

Policy Brief

Transformative Solution through the Utilisation of Urban Blue-Green Spaces for Nature-based Solutions in Metropolitan Areas

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Summary

High population growth and urban expansion pose a constant threat to the urban environment and exacerbate the risk of climate-related disasters. Several metropolitan areas in Indonesia exemplify these issues with significant consequences. The 2025 Greater Jakarta flood, which affected hundreds of thousands of residents, highlighted the recurring flood cycle of major floods, widespread impact, and acute vulnerability of urban areas to climate extremes, land subsidence, and inadequate infrastructure. Similarly, the Bandung Metropolitan Area experiences almost annual flooding, often localised due to basin topography and extensive upstream land conversion. Although the characteristics of these events differ, both cases underline the limitations of conventional grey infrastructure and its connectivity, which often fails under extreme conditions. In response, this policy brief examines Nature-based Solutions (NbS) as a sustainable and adaptive strategy to metropolitan flood management. By leveraging natural blue-green systems, such as wetlands, urban green spaces, and vegetated corridors, NbS offers both hydrological benefits and co-benefits, including improved biodiversity, urban cooling, and improved well-being. Lessons from Greater Jakarta and Greater Bandung highlight the urgency of integrating NbS into spatial planning and enhancing watershed management policies for metropolitan resilience.

Introduction

In recent years, many metropolitan areas in Indonesia have become symbols of urban vulnerability, where the convergence of climate extremes, land subsidence, inadequate drainage infrastructure, and uncontrolled urbanisation has occurred. The 2025 Greater Jakarta flood was among the most devastating urban disasters in recent memory, affecting over 120,600 residents across Jakarta, Bekasi, and nearby cities, with estimated economic losses exceeding IDR 5 trillion. With water levels ranging from 15 to 300 cm, submerging critical infrastructures and inundating settlements up to 4 m deep (Alam et al., 2025). Similar major floods have also occurred in the past, such as the 2007 flood with estimated losses reaching IDR 7.3 trillion, the 2013 flood inundated more than 400 km² and displaced around 45,000 people, and the 2020 flood in which more than 60 people died (Priyambodoho et al., 2022; Sagala et al., 2013; Takagi et al., 2016). These events highlight Greater Jakarta's recurring flood cycle with widespread socio-economic impacts. In Greater Bandung, the basin-shaped landscape, sloping terrain, and high rate of land conversion in mountainous areas accelerate surface runoff and exacerbate flooding in densely populated urban areas with limited vegetation, such as Bandung City and Cimahi City (Agustina et al., 2023). Despite efforts such as the Sustainable Urban Drainage Systems (SUDS) approach in spatial planning, floods continue to occur every year (Sagala et al., 2021).

Despite numerous mitigation measures and flood control projects, risks remain. During the 2025 Greater Jakarta flood, major drainage projects and flood pumps were operational but overwhelmed due to unregulated settlements along waterways. Likewise, in Greater Bandung, several retention ponds have been built, yet remain poorly integrated from upstream to downstream (Permanasari et al., 2025).

To move towards more sustainable and adaptive flood solutions, there is growing recognition of Nature-based Solutions (NbS) as a strategic alternative (Cohen-Shacham et al., 2016). NbS leverages natural systems, such as wetlands, open green spaces, bioretention areas, river floodplains, and green corridors to manage water flow, enhance infiltration, and reduce surface runoff (World Bank, 2021). This increases infiltration, stores excess runoff, and reduces peak flows during storms while delivering vital co-benefits, including increased biodiversity, better water and air quality, and improved community well-being (Ommer et al., 2022).

This policy brief draws lessons from Greater Jakarta and Greater Bandung to explore how NbS implementation with the utilisation of urban blue-green spaces can contribute to metropolitan risk reduction.

Issue #1: Land Use Changes and Reduction of Catchment Area

Rapid urbanisation in Greater Bandung and Greater Jakarta has transformed natural and agricultural landscapes into densely built environments, diminishing the hydrological functions of upstream catchment areas. The conversion of forest and farmland into residential, commercial, and industrial zones has increased surface runoff, decreased groundwater infiltration, and contributed to sedimentation in river systems.

In Greater Jakarta, the upper catchments of the Ciliwung, Cisadane, and surrounding tributaries, located primarily in Bogor and Depok areas, play a key role in regulating inflow into the metropolitan basin. Land use change in these upstream zones has significantly altered watershed balance. Hasibuan et al. (2022) found that expansion of

built-up areas in the upper Ciliwung has increased runoff and altered the hydrological response of the watershed. Similarly, modelling by Farid et al. (2021) demonstrates that conversion of vegetated land to urban or bare surfaces leads to higher peak discharge, flood extent, and volume in the Ciliwung Basin. These shifts reduce infiltration capacity and amplify downstream flood risk in East Jakarta, Bekasi, and Tangerang. Although peer-reviewed documentation remains limited, qualitative assessments indicate that development in hilly zones around Puncak and Ciawi has encroached upon forested land, contributing to erosion and sedimentation that further burden river systems.

