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Climate and Disaster Risk Assessment (CDRA)-Guided Prioritization of Multi-Hazard Nature-based Solutions for Resilient Land Use Planning in General Luna, Surigao del Norte

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ABSTRACT

This study develops a Climate and Disaster Risk Assessment (CDRA)-guided framework for prioritizing multi-hazard Nature-based Solutions (NbS) in General Luna, Surigao del Norte. A qualitative-dominant mixed-methods, planning-oriented case-study design integrates documentary and policy analysis, CDRA extraction, exposure and vulnerability analysis, barangay-level screening, ecological-asset inventory, hazard-NbS matching, local multi-criteria analysis (MCA), sensitivity analysis, planning-mainstreaming analysis, and a non-compensatory diagnostic screen based on the IUCN Global Standard for Nature-based Solutions, Second Edition. The eight locally derived MCA criteria rank alternatives; they are analytically distinct from IUCN's eight integrity criteria and 27 indicators. General Luna is exposed to flooding, rain-induced landslide, storm surge, tsunami, liquefaction, sea-level rise, karst subsidence, and erosion. The coastal mangrove-beach forest buffer and shoreline setback system ranks first across all weighting scenarios, followed by tourism-corridor green streets and permeable public realm and riparian-waterway rehabilitation with sustainable drainage systems. The IUCN crosswalk shows strong planning-level coverage of problem definition and systems integration but incomplete evidence for stakeholder-led prioritization, biodiversity baselines, alternatives-based economic justification, secured finance, agreed grievance processes, and implemented adaptive management. Findings are planning-level decision support, not IUCN conformity, measured performance, completed ecological validation, or formal local-government approval.

Keywords: *CDRA; Nature-based Solutions; IUCN Global Standard; Multi-hazard planning; Green-blue infrastructure; CLUP; General Luna; Resilient land use planning*

INTRODUCTION

Climate change, disaster risk, ecological degradation, and rapid spatial transformation increasingly require land use planning approaches capable of addressing several risks within the same territorial system. The Intergovernmental Panel on Climate Change frames climate risk as the interaction of hazards, exposure, and vulnerability and emphasizes that climate-related risks are increasingly compound, cascading, and interconnected (IPCC, 2022). The Sendai Framework for Disaster Risk Reduction 2015-2030 identifies four priorities for action — understanding disaster risk, strengthening risk governance, investing in resilience, and enhancing preparedness — that are directly connected to land use planning because land allocation, zoning, infrastructure siting, environmental protection, and public investment determine whether risk is reduced, transferred, or reproduced (UNDRR, 2015).

Nature-based Solutions (NbS) provide a planning pathway for linking climate adaptation, disaster risk reduction, ecosystem management, and spatial development. The United Nations Environment Assembly defines NbS as actions to protect, conserve, restore, sustainably use, and manage natural or modified ecosystems in ways that address societal challenges effectively and adaptively while providing human well-being, ecosystem-service, resilience, and biodiversity benefits (UNEA, 2022). This definition distinguishes NbS from ordinary greening: a defensible intervention must respond to a societal challenge, rely on ecological processes, and produce measurable benefits for people, resilience, and biodiversity. Seddon et al. (2020), Chausson et al. (2020), and Raymond et al. (2017) support a constructive but qualified use of NbS, contingent on biodiversity protection, ecological condition, intervention design, governance, and multi-domain co-benefit assessment. Coastal ecosystems such as mangroves, wetlands, reefs, and beach forests can reduce exposure to waves, flooding, erosion, and storm impacts, but their performance varies with habitat type, condition, width, elevation, and hydrodynamic setting and should not be presumed uniform (Narayan et al., 2016).

In the Philippine planning context, the Department of Human Settlements and Urban Development's Resilient Urban Design and Development Guidelines incorporate ecosystem-based adaptation, water-sensitive urban design (WSUD), sustainable urban drainage systems (SuDS), open-space networks, and Comprehensive Land Use Plan (CLUP) and Zoning Ordinance (ZO) integration, providing a national pathway for translating ecological and design-based interventions into local spatial policy, development regulation, and investment programming (DHSUD, 2025).

