

Monitoring and Evaluation of Nature-Based Solutions in Indonesia: A Critical Review of Indicators, Frameworks, and Knowledge Gaps

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Despite the growing integration of Nature-based Solutions (NbS), such as peatland restoration, mangrove rehabilitation, and urban green infrastructure development, into Indonesian environmental policy, monitoring and evaluation (M&E) systems still lag behind on-ground execution. This critical narrative review synthesizes 33 Scopus-indexed studies published between 2020 and 2026 to systematically map current M&E frameworks, indicator categories, and overarching knowledge gaps. We find that while international models like the IUCN Global Standard and logic-chain frameworks are frequently cited, they are rarely tailored to Indonesia's local institutional realities. Monitoring across all three ecosystems remains heavily biased toward ecological metrics, leaving social and institutional dimensions under-measured. This deficit is most pronounced in peatland programs. Where economic evaluations are present, a majority of studies (71%) confirm NbS is consistently cost-effective, peaking at an 80% effectiveness rate compared to conventional engineering alternatives. We identify three primary research gaps: the absence of sustained post-implementation tracking, weak social-institutional indicators, and a lack of cross-ecosystem comparative analysis. Rather than proliferating additional frameworks, Indonesia's NbS agenda urgently requires context-specific, participatory M&E systems that field managers can sustain independently.

Keywords: nature-based solutions; monitoring and evaluation; indicators; Indonesia; knowledge gaps.

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1. Introduction

The limitations of relying solely on grey infrastructure to combat climate change, land degradation, and escalating hydrometeorological disasters have driven the rapid policy adoption of nature-based solutions (NbS). Defined as actions inspired by nature that simultaneously address social, economic, and environmental challenges, NbS has swiftly moved up the policy agenda [1]. The concept gained a unifying reference point with the IUCN's 2020 Global Standard. Building on this momentum, these interventions now feature prominently in climate agendas globally and in Indonesia. This shift is supported by a growing body of evidence demonstrating their capacity to mitigate climate impacts while co-delivering ecological and social benefits [2]. Indonesia presents a highly strategic context for these interventions, possessing the world's largest tropical peatlands, extensive mangrove forests, and critical coastal protectors such as seagrass meadows and coral reefs. Initiatives such as peatland restoration under the Peatland and Mangrove Restoration Agency (BRGM), the National Mangrove Rehabilitation Program, and various donor-backed urban resilience projects indicate that NbS has transitioned from conceptual discourse to tangible policy action [3]. Notably, peatland restoration alone has been credited with reducing fire risks by 6–37%, providing a climate mitigation potential of 0.002–0.36 Pg CO₂e per year, and supporting the conservation of peatland specialist species [4].

Despite this implementation momentum, a critical gap exists between the rapid pace of NbS deployment and the development of commensurate monitoring and evaluation systems. Many projects are measured solely through spatial metrics, such as hectares "successfully restored," lacking the ecological, social, or institutional indicators necessary for rigorous verification. Research indicates that even as political traction increases, on-ground execution remains fragmented and highly context-dependent, widening the implementation gap between policy ambitions and practical outcomes [1]. Without credible monitoring and evaluation (M&E) systems, policymakers and practitioners lack the foundational data necessary to validate successes, replicate effective models, or scale up these interventions into broader policy frameworks.

To address this shortfall, this review focuses specifically on the M&E dimensions of NbS, rather than assessing general ecological effectiveness. The scope is deliberately narrowed to the three ecosystems that dominate Indonesia's NbS portfolio: peatlands, mangroves and coastal zones, and urban green infrastructure. Drawing on peer-reviewed literature published between 2020 and 2026, the study examines both global M&E frameworks and their specific applications within Indonesia to objectively assess the robustness of current evidence and identify areas where data remains limited.

Although research on NbS in Indonesia has grown, studies generally examine peatlands, mangroves, or urban settings separately. As a result, it remains unclear whether the well-documented weaknesses in social and institutional indicators are unique to particular ecosystems or reflect a broader pattern in Indonesia's NbS portfolio. This review addresses this gap by systematically mapping and comparing M&E frameworks across these three ecosystems. To our knowledge, it is the first synthesis to bring these ecosystem contexts together and examine how M&E practices and indicators vary across them.

Based on this rationale, this study pursues three primary objectives: (1) mapping global and Indonesia-specific NbS M&E frameworks and their associated indicators; (2) analyzing how implementation strategies and indicator applications differ across peatland, coastal, and urban ecosystems; and (3) identifying the most pressing knowledge gaps that require future research and policy attention.

2. Literature Review and Problem Statement

Internationally, several M&E frameworks for NbS have emerged. The IUCN Global Standard offers the broadest application scope, functioning as an overarching, process-oriented framework. It emphasizes stakeholder engagement and adaptive management rather than purely measuring physical outcomes; however, its contextual specificity and the depth of its practical guidance still require improvement [5]. To complement such comprehensive standards, researchers have developed structured procedures for indicator selection. For instance, a five-step procedure was proposed to make the selection process faster and more reproducible, as demonstrated in the Horizon 2020 CLEVER Cities project [6]. Similarly, a systematic review of NbS effectiveness identified approximately 130 candidate indicators encompassing stakeholder participation, policy capability, economic efficiency, trade-off analysis, spatial scale, and long-term performance. The authors concluded that a universal, "one-size-fits-all" indicator list is impractical; instead, indicator selection must be adapted to the specific context, scale, and project stage [7]. Expanding on this logic, a water-focused NbS framework structures evaluation across three stages (context assessment, implementation and adaptation, and results), explicitly linking NbS targets to the Sustainable Development Goals (SDGs) and capturing often-neglected long-term co-benefits [8].

