

RESEARCH

Environmental Sustainability and Climate Challenges in Local Urban Indonesia

 Safrin Salam^{1*}  Mahyudin²  Asmah³ and  Nurul Miqat⁴

*Correspondence:

^{1*}Faculty of Law, Universitas Muhammadiyah Buton, Indonesia,
<https://orcid.org/0000-0002-9509-0920>,
safrin.salam@umbuton.ac.id,

²Faculty of Social and Political Sciences, Universitas Muhammadiyah Buton, Indonesia,
<https://orcid.org/0000-0002-3588-8893>,
mahyuddinfaith2018@gmail.com

³Faculty of Law, Universitas Sawerigading, Indonesia.
unsaasmah@gmail.com

⁴Faculty of Law, Universitas Tadulako, Indonesia.
<https://orcid.org/0000-0002-4617-1011>,
nurulmiqat@gmail.com

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Abstract

This paper studies the partial relationship between environmental sustainability and climate challenges in local urban Indonesia, with an attempt to explain cross-level interaction among ecological stress, climate vulnerability as well as governance capacity taking place within medium cities of a developing country. This study attempts to provide a more integrated approach of local urban sustainability beyond the usual concerted focus on large metropolitan areas. The article, based on both qualitative descriptive and integrative review approach as well the comparison from urban analysis discusses academic literature complemented by policy documents, climate reports, source of development planning in its general sense related to sources on Indonesian Urban cases ([I]). The results indicate that local government in Jakarta needs to control several pressures including flooding, urban heat water contamination pollution green space loss and low performance of waste management within the urban area. Climate change exacerbates these environmental challenges by contributing to more intense precipitation, hotter temperatures and greater hydrological variability. It also shows that a majority of local governments struggle with inadequate technical skills, and their planning is disjointed leading to poor policy coordination where sustainability strategies tend towards reactivity as opposed to pragmatism. The conversation then shifts to one urban system where climate risk, land management, infrastructure and water security are linked through governance. The study proposes that in order to achieve environmental sustainability (in urban Indonesia), policy and planning should be conducted simultaneously by emphasizing green infrastructure, spatial amenity climate change-sensitive dimensional regional drainage design / waste system of the city as well as inter-sectoral institutional structured community-based adaptation right down from making policies. However, their effect is important in planning research and urban development related to climate adaptation policies in Indonesia

Keywords : Environmental Sustainability, Climate Challenges, Local Urban, Indonesia

INTRODUCTION

Local urban areas in Indonesia are increasingly exposed to environmental degradation and climate-related risks, yet their sustainability trajectories remain far less visible in academic and policy debates than those of major metropolitan centres. This neglect is increasingly significant because Indonesia's urban population reached 58.8% of the total population in 2024, and official projections indicate that urbanization will continue to rise through 2035. At the same time, flooding is estimated to affect around 1.5 million people annually and to cause expected urban damage of about US\$1.4 billion, while national waste-management data show that a large share of waste in reporting districts and cities remains unmanaged. These trends indicate that environmental sustainability in local urban Indonesia should not be understood merely in terms of pollution control or greening projects, but as a broader process of aligning urban growth with ecological resilience, public health, social inclusion, and adaptive governance.

Accordingly, this study adopts a three-dimensional conceptual framework that links climate exposure, environmental performance, and governance readiness. Climate exposure refers to risks associated with flooding, heat stress, rainfall variability, and water-related hazards. Environmental performance refers to the condition of green-blue infrastructure, water quality, ecological buffering, land-use management, waste systems, and other local sustainability indicators. Governance readiness refers to the capacity of institutions to integrate policy, coordinate across sectors, engage communities, and implement resilience-oriented planning. This framework is used to explain how ecological stress is translated into urban vulnerability and why sustainability outcomes differ across Indonesian cities, especially outside the metropolitan core.

Recent studies indicate that the discourse on environmental sustainability in Indonesian urban development has shifted toward more integrated approaches that connect ecological planning, livelihoods, and resilience-oriented governance. Astuti et al. (2025), for example, show through the case of Kendari that urban farming can generate social, economic, and environmental co-benefits in coastal cities. Their findings suggest that community-based urban agriculture can improve food access, strengthen local adaptive capacity, and support nature-based urban development, thereby complementing large-scale engineered infrastructure rather than being treated as a marginal practice.

A similar tendency appears in planning discussions on Nusantara, where blue-green infrastructure and land-use management are positioned as strategic tools for climate-responsive urban development. Pradana et al. (2025) show that integrated blue-green planning can reshape land use and land cover, improve ecological connectivity, and moderate urban microclimates. Although Nusantara is a planned capital city, the implications of this study extend beyond that case by demonstrating how Indonesian urban planning can incorporate water-sensitive design, ecological corridors, and blue-green networks into a sustainability agenda that is simultaneously spatial, climatic, and developmental. This suggests that environmental sustainability in urban Indonesia should be treated not as a separate policy objective, but as a guiding principle for urban expansion, infrastructure provision, and long-term resilience.