General Luna, Surigao del Norte, presents a compelling setting for examining NbS as a Climate and Disaster Risk Assessment (CDRA)-guided planning intervention. The municipality occupies 5,551 hectares in the southern portion of Siargao Island across nineteen barangays, including mainland coastal, Poblacion, upland, rolling, and island communities (Municipality of General Luna, 2023a). Its development trajectory is strongly shaped by tourism: the 2023-2032 CLUP identifies a tourism corridor extending approximately 15 kilometers from Barangay Malinao to Barangay Santa Cruz, intersecting coastal ecosystems, settlements, roads, and coastal-hazard exposure. The municipality also possesses a substantial ecological base — 414.85 hectares of mangroves, 412.07 hectares of watersheds, 98.65 hectares of rivers, 4.13 hectares of creeks, 360.74 hectares of strict protection areas, and 271.28 hectares of agroforestry areas under natural-resource use (Municipality of General Luna, 2023a) — while remaining exposed to flooding, rain-induced landslide, storm surge, tsunami, liquefaction, sea-level rise, karst subsidence, and erosion. Its risk context is also demographic and social: a 2020 population of 22,853 persons in 6,630 households, and documented vulnerable groups including preschool children, senior citizens, persons with disabilities, disadvantaged women or solo parents, and Pantawid Pamilyang Pilipino Program families (Municipality of General Luna, 2023b).

Despite the availability of the CLUP, CDRA, hazard maps, ecological data, and Sectoral Studies, the central planning challenge remains the operational translation of risk evidence into geographically differentiated, ecologically suitable, socially safeguarded, and policy-ready interventions. CDRA identifies hazards, exposed elements, vulnerabilities, and risk areas, but it does not by itself determine which NbS interventions are locally appropriate, which barangays should be prioritized, which ecological assets can perform protective functions, how multiple hazards should be evaluated together, or how selected interventions should be translated into enforceable and fundable planning instruments.

Accordingly, this study addresses the general problem of how the Climate and Disaster Risk Assessment of General Luna can be used to prioritize multi-hazard Nature-based Solutions for resilient land use planning, environmental preservation, and sustainable tourism development. It answers seven research questions concerning (1) documented hazards and exposed/vulnerable elements; (2) barangay-level documentary multi-hazard recurrence; (3) existing ecological assets and green-blue infrastructure elements; (4) suitable NbS interventions and their IUCN Second-Edition integrity conditions; (5) local multi-criteria prioritization of NbS packages; (6) the extent to which NbS is already reflected in existing planning instruments; and (7) a CDRA-guided NbS mainstreaming framework for CLUP, ZO, Local Urban Design Guide, Local Development Investment Program (LDIP), Annual Investment Program (AIP), and local programs, projects, and activities (PPAs) integration. The study's scope covers General Luna's nineteen barangays over the 2023-2032 CLUP planning period; it does not undertake engineering design, hydrodynamic or hydraulic modeling, geotechnical testing, or a complete biodiversity field inventory, and its outputs are planning-level decision-support products rather than substitutes for formal LGU adoption, site-specific ecological assessment, or verification against the IUCN Global Standard.

The study is anchored on the proposition that climate and disaster risk in a coastal tourism municipality is produced through the interaction of hazards, exposed people and assets, ecological conditions, land use decisions, infrastructure, tourism development, social vulnerability, and governance capacity. It draws on social-ecological systems theory (Berkes & Folke, 1998; Ostrom, 2009), resilience theory (Folke, 2006; Walker et al., 2004), risk-informed land use planning (IPCC, 2022; UNDRR, 2015), NbS and green-blue infrastructure (UNEA, 2022), environmental governance and justice (Anguelovski & Corbera, 2023; Kabisch et al., 2022; Kiss et al., 2022), and sustainable tourism governance. The resulting conceptual model begins with risk-and-development, ecosystem-condition, and stakeholder-priority evidence streams; proceeds through NbS theory-of-change and alternatives, IUCN integrity screening, local multi-criteria-analysis (MCA) prioritization, validation, planning and investment decisions, implementation with safeguards, and outcomes for people and nature; and closes an adaptive-learning loop that returns monitoring evidence to problem framing. It is a conditional theory of change: its intended outcomes depend on the documented assumptions and integrity conditions being satisfied, and monitoring must test both implementation performance and the causal assumptions linking actions to outcomes.