A similar pattern is evident in Greater Bandung, particularly within the upper Citarum Basin, which covers highland areas such as Lembang, Cimencyan, Bojongsoang, and Baleendah. Rapid urban expansion in these zones has transformed large portions of vegetated and agricultural land into residential and industrial areas, significantly altering hydrological processes. Land use modelling by Anggraheni et al. (2025) shows that between 2000 and 2023, developed land in the upper Citarum increased from approximately 4 percent to 24 percent, while low flow discharge decreased by up to 48 percent and sediment rates rose by about 20 percent in key monitoring sites such as Dayeuhkolot. These shifts signify declining infiltration capacity and increasing surface runoff, which heighten downstream flood hazards. Supporting evidence from Rahayu et al. (2023) confirms that in West Java, increased built-up land and reduced vegetative cover have statistically strengthened the correlation between land cover change and flood frequency. The cumulative effect of these transformations, including declining forest cover, soil compaction, and sediment accumulation, has contributed to more frequent and prolonged flooding across Bandung City and its surrounding lowlands.

The combination of reduced catchment capacity, intensified surface runoff, and weak enforcement of spatial plans has contributed to greater hydrological instability. Limited coordination between upstream and downstream jurisdictions further undermines integrated watershed management. Addressing these challenges requires aligning metropolitan planning with hydrological boundaries, implementing reforestation and agroforestry programmes, and adopting NbS such as Sustainable Urban Drainage Systems (SUDS) to restore infiltration capacity and strengthen flood resilience (Davis & Naumann, 2017; Sagala et al., 2021).

Issue #2: Orientation to Grey Infrastructure: Inadequate Flood Protection

Existing flood management infrastructure, including flood barriers, drainage systems, and river normalisation projects, has repeatedly failed to withstand extreme rainfall events. Engineered urban drainage systems remain highly vulnerable to uncertain urbanisation patterns and the impacts of climate change (Dong et al., 2017). The March 2025 floods starkly illustrate this inadequacy. In Bekasi, a three-metre flood barrier collapsed in Pondok Gede Permai, while in Bandung, the Cinambo river dyke breached and inundated nearly 800 homes in Bumi Adipura. These concurrent incidents highlight the urgent need for more resilient and adaptive infrastructure.

Current NbS, including water retention areas and river normalisation, remain limited in effectiveness due to poor integration within urban planning frameworks. In metropolitan areas across Indonesia, including Greater Jakarta and Greater Bandung, NbS interventions have not been optimally implemented, hindered by an

inconsistent shift from grey to blue-green infrastructure and the absence of a stable policy focus on using NbS for flood mitigation. Nevertheless, the ongoing implementation of grey infrastructure should not be dismissed; in certain cases, such as Jakarta, engineered flood control measures have contributed to flood reduction efforts (Adha & Salomo, 2024).

A key challenge lies in the fragmented integration of NbS into spatial and urban planning. NbS initiatives are often implemented in isolation rather than as part of a cohesive and comprehensive flood mitigation strategy. Current flood management has predominantly relied on engineering-based solutions, which have not optimally addressed urban flooding (Asare et al., 2023). This reflects the broader gap in embedding NbS principles into spatial planning processes. However, the characteristics of NbS, when properly integrated with urban planning, can significantly reduce environmental challenges, including urban flooding (Grădinaru & Hersperger, 2019). The NbS strategies, such as through low-impact development (LID) tools integrated in urban planning, revealed the optimal mitigation for flood-prone cities (Mabrouk et al., 2023).

Issue #3: Weak Enforcement of Policies, Spatial Planning, and Governance

The recent flooding events in Indonesia highlight the growing risks compounded by governance and policy challenges in implementing NbS. Despite the existence of international standards such as the IUCN Global NbS Standard, most NbS studies in Asia, excluding China and Singapore, are still in their infancy and lack a definitive and replicable framework (IUCN, 2020; Ying et al., 2022). This uncertainty weakens political will in Indonesia, where debate continues over the

benefits of NbS implementation compared to hard infrastructure (Calderón-Argelich et al., 2022). Policy inconsistencies further constrain NbS adoption. Existing regulations often fail to accommodate NbS approaches, thereby exacerbating hydrometeorological risks (Mustofa et al., 2024). Existing spatial plans, such as the Bekasi Regional Spatial Plan (Rencana Tata Ruang Wilayah/RTRW) 2011-2031 and the Greater Bandung Spatial Plan (Rencana Tata Ruang/RTR), focus primarily on drainage systems and flood control infrastructure, but lack sustainable adaptation and mitigation measures that incorporate NbS principles (Yuanita & Sagala, 2025).