Water security constitutes another major dimension of the sustainability challenge. Dharmayanti (2025) demonstrates that groundwater quality in Indonesian urban areas is strongly influenced by the interaction among precipitation patterns, urbanization processes, and domestic sanitation practices. This relationship is crucial because it links climate change directly to public health and everyday urban

safety. When urban growth outpaces sanitation provision, drainage systems remain inadequate, and rainfall variability alters groundwater recharge and runoff patterns, the risk of contamination increases. This evidence shows that climate vulnerability in Indonesian cities extends beyond floods and heatwaves to include slower-moving but equally serious threats to water safety, environmental health, and the long-term functioning of urban service systems.

Taken together, these studies suggest that environmental sustainability in Indonesian cities is best understood as an integrated system composed of nature-based solutions, green and blue infrastructure, urban agriculture, water-sensitive planning, and governance capacity. Astuti et al. (2025) emphasize the ecological and livelihood significance of urban agriculture; Pradana et al. (2025) highlight the microclimatic and spatial benefits of blue-green strategies; Kurniawan et al. (2024) show the consequences of degraded ecological buffers and pollution in flood-prone urban areas; and Dharmayanti (2025) explains how climate, sanitation, and urbanization interact to shape water-security outcomes. At the same time, vulnerability varies across urban scales. In coastal cities such as Kendari, vulnerability is shaped by coastal exposure, limited institutional resources, and greater reliance on community-based adaptation. In Jakarta, by contrast, vulnerability emerges from dense settlement patterns, severe flood exposure, pollution, and broader social consequences, including displacement and health risks. These differences show that climate vulnerability in Indonesia is highly context-specific rather than uniform.

Despite these contributions, the literature still lacks a cohesive analytical model that systematically integrates climate challenges, environmental sustainability indicators, and local governance capacity. Much of the existing research remains organized around one hazard, one city, or one policy instrument, making it difficult to explain how multiple pressures interact across local and metropolitan contexts. This article addresses that gap by proposing a contextual framework for analysing local urban sustainability in Indonesia through the integration of three dimensions that are often treated separately: climate exposure, environmental performance, and governance readiness. By combining these dimensions, the study aims to move beyond fragmented diagnosis and provide a more operational understanding of how Indonesian cities can pursue sustainability under conditions of climate stress.

Based on this framework, the study is guided by three research questions: first, what are the main environmental sustainability problems faced by urban areas in Indonesia; second, how do climate risks intensify these problems; and third, what policy and planning strategies can strengthen local urban resilience and sustainability? These questions are intended not only to identify environmental problems, but also to clarify the relationship among ecological degradation, climate stress, and institutional response. Ultimately, the article seeks to reposition local urban Indonesia within national and international sustainability debates by showing that these cities are critical sites where ecological fragility, development pressure, and governance capacity intersect most directly.

The main point of this article is to try to put local urban Indonesia back into the national and international discussion about sustainability. If the conversation keeps focusing on big cities, then the

environmental problems that many Indonesian cities face every day will not be fully understood or dealt with. But it is in these local urban areas that issues of governance capacity, ecological fragility, and the need for development come together most clearly. To comprehend how Indonesian cities can achieve resilient, inclusive, and environmentally sustainable futures amidst escalating climate uncertainty, an integrated local-urban perspective is imperative (Astuti et al., 2025; Dharmayanti, 2025; Kurniawan et al., 2024; Pradana et al., 2025).

RESEARCH METHODS

This study employs a qualitative descriptive approach using an integrative review framework and comparative urban analysis to examine the relationship between environmental sustainability and climate pressures in urban Indonesia. The analytical design is interpretive and multisource, aiming to synthesize empirical findings, policy insights, and urban-environmental indicators from Indonesian cities with different geographic and developmental characteristics. A total of sources were included in this study, consisting of twenty scholarly journal articles, two environmental reports, two climate evaluations, two urban planning documents, three governmental publications, and two statistical records. This design was selected because urban climate vulnerability in Indonesia cannot be adequately understood through a single dataset or one hazard category alone; instead, it requires the integration of environmental, climatic, and institutional evidence to explain how risks are produced, experienced, and governed in local urban contexts (Kurniawan et al., 2024; Dharmayanti, 2025; Boldrin & Formiga, 2023; Lungman et al., 2025).

The empirical focus of the study is on local urban areas and medium-sized cities in Indonesia that represent different forms of climate exposure, ecological stress, and governance capacity. Larger cities such as Jakarta, and where relevant Surabaya or Bandung, are used only as comparative references to situate local urban patterns within the broader dynamics of Indonesian urbanism. Jakarta is included as a strategic comparison because its climate-induced flooding clearly illustrates the interaction among environmental degradation, pollution, and fragmented governance in shaping urban vulnerability and social impacts (Kurniawan et al., 2024). The inclusion of local and medium-sized cities enables the study to better capture sustainability challenges in settings with more limited institutional resources, where adaptation often depends on local planning capacity and community engagement.