Four propositions guide the inquiry: that documentary CDRA evidence can screen barangays and planning contexts for priority attention, subject to subsequent geospatial and site validation; that NbS suitability depends on ecological condition, land use compatibility, exposed elements, and implementation feasibility rather than hazard count alone, with local MCA priority and IUCN integrity treated as answering different questions; that interventions addressing multiple hazards and generating ecological, social, livelihood, and tourism co-benefits have greater planning value, subject to equity and feasibility safeguards; and that priority interventions become operational only when mainstreamed into local planning, zoning, urban design, investment, implementation, and monitoring instruments. Two operational terms recur throughout: documentary multi-hazard recurrence, a barangay's appearance in two or more source-identified hazard-priority lists, used strictly as a screening signal rather than a measure of probability or geospatial intersection; and multi-hazard NbS, an intervention addressing at least two hazards, with strategic multi-hazard NbS addressing three or more hazards and demonstrating high ecological, social, and implementation value, targeted NbS responding to one principal hazard, and complementary NbS supporting but not solely controlling a hazard.

LITERATURE REVIEW

The IUCN Global Standard for Nature-based Solutions™, Second Edition, operationalizes the UNEA definition of NbS through eight interdependent criteria and 27 indicators spanning societal challenges; ecological, economic, social, and cultural systems; positive biodiversity change and ecosystem integrity; financial feasibility and economic justification; inclusive governance; equitable reconciliation of trade-offs; evidence-based adaptive management; and enabling conditions (IUCN, 2026). The Second Edition is a process-oriented learning and quality-assurance framework rather than a fixed-threshold certification scheme; this study accordingly treats it as a non-compensatory integrity layer distinct from the eight local MCA criteria that rank packages against General Luna's planning needs. Nesshöver et al. (2017) and Castellar et al. (2021) note that NbS operates at the intersection of science, policy, and practice and that urban NbS terminology remains diverse, requiring classification by ecological basis, spatial scale, urban challenge, and ecosystem service.

NbS is closely associated with green-blue infrastructure — connected vegetated and water-dependent systems that regulate runoff, recharge groundwater, reduce heat, support biodiversity, and strengthen landscape identity. Kabisch et al. (2022) argue that urban NbS should be planned through a systemic perspective recognizing spatial connectivity, long-term management, and social inclusion, since disconnected interventions lose ecological and hydrological effectiveness. In coastal settings, Narayan et al. (2016) found that natural and nature-based defenses can reduce wave energy, erosion, and flood exposure, but effectiveness depends on habitat type, width, elevation, and hydrodynamic conditions; sea-level rise may further reduce long-term effectiveness when landward ecosystem migration is blocked by fixed development, producing coastal squeeze.

The contribution of NbS to climate adaptation and disaster risk reduction is strongest for water-related hazards: rain gardens, permeable surfaces, vegetated swales, detention systems, and wetlands reduce and delay runoff and lessen pressure on conventional drainage (Huang et al., 2020; Ferreira et al., 2020), and WSUD/SuDS translate these hydrological principles into urban planning through source control, conveyance, infiltration, and treatment (DHSUD, 2025). Mangroves, beach forests, and coastal wetlands can reduce wave energy and stabilize sediments — Menéndez et al. (2018) demonstrated at national scale that Philippine mangroves provide substantial protection to people and property from coastal flooding — but their adaptation value is conditional on width, density, species composition, and maintenance; Primavera and Esteban (2008) found that many Philippine mangrove rehabilitation projects experienced low long-term survival because of unsuitable site and species selection, establishing ecological suitability as a prerequisite rather than a secondary criterion. Reyes et al. (2026), using hydrologic and hydraulic modeling of the Antiao River catchment, found that a hybrid scenario combining flood-protection dikes with reforestation, mangrove restoration, and constructed wetlands outperformed a dike-only scenario on several hydraulic indicators, illustrating that conventional and nature-based interventions can be complementary at catchment scale. Tsunami, liquefaction, ground shaking, and karst subsidence, by contrast, remain only indirectly responsive to NbS and require land use avoidance, evacuation planning, and geotechnical investigation.

CDRA is central to risk-informed land use planning because it organizes information on hazards, exposure, vulnerability, adaptive capacity, and risk (Republic Act No. 10121, 2010), but a plan that identifies risk while continuing to allocate high-intensity development to exposed areas is risk-aware without being risk-responsive. Dulawan et al. (2024) demonstrate that flood-risk patterns in Metro Manila change materially when social vulnerability is integrated with hazard information, directly supporting the incorporation of vulnerable-group considerations into local NbS prioritization rather than treating hazard exposure alone as decisive.