Despite the proliferation of these frameworks, a persistent evidence gap remains, particularly concerning geographic representation. Global evidence synthesis indicates that the Global South, including Indonesia, is consistently underrepresented in the empirical base for NbS effectiveness, with the majority of studies originating from high-income countries [2]. A systematic map of coastal NbS evidence across six biogenic

ecosystems highlighted similar deficiencies, revealing pronounced gaps in economic and social outcome reporting and noting that most evaluations are confined to short time frames of less than five years [9]. In the Indonesian context, this general pattern is compounded by a secondary issue: the literature is heavily fragmented by ecosystem. Peatland, mangrove, and urban NbS programs have each developed largely independent indicator traditions. Consequently, no single framework has been adequately adapted or comparatively analyzed across sectors within Indonesia's specific institutional and decentralized governance context.

This dual challenge forms the basis of the present study's problem statement. While existing global M&E frameworks provide robust conceptual foundations, it remains unclear which of these frameworks and indicators have actually been applied to NbS projects in Indonesia, how consistently they capture both ecological and social-institutional dimensions, or where the resulting evidence base is strong versus thin. Accordingly, this review asks: What indicators and M&E frameworks have been used to assess NbS in Indonesia, and what critical knowledge gaps remain? Given the methodological heterogeneity and varied reporting formats across the available literature, this question is addressed descriptively and exploratorily rather than through hypothesis testing.

3. Method

This study adopts a critical narrative review rather than a systematic review with meta-analytic pooling. This methodological choice was deliberate. The available corpus on NbS monitoring and evaluation (M&E) in Indonesia is methodologically diverse, encompassing varied ecosystems and reporting formats. Existing systematic maps in this field predominantly report narrative, non-poolable outcome data rather than comparable effect sizes [9], rendering quantitative pooling unfeasible. Beyond data limitations, the core objective of this study is to map conceptual and institutional patterns, framework adoption, indicator emphases, and governance enablers, rather than to test a hypothesis regarding effect sizes. A narrative approach is better suited for this purpose, as it allows for a transparent and nuanced reporting of contradictory or inconclusive findings across different ecosystems without forcing them into uniform conclusions.

Literature searches were conducted across Scopus-indexed journals, alongside targeted searches in specialized outlets such as *Ambio*, *Global Change Biology*, *Environmental Research Letters*, *Forests*, *Land*, and *PNAS*. Search strings combined combinations of "nature-based solutions," "monitoring and evaluation," "indicator," "Indonesia," "mangrove," "peatland restoration," and "urban green infrastructure." The publication window was restricted to 2020 through 2026 to capture the post-IUCN Global Standard era. Articles were included if they explicitly discussed NbS M&E frameworks, indicators, or practical applications within global or Indonesian settings. Studies focusing exclusively on ecological effectiveness without an M&E component were excluded unless they provided essential ecosystem context. Grey literature was utilized sparingly to ensure data verification and academic rigor. This screening process yielded a final sample of 33 peer-reviewed sources, which forms the empirical basis of this analysis.

Each selected article was systematically analyzed based on three criteria: the type of M&E framework employed, the specific indicator categories emphasized (ecological, social, or institutional), and the knowledge gaps explicitly acknowledged by the authors. Findings were then cross-compared across the three primary ecosystem types (peatlands, mangroves and coastal zones, and urban areas) to identify patterns that were consistent across sectors versus those that were ecosystem-specific. To structure the synthesis, Figure 1 illustrates the logic-chain framework adapted from the IUCN Global Standard and the broader literature synthesis.