Weak cross-jurisdictional coordination and funding gaps trigger bottlenecks in the scalability of the NbS. Although metropolitan spatial plans (RTR/RTRW) have been developed for both Greater Jakarta and Greater Bandung, watershed-scale management remains fragmented and lacks integration from upstream to downstream (Yuanita & Sagala, 2025). NbS projects also struggle with financial viability, as they often lack clear economic metrics or short-term revenue streams (Kuller et al., 2022). Progress is further hindered by governance-related barriers, including top-down decision-making, commercial interests that outweigh community needs, and insufficient systemic planning (Balzan et al., 2022; Kuller et al., 2022). To address these issues, Indonesia must align policies with NbS principles, improve governance across the watershed, and secure long-term investments. Without these reforms, reliance on grey infrastructure will continue, leaving cities vulnerable to increasing flood risk.

Furthermore, the transformative nature of NbS lies not only in its ecological and technical functions but also in its ability to reshape urban governance and development paradigms. In Indonesia, traditional flood control has long relied on grey infrastructure, often prioritising

short-term physical outcomes over systemic resilience. In contrast, NbS fosters a shift toward ecosystem-based planning that integrates hydrological processes, urban ecology, and social inclusion within decision-making. This approach transforms the way cities manage risks, moving from reactive engineering responses to proactive, adaptive, and participatory governance. NbS thus becomes transformative when it redefines institutional collaboration, financing schemes, and spatial priorities to simultaneously achieve environmental, social, and economic resilience.

Recommendation #1: Mainstreaming NbS into Spatial Planning for Long-Term Impact

- Integrate NbS into Spatial Planning. Nature-based Solutions should be embedded within *Rencana Tata Ruang Wilayah* (RTRW) and *Rencana Detail Tata Ruang* (RDTR) documents to ensure ecological zones, upstream areas, floodplains, and buffer zones are preserved and prioritised for blue-green infrastructure interventions. This integration must extend beyond zoning, influencing spatial development permits, land allocation, and infrastructure investment decisions.
- Adopt Sustainable Urban Drainage Systems (SUDS), encourage the use of bioswales, permeable pavements, retention ponds, and rain gardens in urban design to complement traditional drainage systems and enhance flood mitigation (Davis & Naumann, 2017). These systems should be included as mandatory components in new urban developments and retrofitting programs in flood-prone areas.
- Establish Regulatory Incentives and Zoning Controls. Implement zoning restrictions to prevent further land conversion in environmentally sensitive areas and offer incentives for developers who integrate NbS into building designs and community planning,

for example tax reductions, etc

- Ensure consistency with the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015) and Indonesia's National Medium-Term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional/ RPJMN*) by incorporating NbS as a central element of adaptive spatial governance.
- Ensure the NbS planning is evidence-based and scalable through strengthening data integration and institutional capacity.

Recommendation #2: Enforcement of NbS into Climate Adaptation and Disaster Management Policies and Regulation Cross-Boundary

- Harmonise NbS frameworks at different scales by aligning regional (Southeast Asia) and national policies to ensure coherence in climate adaptation and disaster management strategies.
- Develop technical guidelines and/or standards for planning, design, implementation, and monitoring of NbS, tailored to different typologies (e.g., riverine, urban, coastal, and mountainous) and hazards (e.g., flood, landslide, and storm) to ensure locally adaptable solutions.
- Strengthen policy instruments and regulatory integration by incorporating NbS into metropolitan spatial planning and linking compliance with incentives. Some global best practices demonstrate the potential of such instruments, such as discounts on stormwater fees based on reduced impervious area or adoption of NbS (Minneapolis, USA), increased building volume or height allowances in exchange for public green space (Melbourne, Australia), and Payments for Ecosystem Services (PES) to landowners who maintain ecosystem services (Syracuse, USA) (Longato et al., 2024). Encouraging private sector participation in

urban resilience initiatives.

- Establish a dedicated NbS funding mechanism linked to measurable benefits to enable scalable cross-regional projects and attract public-private investment.

Recommendation #3: Enhance Integrated Watershed Management and Collaboration

- Recognise the watershed as a single, interconnected eco-region that transcends administrative borders. Effective management of the Ciliwung Hulu Watershed is vital for regulating hydrological functions and supporting both conservation and socio-economic productivity in the greater Jabodetabek region.
 - **Upstream:** Focus on preserving natural ecosystems and forest cover to protect the water source and regulate the climate.
 - **Midstream:** Promote sustainable land use practices that balance human needs with water catchment functionality. Expand green spaces and increase areas for water retention.
 - **Downstream:** Prioritise flood risk reduction and infrastructure development, such as river embankments and disaster management systems, to cope with the cumulative water flow.
- Strengthen collaboration between sectors and across regions to avoid overlapping policies, reduce potential conflicts of interest, and connect ecological networks across regions.
- Adopt a flexible and adaptive management framework. Acknowledge that each watershed has unique geography, land use dynamic, and vegetation characteristics. Management approaches must be flexible, responsive to local conditions, and continually readjusted to reflect

ecological and social changes. Adaptive watershed management ensures long-term resilience for both ecosystems and human settlements.

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