Coastal and urban municipalities are rarely affected by hazards in isolation; flooding, drainage congestion, sea-level rise, and impervious-surface growth interact, as do coastal erosion, vegetation loss, and tourism construction. Multi-criteria decision analysis provides a structured method for combining spatially variable criteria and decision preferences (Malczewski, 1999, 2006), and the Analytic Hierarchy Process offers one method for deriving weights through pairwise comparison (Saaty, 1980). A defensible prioritization process requires conceptually distinct criteria, transparent weights, and sensitivity analysis to test whether rankings remain stable when weights change; co-benefits and disbenefits must be incorporated together, since a mangrove restoration project may strengthen coastal protection while reducing access to fishing grounds if poorly designed (Raymond et al., 2017; Ommer et al., 2022).

Tourism is a spatial process, not merely an economic sector: it affects land conversion, water demand, wastewater generation, and public access, and is often concentrated in the same low-lying areas that contain the beaches, mangroves, reefs, and hazard-exposed settlements that make destinations attractive. The relationship between NbS and tourism is not automatically positive — tourism-oriented greening may prioritize aesthetics over ecological function or restrict community access — so sustainable tourism governance requires NbS to be evaluated by ecological performance, public benefit, and long-term maintenance rather than tourism branding alone.

Philippine empirical literature is strongest in mangrove restoration and coastal protection. Beyond Menéndez et al. (2018) and Primavera and Esteban (2008), Delfino et al. (2015) found that Leyte and Eastern Samar communities in areas with more extensive, wider, and species-richer mangroves experienced lower housing damage and perceived stronger protective benefits after Typhoon Haiyan; Quevedo et al. (2020, 2021) found that community awareness, participation, and local stewardship are central to sustained mangrove ecosystem-service delivery; Gagarin et al. (2022) documented measurable willingness to pay for mangrove coastal protection in Calauag, Quezon; Malabrigo (2021) and Marquez and Olavides (2024) emphasize that restoration targets based on planting numbers can obscure poor ecological outcomes, and that integrating science-based and local ecological knowledge strengthens long-term success. Escobin and Briones (2001) add that the rehabilitation of the Biñan River depended on multisectoral partnerships and sustained institutional commitment. Taken together, this literature identifies five recurring conditions for effective Philippine NbS: hydrology- and species-appropriate ecological design; recognizable local livelihood and cultural benefit; clear and sustained local-government and community roles; monitoring focused on ecological and risk-reduction performance rather than activity counts; and integration with land use regulation and conventional infrastructure.

Mainstreaming — the systematic incorporation of NbS into ordinary planning, regulatory, budgeting, and monitoring processes — is an institutional challenge involving policy integration, organizational coordination, and resources (Wamsler et al., 2014). The DHSUD (2025) Guidelines provide a practical Philippine pathway spanning technical-working-group organization, priority-area selection, site verification, CLUP/ZO integration, implementation, and review. For this study, mainstreaming has six dimensions: substantive, spatial, regulatory, investment, institutional, and monitoring.

NbS is not automatically equitable. Anguelovski and Corbera (2023) warn that nature-oriented redevelopment may produce "nature-enabled dispossession" when ecological improvement becomes connected to exclusionary development or restricted access; Kabisch et al. (2022) emphasize inclusion and context sensitivity as governance principles; and Kiss et al. (2022) show that citizen participation affects governance, ownership, learning, and long-term maintenance. These concerns are especially relevant in tourism municipalities where coastal greening and waterfront renewal may increase land values and competition for space, reinforcing the need to treat distributional, procedural, and recognitional justice as substantive rather than incidental design criteria.

The reviewed literature reveals four interrelated gaps that this thesis addresses: an evidentiary integration gap, since hazard, ecological, social, tourism, and land use data are commonly held in separate planning documents; an analytical gap, since there is no routine local method for matching hazard combinations with suitable NbS through transparent criteria; a spatial gap, since priorities must be located relative to barangays, ecosystems, and tourism corridors; and an implementation gap, since priority interventions must be translated into CLUP, ZO, Local Urban Design Guide, LDIP, AIP, and institutional instruments. Nature-based Solutions become meaningful land use planning instruments only when guided by risk evidence, matched with local ecological and spatial conditions, evaluated through multi-hazard and equity criteria, and embedded in enforceable, fundable, and adaptively managed planning systems.