The data were collected from six categories of sources: scholarly journal articles, environmental reports, climate evaluations, urban planning documents, governmental publications, and statistical records. Source selection followed explicit inclusion and exclusion criteria. The inclusion criteria were: (1) sources directly related to urban Indonesia or providing concepts clearly applicable to Indonesian urban contexts; (2) sources discussing at least one of the three analytical dimensions of this study, namely environmental conditions, climate challenges, or institutional/governance response; (3) sources published in peer-reviewed journals or issued by credible institutions such as government agencies, international organizations, or recognized research bodies; and (4) sources containing relevant empirical findings, policy analysis, or official statistical information. The exclusion criteria were: (1) sources not relevant to urban sustainability or climate vulnerability; (2) publications focused solely on non-urban or non-Indonesian settings without transferable analytical relevance; (3) opinion pieces, non-academic web materials, or documents without clear methodological or institutional credibility; and (4) duplicate or redundant sources that did not contribute additional analytical value. Conceptually, the study uses multisource urban sustainability assessments that integrate

environmental monitoring, governance analysis, and risk interpretation in the water and climate sectors (Miguel, 2023; Boldrin & Formiga, 2023; Bandara et al., 2025). The analytical framework is organized into three components: environmental conditions, climate challenges, and institutional response. Environmental conditions include land-use and land-cover change, green open space, vegetation density, water quality, air pollution, waste management, and land conversion. These indicators are supported by remote sensing and GIS-based methods such as NDVI, land surface temperature, and LULC analysis, which have been shown to capture the relationship between urban expansion, ecological transformation, and heat intensity (Choudhury et al., 2023; Khachoo et al., 2023). Climate challenges include flood exposure, rainfall variability, heat stress, extreme temperature events, and vulnerability to climate variability, as identified through rainfall datasets, satellite-based observations, and GIS- or machine-learning-based heatwave analysis (Dharmayanti, 2025; Chongtaku et al., 2024).

A further analytical dimension concerns water and groundwater quality, given the central role of water security in the sustainability of Indonesian urban areas. The reviewed sources therefore include studies using microbial indicators such as *Escherichia coli*, groundwater-contamination assessments, sanitation indicators, and IoT-based water-quality monitoring systems to evaluate environmental health risks under urban and climatic pressures (Dharmayanti, 2025; Bandara et al., 2025; Boldrin & Formiga, 2023). Institutional response was assessed through evidence on local planning capacity, environmental governance, adaptation policy, budget allocation, cross-sector coordination, and the implementation of nature-based solutions. This dimension draws on governance-oriented studies showing that resilience outcomes depend not only on hazard intensity, but also on policy integration, institutional preparedness, and urban management capacity (Kurniawan et al., 2024; Thanekar et al., 2024; lungman et al., 2025).

The selected data were analysed through thematic coding and cross-case comparison. Thematic coding was used to identify recurring concepts, forms of vulnerability, and patterns of institutional response across the selected literature and policy documents. Cross-case comparison was then applied to distinguish broader national trends from more localized dynamics, particularly in relation to urban scale, environmental stress, and governance structure. This analytical strategy supports the development of a conceptual framework that explains the intersection of sustainability pressures and climate risks in urban Indonesia while preserving local contextual diversity and emphasizing policy-relevant trade-offs in environmental planning (Filho et al., 2025; lungman et al., 2025).

RESULTS AND DISCUSSION

Environmental Stress and Climate Vulnerability in Local Urban Indonesia

This study's findings suggest that urban areas in Indonesia are influenced by a complex interplay of ecological stress, climate vulnerability, and institutional constraints. Many medium-sized and growing cities don't just have one environmental problem; they have many at once. For example, flood-prone areas are made worse by land conversion and drainage decline, dense built environments raise local heat stress, and weak waste and pollution control raise environmental health risks. The literature consistently demonstrates that these dynamics are neither random nor isolated. They are the result of a lot of things happening at once, like cities growing quickly, hydrological systems changing, not enough green infrastructure, and broken governance systems that can't keep up with changes in the environment (Kurniawan et al., 2024; Dharmayanti, 2025; Miguel, 2023).

In many cities, rapid physical growth often makes land surfaces less permeable, messes up natural water flows, and makes runoff stronger. This trend is especially important in low lying and coastal areas, where cities are growing in areas that are sensitive to the environment. The results indicate that flood exposure is influenced not only by rainfall intensity but also by the interplay between climate-induced hydrological changes and unsustainable land management practices. Kurniawan et al. (2024) demonstrate that in Jakarta, climate-induced flooding is exacerbated by non-point source pollution, environmental degradation, and compromised ecological buffers, leading to increased flood depth and duration as well as enhanced pollutant transport during flood events. Jakarta is a big city, but the same structural logic applies to other cities in Indonesia: when drainage systems are weak, impervious surfaces grow, and ecological retention areas shrink, even small amounts of rain can cause serious flooding (Kurniawan et al., 2024).