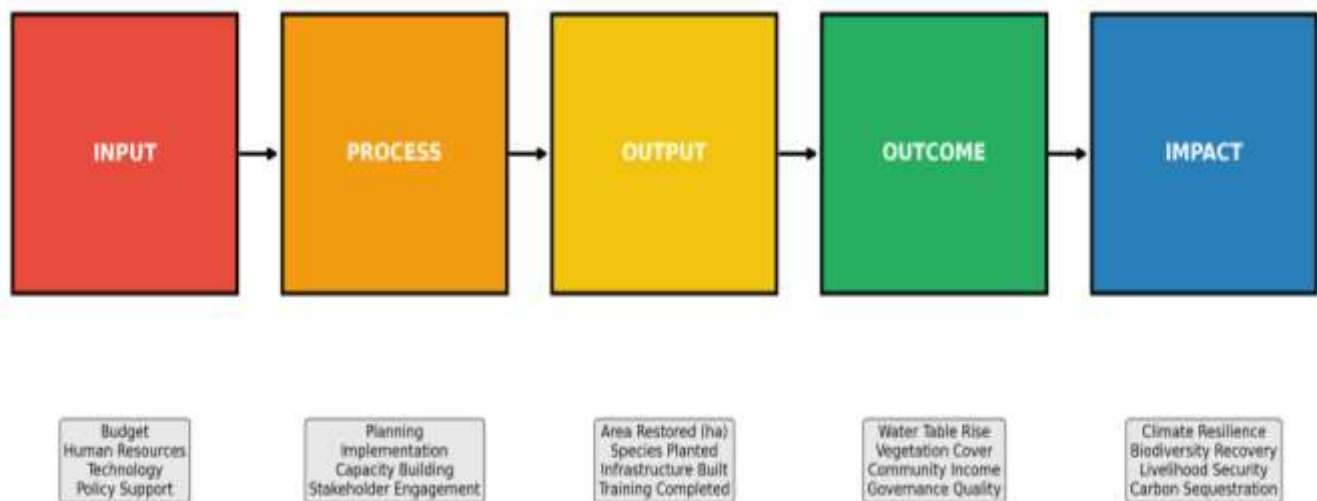


Fig. 1 Logic Chain Framework for NbS Monitoring and Evaluation (adapted from the IUCN Global Standard and literature synthesis, 2020-2026)

4. Results And Discussion

Result and Finding

The research results map the application of NbS M&E frameworks in Indonesia, identify indicator preferences across ecosystems, assess cost-effectiveness, and highlight critical knowledge gaps. Prior to the detailed thematic analysis, Figure 2 illustrates the geographic and ecosystem distribution of the 33 reviewed articles, highlighting the dominance of peatland and mangrove studies. These overarching findings are synthesized in Table 1.

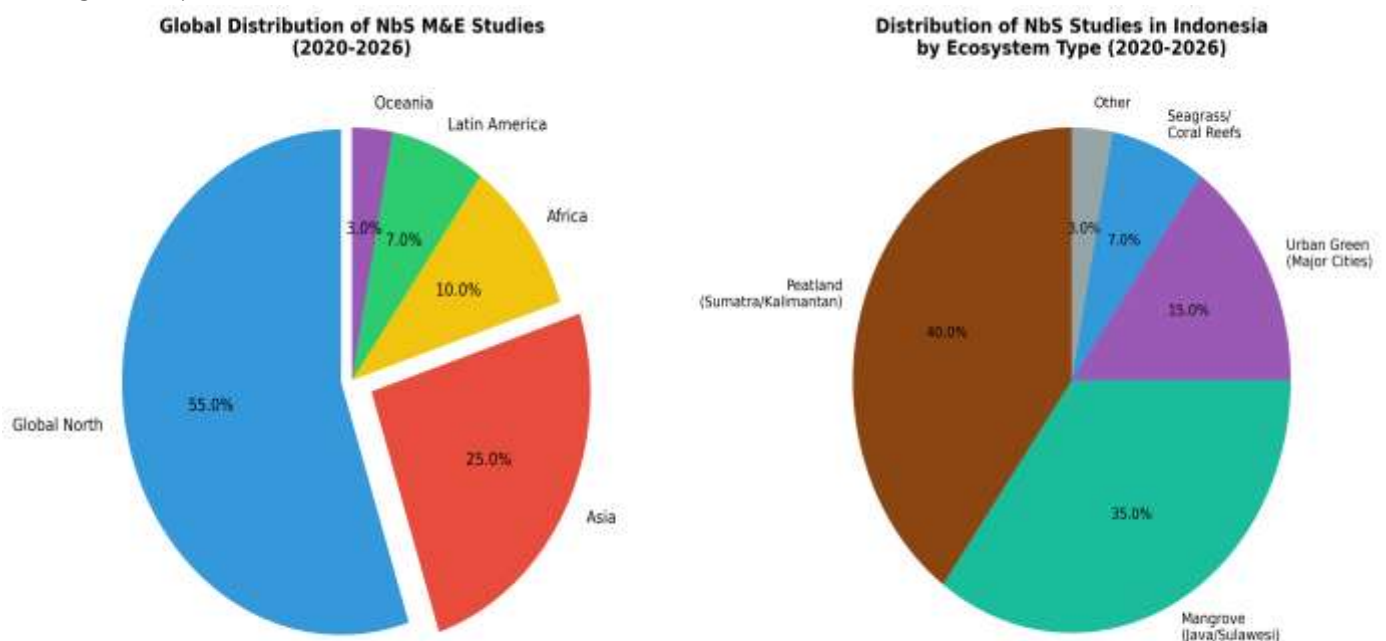


Fig. 2. Geographic Distribution of NbS M&E Studies: Global vs Indonesia (Based on Literature Review 2020-2026)