MATERIALS AND METHODS

Research design

This study employs a qualitative-dominant mixed-methods, planning-oriented case study and framework-development design, appropriate for examining a bounded planning system — the Municipality of General Luna, its CLUP/CDRA, Sectoral Studies, ecological assets, tourism-development pattern, and local planning instruments — where the phenomenon and its institutional and spatial setting cannot be meaningfully separated (Yin, 2018). The qualitative strand consists of documentary, policy, and institutional analysis (Bowen, 2009); the quantitative screening strand consists of hazard-recurrence coding, ecological-asset coding, local multi-criteria suitability scoring, weighted prioritization, and sensitivity analysis (Malczewski, 1999, 2006), without a GIS-MCDA overlay. Integration occurs during recurrence screening and ecological-asset inventory, in operationalizing qualitative judgments through the scoring rubric, and in reintegrating prioritization results with policy evidence to develop the mainstreaming framework (Creswell & Creswell, 2018).

Research locale and units of analysis

The study is conducted in the Municipality of General Luna (5,551 hectares; nineteen barangays: Anajawan, Cabitoonan, Catangnan, Consuelo, Corazon, Daku, La Januza, Libertad, Magsaysay, Malinao, Poblacion 1–5, Santa Cruz, Santa Fe, Suyangan, and Tawin-tawin), selected for its rapidly developing tourism economy, coastal concentration of settlement, extensive green-blue resources, and exposure to eight documented hazards. Nested units of analysis connect municipal-scale planning with barangay- and site-relevant intervention logic: the barangay as the principal administrative comparison unit; hazard areas/risk zones as spatial-risk units; ecological assets as environmental-function units; planning instruments as governance units; and NbS packages as the intervention units evaluated and ranked.

Data sources and reconciliation

The controlling local sources are the 2023-2032 CLUP, including its CDRA, for geographic, land-use, ecological, hazard, exposure, risk, and policy evidence, and the 2023 Sectoral Studies for demographic, housing, tourism, infrastructure, utility, and institutional evidence (Municipality of General Luna, 2023a, 2023b). The IUCN Global Standard, Second Edition (IUCN, 2026), supplies the international integrity framework, and the DHSUD (2025) Guidelines supply the national planning and technical pathway; peer-reviewed literature interprets local conditions and establishes defensible criteria rather than substituting for local evidence. Where local documents contain inconsistent figures, a source hierarchy applies — a detailed table with an identified source and internally consistent values takes precedence over an inconsistent narrative statement — with arithmetic checks applied to totals, percentages, and weighted scores; unresolved inconsistencies (e.g., the karst subsidence high-risk-area figure) are disclosed and excluded from quantitative comparison rather than silently corrected.

CDRA extraction and multi-hazard recurrence screening

Hazard data were extracted from CDRA summary tables and maps for flooding, rain-induced landslide, storm surge, tsunami, liquefaction, sea-level rise, karst subsidence, and erosion, recording exposed area, affected population/households, recurrent barangays, and NbS relevance. Documentary multi-hazard recurrence screening then assigned each barangay a binary code (1/0) for appearance in a source-documented high-risk or moderate-to-high-risk hazard list; the resulting count is a reproducible screening indicator, not a measure of probability, severity, or geospatial intersection, since validated georeferenced layers were unavailable. An intervention is classified as multi-hazard NbS when it addresses at least two hazards; strategic multi-hazard NbS addresses three or more hazards with high ecological, social, and implementation value; targeted NbS addresses one principal hazard; and complementary NbS supports but does not solely control a hazard.

Ecological-asset inventory and hazard-NbS matching

Natural-resource-use, land-cover, watershed, riparian, mangrove, agroforestry, and open-space information was encoded in an ecological-asset inventory classified by location, extent, ecological function, potential risk-reduction function, and associated hazards. Hazard-NbS matching then compared the process through which each hazard produces risk with the ecological function of a potential intervention — for example, matching flooding and drainage congestion with riparian rehabilitation, rain gardens, and watershed management, and matching storm surge, sea-level rise, and coastal erosion with mangrove protection, coastal buffers, and setbacks — while treating tsunami, liquefaction, and karst subsidence as hazards for which NbS has complementary rather than direct preventive functions.