Flood-related risk is intricately linked to water-security issues. Contamination of groundwater and surface water is still a big problem in cities in Indonesia, especially where sanitation systems are not very good and people rely on local water sources a lot. Dharmayanti (2025) shows that rainfall variability, urbanization patterns, and domestic sanitation practices have a big effect on water quality. This means that climate change affects urban sustainability not only through disasters that are easy to see, but also through less obvious public health pathways. This is supported by extensive urban water studies indicating that runoff transports pollutants and nutrients that deteriorate urban water systems and jeopardize long-term water security (Tran et al., 2025; Miguel, 2023). In practical terms, this means that policies about flood risk and water pollution should not be separate. In Indonesian cities, hydrology, waste, land use, and public health are all part of the same environmental system.

Urban heat stress and how the urban heat island effect is becoming more important. The literature indicates that dense and highly impervious urban form contributes to increased land surface temperature, reduced thermal comfort, and greater exposure to heat-related health risk. Local Indonesian cities may not always receive the same level of heat analysis as major metropolitan centers, but the evidence suggests that similar processes are underway: reduced vegetation cover, limited urban greening, and the expansion of hard infrastructure intensify local warming patterns. Pradana et al. (2025) illustrate that blue-green spatial design in Nusantara can markedly influence urban microclimate, while extensive research on greening and vegetation-based cooling indicates significant temperature advantages linked to enhanced greenspace scenarios and nature-based interventions (Al-Hajri et al., 2025; Pradana et al., 2025). Astuti et al. (2025) suggest that localized urban greening initiatives, such as urban agriculture, can yield both ecological and social co-benefits, enhancing environmental sustainability while simultaneously bolstering local economies. The situation can show by this figure 1:

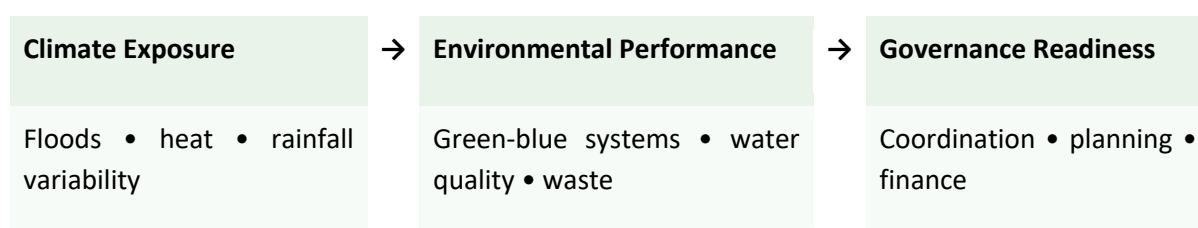


Figure 1. Conceptual diagram: Integrated local-urban sustainability framework

Figure 1 shows The conceptual diagram presents the article's analytical framework as a sequential yet interactive model of local-urban sustainability in Indonesia. At its core, the figure suggests that urban resilience outcomes are not produced by any single environmental or institutional factor, but rather emerge from the dynamic relationship among climate exposure, environmental performance, and governance readiness. The three-block flow indicates a logical progression: climate pressures create stress on urban systems, environmental conditions mediate how severely those pressures are experienced, and governance capacity determines whether cities can respond effectively, adapt, and recover.

The first block, Climate Exposure, refers to the external pressures that increasingly shape the vulnerability of Indonesian urban areas. The inclusion of floods, heat, and rainfall variability highlights that local cities are exposed not only to sudden disasters but also to slower and cumulative climatic changes. Flooding represents acute hydrological risk, especially in low-lying and rapidly urbanizing areas. Heat signals the growing significance of urban thermal stress caused by both climate change and built-form intensification. Rainfall variability adds another layer of uncertainty because changing precipitation patterns affect drainage systems, water availability, and ecosystem stability.

The second block, Environmental Performance, functions as a mediating layer between climate stress and urban outcomes. This is a crucial element of the framework because it implies that climate hazards do not affect all cities equally; rather, their impacts depend heavily on the quality of the urban environment itself. The indicators listed in this block green blue systems, water quality, and waste represent the ecological and infrastructural conditions that shape a city's capacity to absorb or intensify climate pressures. Strong green-blue systems can reduce runoff, lower temperatures, and improve ecological buffering. Good water quality reflects better environmental health and safer urban living conditions. Effective waste management reduces blockages in drainage, minimizes pollution, and improves overall urban sanitation.

The third block, Governance Readiness, emphasizes that resilience is not simply a technical or ecological issue but also an institutional one. The key terms here coordination, planning, and finance suggest that even where environmental interventions are known, their implementation depends on governance capacity. Coordination is needed because climate and sustainability challenges cut across sectors such as housing, water, sanitation, health, and transport. Planning ensures that responses are anticipatory rather than reactive, embedding resilience into land use and infrastructure decisions. Finance is equally critical because adaptation measures, environmental maintenance, and monitoring systems require sustained investment. This block therefore underlines that urban resilience depends on whether institutions are capable of translating knowledge into action. The diagram points toward Urban Resilience Outcomes as the cumulative result of these three dimensions working together. The mention of feedback arrows from policy learning and community adaptation reinforces that resilience is not a final static condition, but an ongoing process of adjustment. As cities experience climate stress and test policy responses, they generate lessons that can improve future governance and environmental strategies. Community adaptation likewise contributes local knowledge, social participation, and practical innovation.