Table 1. Aspect-Based Summary of Key Results

Aspect	Description
Dominant Indicators	Ecological indicators heavily dominate M&E across all three ecosystems. Social and institutional indicators remain comparatively weak, particularly in peatland programs.
Cost-Effectiveness	A majority of studies (71%) confirm NbS is consistently cost-effective, with specific interventions like mangrove restoration peaking at an 80% effectiveness rate relative to engineering alternatives [10].
Comparison with Previous Research	Aligns with global systematic maps showing pronounced economic/social outcome gaps [9]. Indonesia's pattern reflects a local manifestation of a documented global asymmetry, specifically Global South underrepresentation, rather than a unique anomaly [2].
Phenomena and Explanations	The dominance of ecological indicators is largely driven by project funding architectures: physical metrics are faster and cheaper to monitor within short project cycles compared to social indicators requiring sustained engagement [7].
Preliminary Conclusions	The core challenge is not a lack of conceptual frameworks, but the need for contextual adaptation and sustained institutional capacity for M&E beyond rigid project lifecycles

Framework Adoption Patterns

Global literature indicates that the IUCN Global Standard and logic-chain indicator approaches (encompassing inputs, processes, outputs, outcomes, and impacts) are the most frequently referenced frameworks [5], [6]. However, these models were developed primarily from European project experiences (e.g., Horizon 2020 CLEVER Cities) and have not been extensively adapted to fit Indonesia's institutional realities, resulting in sector-specific applications devoid of cross-ecosystem coordination. Governance framework analysis across three case studies identifies critical enablers including polycentric governance involving multiple institutional scales and sectors, co-design through participatory processes, pro-NbS advocacy coalitions, and financial incentives for community-based implementation and monitoring [11]. These enablers prove essential for NbS transitions contributing to disaster risk reduction, climate adaptation, and sustainable development goals simultaneously.

Peatland restoration represents Indonesia's largest NbS program, initiated after the 2015 mega-fires. The Peatland Restoration Agency (BRG, later BRGM) implements rewetting, revegetation, and livelihood revitalization, known as the 3R approach [3]. Large-scale rewetting reduced extreme fire event frequency from seven to four events during 2015–2021, though the mean duration of extreme events increased [12]. A 16-year ecosystem dataset shows burned peat forests experienced 58–98% deterioration in habitat structure, tree density, and canopy cover, with species diversity declines most pronounced for trees, damselflies, and butterflies, although vegetation showed recovery signs over 12 years [13]. Canal-blocking studies find that most smallholder farmers accept canal blocks once they perceive decreased fire risk and no yield impact, though farmers relying on canals for farm access remain more reluctant, underscoring the need for early stakeholder engagement [14].

Indicator Distribution Across Ecosystems

Peatland M&E focuses heavily on physical-hydrological indicators including water table height and rewetting area [3]. Social indicators such as community surveys remain rare while institutional indicators address agency mandates without systematic measurement.

Mangrove/coastal M&E emphasizes ecological indicators with social dimensions emerging through livelihood assessment [15]. Global mangrove carbon stocks declined by 158.4 Mt (1.8%) between 1996 and 2016, though conservation, restoration, and natural forestation have kept net losses relatively low over two decades, underscoring both the scale of the ecosystem monitored and the difficulty of attributing net change to management action alone [16]. Conserving and restoring these ecosystems in Southeast Asia offers a massive climate mitigation potential of 770 ± 97 TgCO₂e annually [17], necessitating rigorous M&E frameworks to verify such ambitious targets. Satellite-based NDVI monitoring from 2000-2018 similarly shows Asian mangroves have the highest vegetation-health index globally, with Southeast Asia showing significant increases alongside localized decline, illustrating the reliance on remote-sensing ecological indicators over ground-based social monitoring in this ecosystem [18]. Broader blue-carbon assessments further caution that tidal wetlands beyond mangroves, saltmarshes, and seagrass, such as peat swamp and freshwater forest types common in Sumatra and Kalimantan, are frequently excluded from carbon-focused M&E despite comparable stocks, a gap with direct relevance for Indonesia's peatland-mangrove mosaic [19].

Urban NbS M&E is dominated by qualitative studies on governance processes rather than quantitative impact measurement [20]. A review of 120 Global South NbS case studies found that most were categorized as blue-green infrastructure, with about two-thirds aligned to national or local policy, while participatory approaches remained largely tokenistic, and private-led NbS shifted toward buildings and campuses rather than public benefit [21]. Complementary evidence from urban green packages in rapidly growing Global South cities shows that implementation and monitoring vary by spatial and temporal scale and are strongly shaped by socio-ecological, cultural, and institutional factors [22]. For instance, NbS aimed at urban flood risk can work standalone or supplement grey infrastructure, though its robustness varies significantly from plot to watershed scale [23]. Consequently, achieving the intended social-ecological co-benefits requires resilience thinking and collaborative trade-off management [24]. These complexities are seldom captured by Indonesia's largely ecological urban indicator sets. This disparity is illustrated in Figure 3 alongside Table 2, which highlights the dominance of ecological metrics over social ones.

Table 2. Comparison of M&E Indicator Emphasis Across NbS Ecosystems in Indonesia

Ecosystem Type	Ecological Indicators	Social Indicators	Institutional Indicators
Peatland	High (water table, fire hotspots, vegetation)	Low (community surveys rare)	Medium (agency mandates)
Mangrove/Coastal	High (vegetation cover, carbon stocks)	Medium (livelihood, income)	Medium (local governance)
Urban Green	Medium (heat island, runoff)	High (recreation, perception)	High (co-governance)

Source: Literature synthesis 2020-2026.