Local multi-criteria suitability scoring and weighting

Eight integrated NbS packages were compared using a weighted additive model with eight local MCA criteria selected from the research objectives, NbS literature, risk-informed planning principles, and available local data — CDRA risk level (20%), number of hazards addressed (15%), exposed population and assets (15%), ecological suitability (15%), land use compatibility (10%), tourism and livelihood relevance (10%), social equity and safeguards (10%), and implementation and mainstreaming feasibility (5%) — which are conceptually and numerically distinct from the eight IUCN integrity criteria. Each package was rated from 1 (very low) to 5 (very high suitability) on each criterion, and the weighted priority score was calculated as Σ (criterion rating × criterion weight), with scores of 4.50–5.00 classified as very high priority, 4.00–4.49 as high, 3.50–3.99 as moderate-high, 3.00–3.49 as moderate, and below 3.00 as low priority or deferred. The model is compensatory — a high rating on one criterion can offset a low rating on another — and the baseline weights and ratings are researcher-derived planning judgments rather than statistically estimated or stakeholder-elicited parameters, which is why the IUCN screen is retained as a separate, non-compensatory gate.

Sensitivity analysis

Sensitivity analysis recalculated scores under four alternative weighting scenarios while holding package ratings fixed: equal weight (12.5% each, testing dependence on the baseline weighting choice), risk-dominant (30/20/20/10/5/5/5/5, emphasizing risk level, hazard coverage, and exposed elements), ecology-equity (15/10/10/25/10/10/15/5, emphasizing ecological suitability and social safeguards), and implementation-oriented (15/10/10/10/15/10/10/20, emphasizing land use compatibility and feasibility). Ranking stability in this study means only that a package remains within the same broad tier or leading group across the five scenarios; the analysis does not test rating, source-data, criterion-dependence, or model-structure uncertainty.

IUCN Second-Edition integrity screening and planning-mainstreaming analysis

The IUCN screen maps the manuscript and proposed framework against all eight criteria and 27 indicators, classifying each as documented at planning-framework level, partially evidenced, not evidenced in the current record, or not yet assessable before implementation (not a weighted score or a substitute for the official Self-Assessment Tool). The screen is non-compensatory: a strong local MCA result cannot offset a missing biodiversity baseline, stakeholder participation record, financing mechanism, grievance process, or adaptive-management evidence. The planning-mainstreaming procedure separately traces how priority packages can be embedded in the CLUP vision, proposed land and water uses, ZO, Local Urban Design Guide, LDIP, AIP, PPAs, institutional responsibilities, funding, and monitoring provisions, producing a policy-integration matrix rather than a legally operative ordinance.

Instruments, trustworthiness, ethics, and limitations

Structured instruments — a CDRA hazard extraction matrix, barangay multi-hazard screening matrix, exposure/vulnerability worksheet, ecological-asset inventory, hazard-NbS matching matrix, local MCA scoring sheet, sensitivity-analysis worksheet, policy-integration matrix, and IUCN 27-indicator crosswalk — support consistency and auditability. Credibility rests on source triangulation across the CLUP/CDRA, Sectoral Studies, IUCN Standard, DHSUD Guidelines, and peer-reviewed literature; dependability on explicit coding rules and an audit trail; confirmability on separating source-derived facts from researcher classification; and transferability on specifying the General Luna context clearly enough for adaptation elsewhere. The study relies on public planning documents and does not require disclosure of personally identifiable information; where vulnerable groups or households in danger areas are referenced, findings are reported at aggregate level consistent with the Data Privacy Act of 2012 (Republic Act No. 10173, 2012) and the ethical principles of the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). Methodological limitations include dependence on the resolution and internal consistency of existing planning documents in the absence of editable GIS layers; the absence of hydrodynamic, hydraulic, geotechnical, or detailed ecological field assessment; the researcher-derived and compensatory character of the weighted additive model, whose five weight scenarios test only selected weight uncertainty; and the single-case design, whose value lies in analytical transferability to similarly situated coastal tourism municipalities rather than statistical generalization.