This has significant consequences for urban sustainability in the area. People often think of heat risk in Indonesian cities as a weather problem, but the results show that it is also a land-management problem. Not only does the atmosphere get warmer, but the way cities are built, paved, vegetated,

and planned also affects the temperature in cities. In this way, a drop in thermal comfort is a clear sign of bad spatial planning and not enough ecological integration. When green space is lost, ecosystem services like shading, evapotranspiration, runoff retention, and habitat support are reduced, making people more vulnerable to heat and flooding. The literature on Nusantara is especially useful because it shows that integrating blue-green systems from the beginning of the planning process can help cities stay cool and adapt to changing climates over time (Pradana et al., 2025). Significant outcome pertains to the enduring challenges of pollution, wastewater, and waste management. The studies that were looked at show that environmental degradation in urban Indonesia gets worse because of poor management of wastewater, limited infrastructure for waste treatment, and not enough control over pollutant flows. Urban runoff carries nutrients, sediments, and pollutants into waterways, which puts more stress on ecosystems and makes the water less clean (Tran et al., 2025; Liao et al., 2023). From a sustainability point of view, these pressures are especially bad because they connect household waste, drainage performance, flood risk, and public health in one unhealthy urban metabolism. Miguel (2023) stresses that resilient urban water systems are more and more dependent on strategies for reusing and treating water that work together. Research on life cycles and green infrastructure shows that bioretention and biochar-based systems can cut down on pollutants while also saving water (Liao et al., 2023; Tran et al., 2025).

Institutional Constraints and Strategic Directions for Sustainable Urban Resilience

The conversation also shows that the major environmental issues mentioned above are very much tied to institutions. A lot of local governments don't have enough technical skills, have planning systems that aren't well-connected, don't work well together, or don't do enough to make climate adaptation a part of urban development. Because of this, sustainability policies are often reactive, only dealing with problems after they happen, like floods, water shortages, or trash buildup, instead of dealing with the root causes ahead of time. Kurniawan et al. (2024) demonstrate that the efficacy of flood governance diminishes when environmental management, pollution control, and urban planning are not synchronized. This finding aligns with extensive governance literature highlighting that adaptive and equitable urban solutions necessitate cross-sector collaboration among environmental, water, health, housing, and transport institutions, bolstered by stakeholder engagement and policy continuity (Das et al., 2024; Addas, 2023; lungman et al., 2025).

Planning capacity is crucial in assessing the feasibility of advancing climate-sensitive development beyond mere rhetoric. The literature review indicates that cities with cohesive planning frameworks are more adept at integrating nature-based solutions, cooling strategies, and resilience-focused infrastructure into land development. Pradana et al. (2025) demonstrate that the early-stage integration of blue-green networks can influence urban morphology in ways that regulate temperature and improve ecological function. This is supported by evidence indicating that greenspace and plant-based interventions yield quantifiable environmental and health co-benefits when executed at an adequate scale (Al-Hajri et al., 2025; lungman et al., 2025). But in many cities in Indonesia, implementation is still limited by budget constraints, weak spatial enforcement, and sectoral silos. As a result, promising sustainability ideas like green roofs, permeable pavements, urban farming, water reuse, and blue-green corridors are often just small pilot projects instead of parts of a

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larger plan for the city (Astuti et al., 2025; Miguel, 2023; Tran et al., 2025). One of fact show in this figure 2:



Figure 2. Urbanization and Risk Context In Indonesia

Figure 2 show that The data presented in the table provide a concise but powerful statistical basis for understanding the urgency of environmental sustainability and climate challenges in urban Indonesia. Collectively, these indicators show that the issue is not merely conceptual or policy-oriented, but deeply rooted in measurable demographic, environmental, and economic pressures. They also help justify why urban Indonesia, particularly local and medium-sized cities, should be treated as a critical site of analysis in sustainability and climate governance research.

The first indicator, showing that 59.2% of Indonesia's population lived in urban areas in 2024, establishes the structural significance of urbanization in the national context. This figure means that more than half of the country's population now depends on urban systems for housing, employment, transportation, water, sanitation, and environmental health. As a result, environmental degradation and climate vulnerability in urban areas are no longer peripheral concerns; they directly affect the majority of the population. The urban transition also implies that local governments face increasing pressure to provide infrastructure and public services while simultaneously addressing ecological decline, land-use change, and growing exposure to climate-related hazards. In this sense, the indicator is important not only

as a demographic statistic but also as evidence that urban sustainability has become central to Indonesia's broader development trajectory.

The second indicator, 1.5 million people affected by flooding annually, demonstrates the scale of recurring human exposure to one of the country's most visible and disruptive climate-related hazards. Flooding in urban Indonesia cannot be understood solely as an episodic disaster event; it is increasingly a chronic condition that affects livelihoods, mobility, health, housing security, and access to public services. The annual number of affected people suggests that flood risk is not confined to a few exceptional cases, but is embedded in the everyday vulnerability of many urban communities. This is especially relevant in low-lying, densely populated, and rapidly urbanizing areas where impermeable surfaces, drainage constraints, and environmental degradation intensify hazard exposure. Therefore, the statistic strengthens the argument that urban flood management must go beyond emergency response and instead become part of long-term sustainability planning.