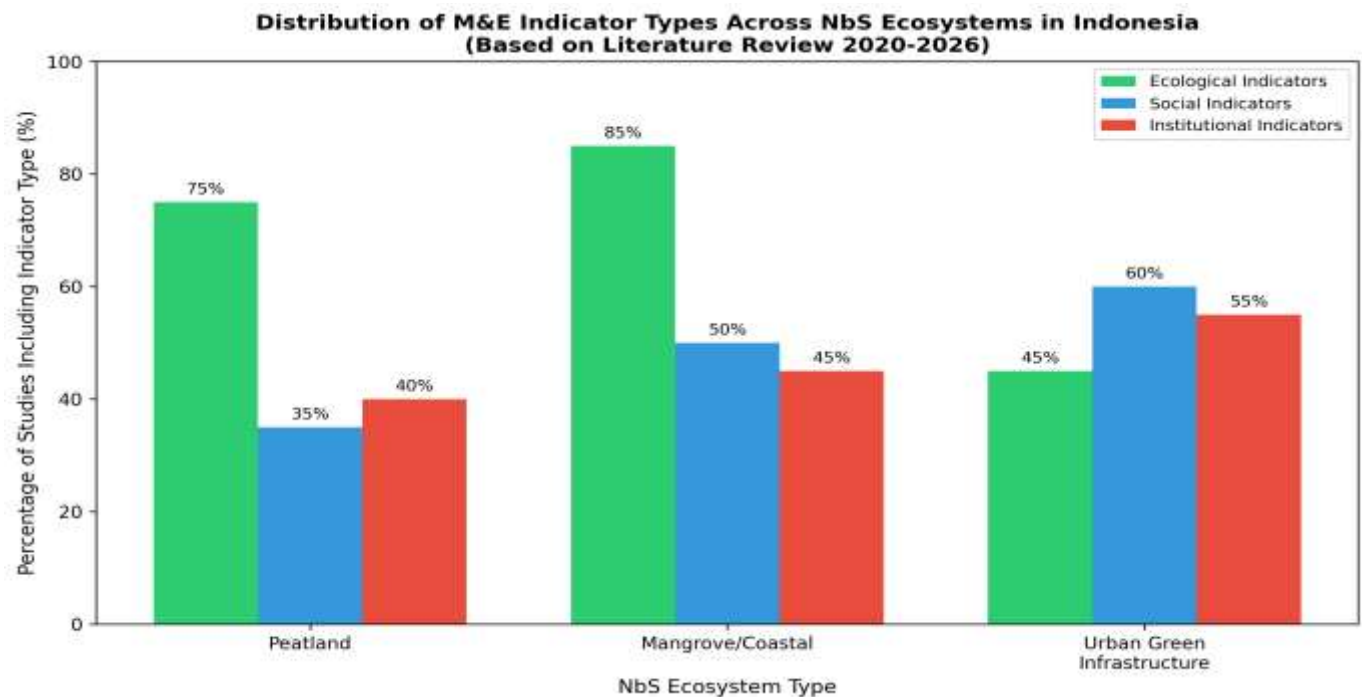


Fig. 3. Distribution of M&E Indicator Types Across NbS Ecosystems in Indonesia (Based on Literature Review 2020-2026)

Cost-Effectiveness Evidence

Economic evaluation synthesis, summarized in Figure 4, found that 71% of studies indicate NbS consistently prove cost-effective for hazard mitigation, with 24% finding cost-effectiveness under certain conditions [10]. Mangrove interventions demonstrated 80% effectiveness, forests 77%, and coastal ecosystems 73%. Compared to engineering solutions, 65% of studies found NbS always more effective while 26% found partial superiority. Restoration cost analysis revealed coastal wetlands like mangroves are more cost-effective (US\$1,800/ton C) compared to inland wetlands (US\$4,200–49,200/ton C), recommending conservation priority for inland wetlands while both approaches suit coastal ecosystems [25].

