystems with adaptive spatial pattern formation. *Ecology Letters*, *23*(3), 414–429. https://doi.org/10.1111/ele.13449

Boston, M., & Jeffrey Thomas Malloy, M. (2021). *Implementing Socially Just Climate Adaptation: A Case Study of*.

Brousseau, J. J., Stern, M. J., Pownall, M., & Hansen, L. J. (2024). Understanding how justice is considered in climate adaptation approaches: a qualitative review of climate adaptation plans. *Local Environment*, *29*(12), 1644–1663. https://doi.org/10.1080/13549839.2024.2386964

Conz, E., & Magnani, G. (2020). A dynamic perspective on the resilience of firms: A systematic literature review and a framework for future research. *European Management Journal*, *38*(3), 400–412. https://doi.org/10.1016/j.emj.2019.12.004

D'Ambrosio, R., Balbo, A., Longobardi, A., & Rizzo, A. (2022). Re-think urban drainage following a SuDS retrofitting approach against urban flooding: A modelling investigation for an Italian case study. *Urban Forestry and Urban Greening*, *70*. https://doi.org/10.1016/j.ufug.2022.127518

Dapilah, F., Nielsen, J. Ø., & Friis, C. (2020). The role of social networks in building adaptive capacity and resilience to climate change: a case study from northern Ghana. *Climate and Development*, *12*(1), 42–56. https://doi.org/10.1080/17565529.2019.1596063

Diana, D., & Angga Mukti, A. (2025). AI-Driven Digital Twin for Predictive Maintenance in Urban Infrastructure: Enhancing Structural Resilience and Sustainability. *Civil Engineering Science and Technology (CEST)*, *1*(1). https://doi.org/10.51903/3c72e647

Foster, S. R., Baptista, A., Nguyen, K. H., Tchen, J., Tedesco, M., & Leichenko, R. (2024). NPCC4: Advancing climate justice in climate adaptation strategies for New York City. *Annals of the New York Academy of Sciences*, *1539*(1), 77–126. https://doi.org/10.1111/nyas.15148

Guptha, G. C., Swain, S., Al-Ansari, N., Taloor, A. K., & Dayal, D. (2022). Assessing the role of SuDS in resilience enhancement of urban drainage system: A case study of Gurugram City, India. *Urban Climate*, *41*. https://doi.org/10.1016/j.uclim.2021.101075

Harrow, J., Drysdale, R., Smith, A., Repo, S., Lanfear, J., & Blomberg, N. (2021). ELIXIR: Providing a sustainable infrastructure for life science data at European scale. In *Bioinformatics* (Vol. 37, Issue 16, pp. 2506–2511). Oxford University Press. https://doi.org/10.1093/bioinformatics/btab481

Iqbal, U., Perez, P., Li, W., & Barthelemy, J. (2021). How computer vision can facilitate flood management: A systematic review. In *International Journal of Disaster Risk Reduction* (Vol. 53). Elsevier Ltd. https://doi.org/10.1016/j.ijdrr.2020.102030

Kala, N., & Balboni, C. (2023). *Co-Editors: Climate Adaptation*.

Lu, K. Di, Zeng, G. Q., Luo, X., Weng, J., Zhang, Y., & Li, M. (2020). An Adaptive Resilient Load Frequency Controller for Smart Grids with DoS Attacks. *IEEE Transactions on Vehicular Technology*, *69*(5), 4689–4699. https://doi.org/10.1109/TVT.2020.2983565

Magnan, A. K., Anisimov, A., & Duvat, V. K. E. (2022). Strengthen climate adaptation research globally: More international incentives and coordination are needed. *Science*, *376*(6600), 1398–1400. https://doi.org/10.1126/science.abq0737

Manzoor, Z., Ehsan, M., Khan, M. B., Manzoor, A., Akhter, M. M., Sohail, M. T., Hussain, A., Shafi, A., Abu-Alam, T., & Abioui, M. (2022). Floods and flood management and its socio-economic impact on Pakistan: A review of the empirical literature. In *Frontiers in Environmental Science* (Vol. 10). Frontiers Media S.A. https://doi.org/10.3389/fenvs.2022.1021862

Mohanty, M. P., H, V., Yadav, V., Ghosh, S., Rao, G. S., & Karmakar, S. (2020). A new bivariate risk classifier for flood management considering hazard and socio-economic dimensions. *Journal of Environmental Management*, *255*. https://doi.org/10.1016/j.jenvman.2019.109733

Natarajan, K. S., Balu, S., & Mangottiri, V. (2023). Smart and sustainable infrastructure for future energy and environmental management. In *Environmental Science and Pollution Research* (Vol. 30, Issue 44, pp. 98993–98994). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s11356-023-29099-z

Nyaupane, G. P., Prayag, G., Godwyll, J., & White, D. (2020). Toward a resilient organization: analysis of employee skills and organization adaptive traits. *Journal of Sustainable Tourism*, *29*(4), 658–677. https://doi.org/10.1080/09669582.2020.1822368

Ogie, R. I. I., Adam, C., Perez, P., Ogie, R. I., & Adam, C. (2019). A review of structural approach to flood management in coastal megacities of developing nations: current research and future directions. *Journal of Environmental Planning and Management*, 1–21. https://doi.org/10.1080/09640568.2018.1547693ï

Pambudi, J. A. A., Dayana, I., Alfirman, D. M., Susanto, D., & Widianingrum, R. (2023). Accelerating Indonesia Sustainable Infrastructure Development through ESG Initiatives in PPP Ecosystem. *IOP Conference Series: Earth and Environmental Science*, *1266*(1). https://doi.org/10.1088/1755-1315/1266/1/012020

Setyadi Tommy, A., & Putra Jaya, R. (2025). Integration of AI and Digital Twin Technology for Smart Infrastructure Management in Urban Cities. *Civil Engineering Science and Technology (CEST)*, *1*(1). https://doi.org/10.51903/t881qw28

Simpong, D. B., Rahim, M. A., & Zulkefli, N. S. (2022). The Sustainability Entrepreneurship In Adaptive Resilience Among Indigenous Community In Malaysia. *Geojournal of Tourism and Geosites* , *42*, 794–803. https://doi.org/10.30892/gtg.422spl20-891

Singh, C., Ford, J., Ley, D., Bazaz, A., & Revi, A. (2020). Assessing the feasibility of adaptation options: methodological advancements and directions for climate adaptation research and practice. *Climatic Change*, *162*(2), 255–277. https://doi.org/10.1007/s10584-020-02762-x

Sun, X., Li, R., Shan, X., Xu, H., & Wang, J. (2021). Assessment of climate change impacts and urban flood management schemes in central Shanghai. *International Journal of Disaster Risk Reduction*, *65*. https://doi.org/10.1016/j.ijdrr.2021.102563

Tansar, H., Duan, H. F., & Mark, O. (2022). Catchment-Scale and Local-Scale Based Evaluation of LID Effectiveness on Urban Drainage System Performance. *Water Resources Management*, *36*(2), 507–526. https://doi.org/10.1007/s11269-021-03036-6

Wang, M., Quesada-Cabrera, R., Sathasivam, S., Blunt, M. O., Borowiec, J., & Carmalt, C. J. (2023). Visible-Light-Active Iodide-Doped BiOBr Coatings for Sustainable Infrastructure. *ACS Applied Materials and Interfaces*, *15*(42), 49270–49280. https://doi.org/10.1021/acsami.3c11525