The third indicator, US\$1.4 billion in expected annual urban flood damage, adds an economic dimension to the urgency of the study. While the number of affected people illustrates the social burden of flood events, this monetary estimate highlights their broader developmental consequences. Urban flood damage affects roads, drainage systems, housing, public facilities, commercial activity, and infrastructure networks. It also generates secondary costs through productivity losses, service disruption, repair expenditure, and reduced economic resilience. In academic terms, this figure is important because it demonstrates that climate-related environmental risks are not only ecological or humanitarian issues, but also major constraints on sustainable urban development. The statistic thus reinforces the need for preventive investment in resilient infrastructure, integrated land-use planning, and ecosystem-based adaptation rather than relying only on post-disaster recovery.

The fourth and fifth indicators together reveal the magnitude of the waste-management challenge. The reported 20.33 million tons of waste per year across 208 districts and cities in SIPSN 2025 indicates that urban environmental sustainability is closely tied to the management of material flows and public sanitation systems. Waste generation on this scale requires strong institutional capacity in collection, transport, processing, recycling, and final disposal. However, the urgency becomes even clearer when this number is read alongside the final indicator: 65.48% of the reported waste remains unmanaged. This proportion suggests that a large share of waste is not being adequately processed within formal management systems, which has direct implications for environmental quality and urban resilience.

Unmanaged waste contributes to multiple forms of urban vulnerability. It can block drainage systems and thereby intensify flooding. It can contaminate land and water resources, degrade neighborhood environments, and increase health risks, especially in areas with weak sanitation infrastructure. It also reflects institutional and financial limitations in local governance. Thus, waste is not simply a sanitation issue; it is part of a wider urban

sustainability problem involving environmental health, infrastructure performance, and governance readiness.

Taken together, these indicators support the central argument that environmental sustainability in urban Indonesia must be addressed through an integrated framework. Rapid urbanization increases the number of people exposed to environmental risks; recurrent flooding imposes both social and economic losses; and poor waste management exacerbates ecological stress while undermining urban resilience. The data therefore do more than describe isolated conditions. They reveal an interconnected system in which demographic concentration, climate exposure, infrastructure pressure, and governance limitations interact. For this reason, the table functions effectively as an urgency panel in the manuscript: it gives the reader an immediate quantitative understanding of why the study matters and why local urban Indonesia deserves stronger scholarly and policy attention.

These results bolster the assertion that environmental sustainability in urban Indonesia ought to be comprehended through a systems perspective. Climate risk, land management, infrastructure, public health, and governance are not separate factors; they are all parts of the same system that makes cities more resilient. Land conversion, bad drainage, and pollution make flooding worse. The loss of plants and the growth of dense, impermeable buildings make heat stress worse. Water insecurity is related to changes in rainfall, gaps in sanitation, pollution from runoff, and not enough monitoring. Accumulation of waste increases hydrological blockage and environmental exposure. When these factors are dealt with one at a time, policy responses are still incomplete and often don't work. When viewed as components of an integrated system, local urban planning can better foresee cumulative risks and formulate preventive measures (Dharmayanti, 2025; Miguel, 2023; Pranoto et al., 2024).

Climate adaptation can be integrated into urban planning in Indonesia most effectively when it is treated not as a stand-alone environmental program, but as a mainstream planning principle embedded in land use, infrastructure, service delivery, and local governance. The Scopus-based literature consistently shows that Indonesian cities need to move beyond reactive responses to floods, heat, coastal hazards, and infrastructure failure toward a planning model that combines risk-sensitive spatial planning, institutional coordination, and long-term investment. In coastal-city research, adaptation is more likely to be implemented when local governments are motivated, when climate measures are linked to everyday development priorities, and when planning institutions can translate climate concerns into urban programs and budgets (Wijaya et al., 2020; Yulandari et al., 2023). This also aligns with Indonesia's broader policy architecture, where RAN-API, the Updated NDC, the Adaptation Communication, and the National Adaptation Plan all emphasize mainstreaming adaptation into development planning rather than handling it as an isolated sectoral agenda (BAPPENAS, 2013; Republic of Indonesia, 2021; UNFCCC, 2022, 2025). At the conceptual level, this direction is also consistent with the IPCC's emphasis on integrated urban planning and climate-resilient development pathways (IPCC, 2022a, 2022b).

A second major lesson from the literature is that adaptation becomes more robust when it is participatory, place-based, and socially embedded. Studies from North Jakarta show that community-based flood adaptation is stronger when urban planning recognizes kampung knowledge, local coping practices, and collaborative governance rather than relying only on technocratic flood-control

approaches (Prana et al., 2024). Similar findings appear in studies on participatory climate-policy implementation and climate-service co-production in Jakarta, where adaptation knowledge becomes more usable when communities, planners, and local agencies jointly produce risk information and spatial responses (Suarma et al., 2018; Putra et al., 2022). Earlier work on urban water management in Indonesia also demonstrates that participatory planning helps align climate adaptation with local water realities and institutional learning (Kirono et al., 2014). In short, adaptation should be built into statutory and informal planning through consultation, local mapping, and sustained collaboration, not added at the end of the planning cycle.