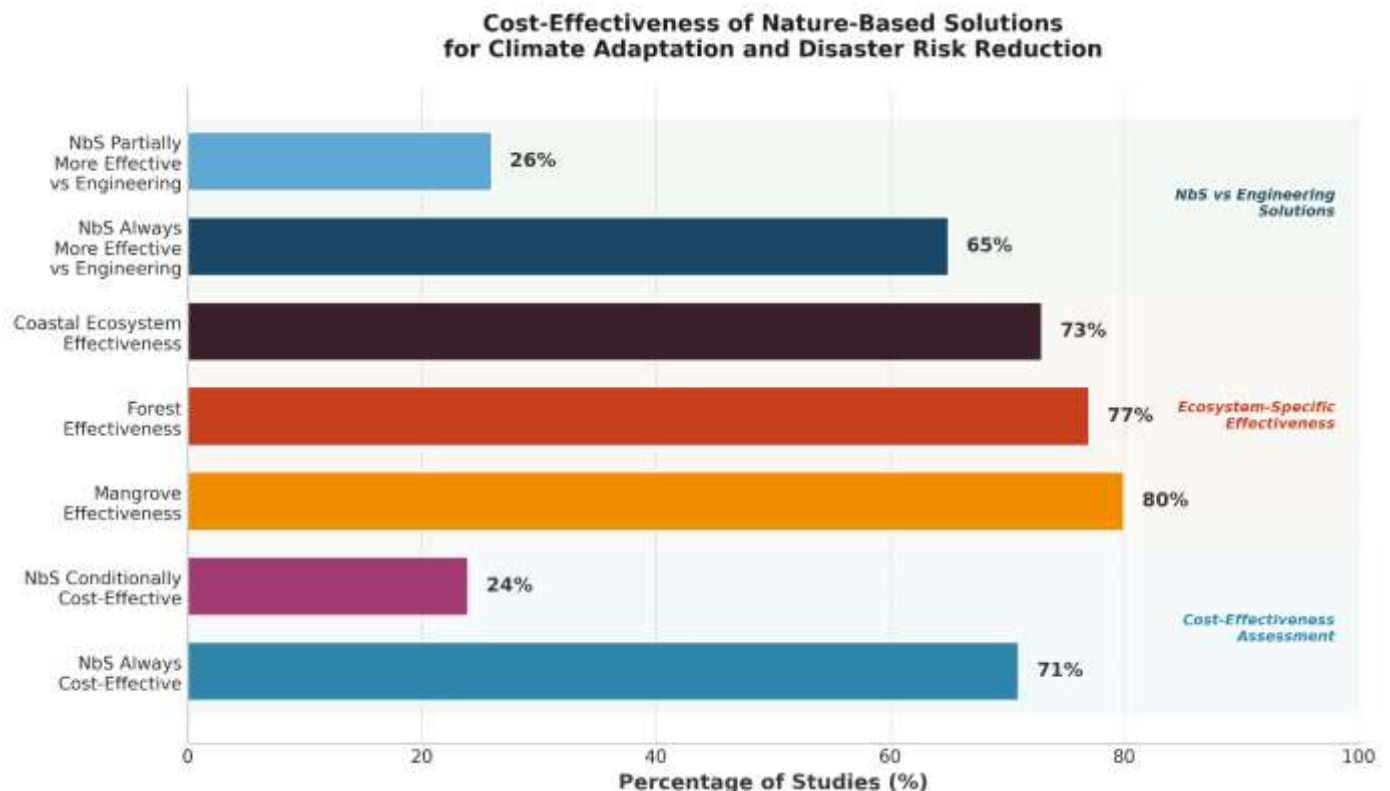


Fig. 4. Cost-Effectiveness of Nature-Based Solutions for Climate Adaptation (Based on Global Evidence Synthesis 2020-2024)

Identified Knowledge Gaps

Three primary knowledge gaps emerged consistently across the literature, as visually synthesized in the comparative radar chart (Figure 5):

Gap 1: Long-term monitoring data deficiency. Most M&E occurs within project timeframes (1–5 years) without post-implementation tracking [9]. Ecosystem restoration success requires monitoring across appropriate recovery periods, yet funding and institutional arrangements rarely support sustained data collection. Forest restoration diversity assessment emphasized that temporal trajectories require larger sample areas and methods incorporating abundance information for reliable long-term inference [26]. Remote-sensing-based approaches, including the ecological recovery wheel, can extend monitoring beyond typical project cycles at comparatively low marginal cost, though their operational uptake by restoration practitioners and government agencies has so far been limited [27].

Gap 2: Social-institutional indicator weakness. Economic and social outcomes represent pronounced evidence gaps [9]. Restoration practitioners increasingly recognize human well-being benefits, but granting programs typically require only ecological goals and monitoring [28]. Studies found almost half of restoration projects set well-being goals with 70% believing they achieved them, yet systematic documentation remains limited compared to ecological metrics.

Gap 3: Cross-ecosystem comparison limitations. Indonesia lacks studies directly comparing M&E frameworks across peatland, mangrove, and urban sectors. Each ecosystem has developed relatively independent indicator traditions without standardization or benchmarking, limiting knowledge transfer and policy coherence.