The literature further shows that nature-based and blue-green infrastructure should be central to urban adaptation in Indonesia. Research on Nusantara indicates that blue-green design, higher green coverage, and integrated flood-control strategies can reduce heat stress and strengthen hydrological resilience (Mustofa et al., 2025; Dewi et al., 2025; Pradana et al., 2025). Similar arguments emerge from Makassar's Tallo watershed, where GIS-based planning identifies green infrastructure as a practical way to address ecological degradation and urban vulnerability (Indrayani et al., 2025). More broadly, adaptation in Indonesian cities also requires linking sanitation, buildings, and public assets to climate planning. Evidence on citywide sanitation adaptation, public-building management, and urban resilience shows that climate-proofing urban systems depends on finance, data, maintenance, and inter-agency coordination, not only on physical design (Willettts et al., 2022; Lukito et al., 2019; Fuady et al., 2025). Jakarta-based work also shows that effective urban climate policy often depends on partnerships across scales, including national-local cooperation and systems-based decision support (Hidayatno et al., 2015).

At the same time, the literature warns that integration will remain limited if spatial planning continues to ignore future risk, coastal change, and institutional fragmentation. Research on Sarbagita, Jakarta, Semarang, and the north coast of Java shows that climate risk is often weakened by fragmented planning, weak enforcement, land subsidence, and development patterns that actually increase exposure rather than reduce it (Rahayu et al., 2018; Rahayu et al., 2020; Bott et al., 2021; Abi Suroso et al., 2018). Djalante and Thomalla (2012) therefore remain highly relevant: Indonesia needs stronger integration between climate change adaptation and disaster risk reduction, especially at subnational level. Overall, climate adaptation should be integrated into Indonesian urban planning through five linked moves: mainstreaming adaptation into statutory planning, strengthening participatory and community-based processes, expanding blue-green and nature-based solutions, using climate and geospatial data for spatial decisions, and building multi-level institutions that can coordinate, finance, and implement resilience over time.

From this viewpoint, various strategic priorities arise for local Indonesian policy and planning. First, local governments should increase the use of nature-based solutions and green infrastructure, such as blue-green networks, urban tree cover, green roofs, retention landscapes, and permeable surfaces. These should be backed up by the right systems for governance and maintenance (Pradana et al., 2025; Liao et al., 2023; lungman et al., 2025; Tran et al., 2025). Second, water reuse, wastewater treatment, and strong urban water infrastructure should be seen as important parts of urban water security instead of just environmental measures (Miguel, 2023; Tran et al., 2025). Third, urban farming and community-based greening should be expanded not only for food and income support but also

for their roles in local cooling, ecological restoration, and social resilience (Astuti et al., 2025; lungman et al., 2025). Fourth, we need to use GIS, remote sensing, and environmental monitoring to plan based on data so that we can find the most important areas for flood prevention, cooling, pollution reduction, and ecosystem restoration (Addas, 2023; Tran et al., 2025). Finally, cross-sector coordination, participatory governance, and sustained financing must be strengthened so that adaptation is embedded in routine urban planning rather than treated as an emergency response (Das et al., 2024; Kurniawan et al., 2024; Addas, 2023).

The findings and discourse indicate that the sustainability challenge in urban Indonesia is not merely a consequence of environmental degradation or climate exposure in isolation. It is the result of a larger change in cities where ecological systems, infrastructure networks, social vulnerability, and governance capacity change in ways that are not always compatible. The main point is that for cities to be resilient, they need to move from managing different sectors separately to planning for the environment as a whole. Indonesian local cities can only effectively respond to the increasing pressures of climate change and urban expansion by integrating land, water, heat, waste, and institutional coordination within a unified framework (Kurniawan et al., 2024; Dharmayanti, 2025; Pradana et al., 2025; Astuti et al., 2025).

CONCLUSION

This study finds that urban Indonesia is at the forefront of environmental degradation and climate-related risk, but it is not well represented in the larger body of work on urban sustainability and climate adaptation. A lot of the talk about climate problems in Indonesian cities is still focused on big cities like Jakarta or on specific problems like flooding, water quality, or making cities greener. This article contends that local urban areas should be comprehended through a holistic perspective, as they encounter concurrent ecological, climatic, infrastructural, and institutional pressures. Consequently, the primary contribution of this study is the provision of a more contextualized analytical framework that connects environmental sustainability, climate vulnerability, and governance readiness in local urban Indonesia, while also demonstrating that these interconnections have direct ramifications for planning and policy.