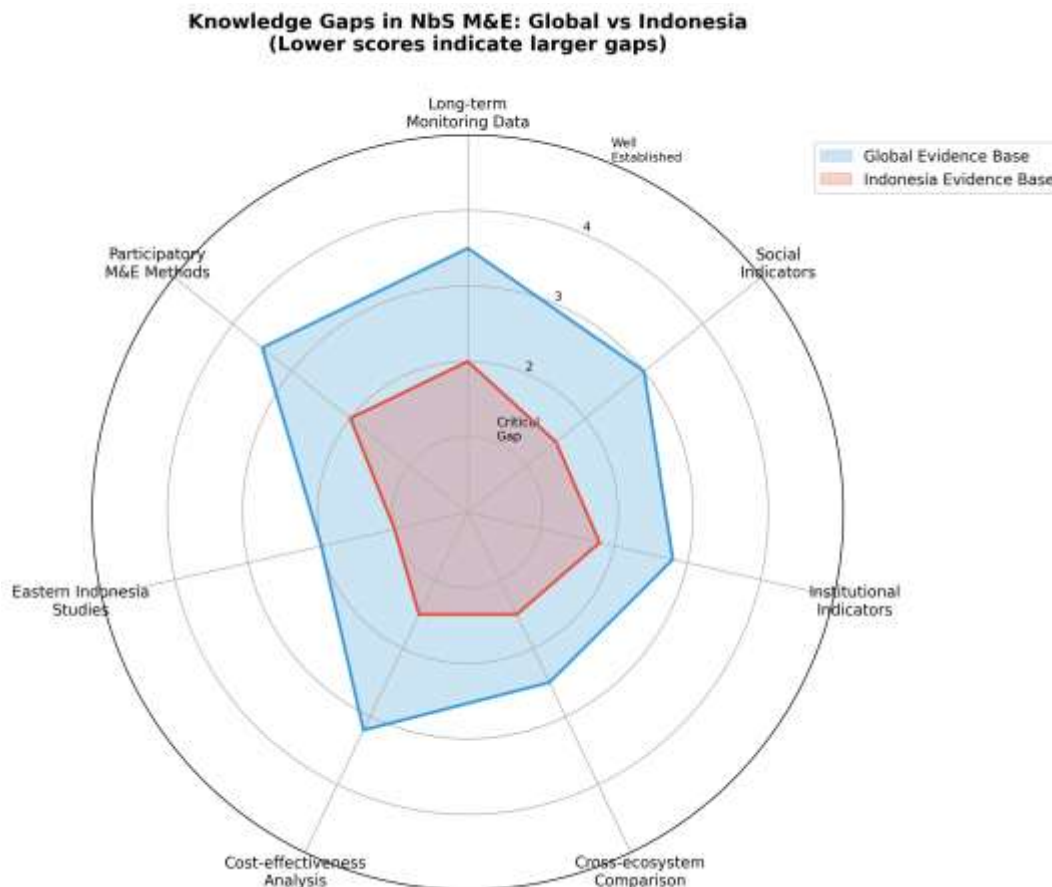


Fig. 5. Knowledge Gaps in NbS M&E: Global vs Indonesia Evidence Base Comparison

Geographic and Temporal Patterns

Geographically, the Indonesia-focused sources in this review skew toward Sumatra, as detailed in Table 3: three of the 33 references name a specific sub-national location, and all three, on rewetting in Riau [12], smallholder perceptions in Sumatra [14], and mangrove management in Batu Bara Regency, North Sumatra [15], are located in Sumatra. A further group discusses Indonesia at the national level without specifying a sub-national location [3], [4], [13], [20] and one addresses Southeast Asia regionally, inclusive of Indonesia [17]. None of the 33 sources names a location in Kalimantan, Java, Sulawesi, or eastern Indonesia specifically. This is a more conservative reading than is sometimes assumed, since Kalimantan's peatlands and Sulawesi's mangroves are commonly associated with Indonesian NbS programming; the absence of sub-nationally identifiable, indicator-focused studies from these areas within the peer-reviewed corpus is itself a relevant finding, consistent with, though not proof of, the broader global pattern in which Global South regions face documented evidence deficits despite high climate vulnerability [2]. This reading should be treated as indicative of the corpus reviewed here rather than as an independent bibliometric census of the Indonesian NbS literature as a whole, since grey literature, government and NGO reports, and local-language publications, potentially more common in eastern Indonesia, were not systematically searched.

Table 3. Sub-Nationally Identifiable Citations by Region in the Reviewed Corpus (2020-2026)

Region	Primary NbS Type	Sub-nationally Identifiable Citations
Sumatra	Peatland restoration, mangrove	3
Kalimantan	Peatland restoration	0
Java	Mangrove, urban	0

Region	Primary NbS Type	Sub-nationally Identifiable Citations
Sulawesi	Mangrove	0
Eastern Indonesia (Maluku, Papua)	Mixed	0
National (location unspecified)	Peatland, urban	4
Southeast Asia (regional)	Peatland, mangrove	1

Source: Tally of the 33 references retained for this review; a description of this review's own corpus, not an independent bibliometric census.

Discussion

Framework Adaptation Challenges

Findings indicate that Indonesia's primary NbS M&E challenge is not framework absence but rather contextual adaptation and implementation sustainability. Global frameworks provide conceptual foundations, yet application demands longitudinal data rarely available for programs experiencing frequent institutional transitions [3]. The transition from BRG to BRGM and subsequent mandate conclusion in 2024 exemplifies how institutional flux disrupts consistent M&E practice regardless of framework quality. Governance capacity analysis across European cities identified three mainstreaming strategies: institutionalizing systems approaches linking NbS to policies across sectors, inclusive collaborations for localized interventions, and reflexivity about how NbS interact with institutional and ecological contexts [29]. Applying these strategies to Indonesia requires accounting for decentralized governance structures and varying local capacity levels.