The evidence examined in this article illustrates that environmental and climate challenges in Indonesian cities are intricately interconnected rather than isolated. Jakarta's flooding exemplifies this relationship with notable intensity. Kurniawan et al. (2024) demonstrate that climate change exacerbates flood dynamics, while non-point source pollution from urban runoff exacerbates environmental degradation and public health risks. The effects are not just flooding; they also include displacement, economic problems, and long-term health problems. Their research shows that the yearly losses are in the hundreds of millions of US dollars and that more than a million people are affected. Recent efforts to fix the problem have only partially worked, such as lowering peak flood levels and shortening flood durations (Kurniawan et al., 2024). Jakarta is an extreme example, but the lesson applies to all of Indonesia's cities: climate change, poor water quality, runoff pollution, and social vulnerability all affect the same urban system. This means that cities in the area can't just use structural flood control to deal with climate change; they also need to improve environmental management, cut down on pollution, and protect ecosystems.

The results also show that adaptation pathways in Indonesia can be more than just defensive; they can also be productive and focused on development. In Kendari, urban farming integrated into the

local coastal economy generates significant economic value, representing approximately 10.66% of the city's gross regional domestic product, while also enhancing environmental sustainability and fostering resilience-oriented livelihoods (Astuti et al., 2025). This shows that adapting to local conditions can have positive effects on both the environment and the economy, especially when sustainability strategies are based on community practices and local resource systems. Planning insights from Nusantara also show that blue-green infrastructure is not just an environmental amenity; it is also a design strategy that responds to climate change and has measurable benefits for temperature. Pradana et al. (2025) assert that a blue-green coverage of approximately 65% could lower urban temperatures by about 2°C, highlighting the significance of incorporating ecological design into urban planning from the beginning. These cases indicate that Indonesian local urban policy should transcend a limited risk-management framework and adopt adaptation as a means to achieve greener, healthier, and more economically resilient cities (Astuti et al., 2025; Pradana et al., 2025).

The research underscores the significance of contextualizing local urban sustainability within a broader water-energy-climate framework. Data from the Citarum watershed illustrates that hydrological systems, ecological conditions, and energy planning are inextricably linked in climate-sensitive regions. Pranoto et al. (2024) demonstrate that climate-adaptive hydropower planning and integrated watershed management are crucial for sustaining resilience in contexts where water availability, ecosystem stability, and energy systems are interconnected. This information is very useful for cities in Indonesia because many of them rely on water processes that happen on a basin scale and cross administrative lines. So, local urban resilience can't depend only on actions taken by the city. It necessitates coherence among urban planning, watershed management, water infrastructure, and comprehensive climate adaptation strategies (Pranoto et al., 2024).

In this context, the article addresses a significant scholarly and practical deficiency by consolidating multi-site Indonesian evidence on floods, urban agriculture, blue-green infrastructure, and integrated water governance within a singular local urban framework. Its significance resides not solely in pinpointing prevailing issues, but in elucidating the interplay between environmental stress, climate exposure, economic outcomes, community adaptation, and governance capacity across various urban settings (Kurniawan et al., 2024; Astuti et al., 2025; Pradana et al., 2025; Pranoto et al., 2024). This makes the framework more useful for policy than separate single-hazard analyses because it better shows how complicated decision-making is in Indonesian cities.

This conclusion leads to a number of suggestions. First, local governments should increase the use of nature-based solutions, blue-green infrastructure, and urban farming because they help with climate resilience, thermal regulation, water management, and local jobs at the same time (Astuti et al., 2025; Pradana et al., 2025). Second, integrated water-energy planning ought to be enhanced in urban development and significant basin systems, especially in regions where watershed dynamics influence both urban sustainability and regional resilience (Pranoto et al., 2024). Third, future research ought to enhance cross-city and data-driven comparative studies to more effectively delineate the diversity of environmental and climate pressures across Indonesian urban areas, while simultaneously guiding more localized planning and adaptation strategies (Kurniawan et al., 2024; Pradana et al., 2025). The study ultimately posits that urban Indonesia should not be regarded as a peripheral case in climate scholarship, but rather as a pivotal locus for comprehending the intersection of sustainability, vulnerability, and governance in the context of rapid climate change.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

During the preparation of this work, the author used generative AI tools to assist with language editing and improving the readability of the manuscript. The AI tool was used solely to refine grammar, wording, and overall clarity of the text. The author reviewed and edited the output as necessary and takes full responsibility for the content of this publication.

No generative AI tools were used for the development of the research design, data collection, data analysis, interpretation of results, or the formulation of the study's conclusions

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Authors Bio*

Safrin Salam is an lecturer in Magister Of Law Faculty Of Law Universitas Muhammadiyah Buton, Baubau, Indonesia. His research interest relate to environmental sustainability and climate change.

Email: safrin.salam@umbuton.ac.id, ORCID: <https://orcid.org/0000-0002-9509-0920>

Mahyudin is an lecturer in Faculty of Social and Political Sciences, Universitas Muhammadiyah Buton, Baubau, Indonesia, e-mail : mahyuddinfaith2018@gmail.com ORCID: <https://orcid.org/0000-0002-3588-8893>

Asmah is an lecturer in Faculty of Law, Universitas Sawerigading, email: unsaasmah@gmail.com

Nurul Miqat is an lecturer in Faculty of Law, Universitas Taduloka, email: Nurulmiqat@gmail.com, ORCID: <https://orcid.org/0000-0002-4617-1011>