Indicator Selection Dilemmas

Social-institutional indicator weakness reflects not merely technical deficiency but a logical consequence of project funding and reporting structures. Physical indicators (area, volume) are more easily reported within short project cycles compared to social indicators requiring repeated surveys and sustained community engagement [7]. M&E systems demanding intensive, ongoing data collection risk non-sustainability once project funding concludes unless designed for local actor implementation without substantial additional burden. Citizen participation analysis across 58 NbS case studies found that while tokenistic participation dominates, deeper engagement strengthens social outcomes including learning, belonging, stewardship, and inclusiveness [30]. However, deeper participation is limited by institutional structures, neoliberal regimes, and inter-actor trust deficits. Strengthening relational and reflexive capacities of public institutions may partially bridge these limitations while creating multiple discussion arenas for new voices and narratives.

Ecosystem-Specific M&E Maturity

Cross-ecosystem comparison reveals differential M&E maturity: peatland systems have relatively institutionalized monitoring despite post-2024 uncertainties; mangrove ecosystems have strong ecological research foundations with emerging social indicators; urban NbS remains in exploratory qualitative phases [20]. Treating all three under a single M&E framework risks ignoring sector-specific requirements and developmental stages. Social-ecological restoration frameworks emphasize including affected communities, privileging local knowledge, empowering representatives, ensuring environmental justice, targeting deep leverage points, and connecting neighboring communities [31]. Ecosystem restoration will be most effective when approached from social-ecological perspectives, potentially through savings and credit structures within neighboring households as sustainable approaches in developing countries.

Implications for Indonesian Policy

The analysis suggests several policy implications. First, M&E frameworks should be contextually adapted rather than wholesale imported from Global North experiences. Second, institutional arrangements must enable long-term monitoring beyond project cycles, potentially through integration with existing local government data systems. Third, indicator selection should balance comprehensiveness with practical implementability by field-level managers. Fourth, cross-ecosystem learning platforms could accelerate knowledge transfer across peatland, mangrove, and urban programs. Land-based climate mitigation analysis indicates cost-effective potential of 8–13.8 GtCO₂e annually from 2020 to 2050, with approximately 50% from forests and ecosystems, 35% from agriculture, and 15% from demand-side measures [32]. Indonesia ranks among top countries contributing to this potential, but realizing mitigation benefits requires overcoming governance, economic investment, and socio-cultural feasibility barriers particularly concentrated in developing regions.

Compared with prior research, these results are broadly consistent rather than novel in kind. A systematic review of 363 empirical observations on climate adaptation in low- and middle-income countries found that nature-based interventions show the strongest positive effects for both the coastal and agricultural sectors, yet evidence remains unevenly distributed and rarely disaggregated by sub-national context [33]. Indonesia's own evidence base mirrors this asymmetry at a finer grain, between ecosystems and between provinces, rather than only between Indonesia and higher-income countries.

Limitations

This review has limitations inherent to narrative approaches. Literature coverage is not as comprehensive as systematic reviews following PRISMA protocols. Emphasis on three ecosystems means other NbS types (seagrass, coral reefs) receive less attention. Eastern Indonesia geographic gap findings are indicative rather than conclusive given potential unretrieved grey literature. The review period (2020–2026) may exclude foundational studies predating the IUCN Global Standard publication.

5. Conclusion

Nature-based Solutions (NbS) have become integral to Indonesian environmental policy, yet monitoring and evaluation (M&E) systems have failed to keep pace. While the IUCN Global Standard and logic-chain indicator approaches provide a useful conceptual foundation [5], [6], neither has been adequately adapted to Indonesia's institutional realities. Consequently, existing applications remain fragmented across sectors, exhibiting a disproportionate focus on ecological metrics over social and institutional dimensions.

Three primary gaps emerge as critical priorities: a lack of long-term, post-implementation monitoring necessary to verify actual outcomes; persistently weak social-institutional indicators driven by current funding and reporting structures; and a near-total absence of cross-ecosystem comparisons among peatland, mangrove, and urban NbS programs, which hinders cross-sectoral knowledge transfer. Crucially, these challenges are not unique to Indonesia; identical patterns pervade the broader Global South evidence base [2].

Moving forward, priority actions should include developing Indonesia-specific M&E frameworks grounded in local institutional realities, conducting longitudinal studies to track outcomes beyond standard project lifecycles, and establishing standardized indicators to enable cross-ecosystem benchmarking. Empirical research must expand beyond Sumatra to explicitly examine Kalimantan, Java, Sulawesi, and eastern Indonesia, rather than presuming regional uniformity. Pairing remote sensing with community-based monitoring offers a practical methodology to achieve both spatial coverage and analytical depth [27]. Future

M&E systems must be sustainable for local actors to operate without external dependence, integrated into government data architectures where feasible, and designed to track meaningful outcomes rather than mere outputs, aligning directly with the objectives of the UN Decade on Ecosystem Restoration (2021–2030) [28].

Credible M&E remains essential for NbS legitimacy, replication, and upscaling. While Indonesia's ecological assets and policy commitments position it to demonstrate NbS effectiveness at a landscape scale, this potential will only be realized through corresponding investments in contextually appropriate, participatory, and sustainable monitoring systems. The challenge lies in developing frameworks that provide credible scientific evidence without overburdening the field-level managers who remain key to NbS implementation success.

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