RESULTS AND DISCUSSION

General Luna is situated in the southern portion of Siargao Island, bounded by Pilar to the north, Dapa to the west, and the Philippine Sea to the east, with a land area of 5,551 hectares across nineteen barangays combining compact Poblacion centers, mainland coastal barangays, upland and rolling areas, and island communities (Municipality of General Luna, 2023a). The municipality is predominantly underlain by Timamana limestone (66.6% of land area) and Quaternary deposits (28.3%), conditions that shape groundwater movement, karst-related geotechnical caution, and liquefaction susceptibility in low-lying coastal areas.

The 2020 baseline population is 22,853 persons in 6,630 households, with 8,968 urban residents in the five Poblacion barangays and 13,885 rural residents across the remaining fourteen; the level of urbanization rose from 32.50% in 2000 to 39.24% in 2020 (Municipality of General Luna, 2023b). Documented vulnerable groups include 629 preschool children in day care, 1,846 senior citizens with identification cards, 452 persons with disabilities, 256 disadvantaged women or solo parents, and 1,495 families under the Pantawid Pamilyang Pilipino Program, alongside a housing backlog of 889 units including 874 households displaced by danger-area, infrastructure, or hazard-related conditions. These conditions require NbS prioritization to weigh who benefits, who bears implementation costs, and whether interventions affect housing, tenure, public access, and livelihoods.

Existing general land use is predominantly natural-resource based (92.48% of municipal land, versus 5.89% urban use and 1.63% roads), even though development pressure is spatially concentrated in a relatively small urban footprint (Municipality of General Luna, 2023a). The ecological-asset base available for NbS comprises 414.85 hectares of mangroves (concentrated in Cabitoonan, Catangnan, Libertad, Magsaysay, Malinao, Santa Cruz, and Tawin-tawin, with documented decline associated with conversion to ecotourism uses), 412.07 hectares of watersheds (concentrated in Corazon, Consuelo, and Malinao), 98.65 hectares of rivers, 4.13 hectares of creeks, 360.74 hectares of strict protection areas, 271.28 hectares of agroforestry areas, 51 reported beach-forest species, and coral reef and seagrass assets of varying condition whose direct hazard-reduction performance requires site-specific validation.

Tourism is the dominant spatial driver: recorded arrivals rose from 4,307 in 2011 to 274,547 in 2019, fell sharply during the pandemic, and reached 112,239 in 2022, while accommodation establishments grew from 29 in 2012 to 438 categorized establishments in 2020 (Municipality of General Luna, 2023b). The approximately 15-kilometer Malinao–Santa Cruz tourism corridor has been accompanied by the gradual conversion of beachside coconut plantations to tourism construction and settlement (Municipality of General Luna, 2023a), reinforcing the planning need for water-sensitive tourism standards rather than tourism restriction as such.

Consolidated hazard and exposure profile

The CLUP/CDRA identifies eight hazards with markedly different spatial and demographic footprints (Municipality of General Luna, 2023a). Flooding exposes 2,076 hectares (545.53 hectares at risk) and 19,304 persons in 5,537 households, concentrated in Malinao, Consuelo, Cabitoonan, Catangnan, and Magsaysay — the broadest documented population exposure of any hazard. Liquefaction exposes 2,097.25 hectares (1,768.52 hectares high-risk) and 18,580 persons in 5,346 households across Malinao, Tawin-tawin, Catangnan, Cabitoonan, Libertad, and Magsaysay. Sea-level rise exposes 1,633.75 hectares (1,262.13 hectares high-risk) and 17,238 persons in 4,909 households in Malinao, Catangnan, Cabitoonan, Libertad, Poblacion 5, and Tawin-tawin. Tsunami exposes 1,434.70 hectares (476.65 hectares high-risk) and 14,907 persons in 4,288 households in Catangnan, Malinao, Cabitoonan, Libertad, Poblacion 5, and Santa Fe. Rain-induced landslide exposes 3,313.38 hectares (8.46 hectares high-risk, concentrated in Malinao, with moderate risk in Consuelo, Corazon, Tawin-tawin, and Libertad) and 5,645 persons in 1,719 households. Storm surge exposes 489.26 hectares (167.64 hectares high-risk) and 9,252 persons in 2,618 households in Poblacion 5, Catangnan, Santa Fe, Malinao, and Cabitoonan. Karst subsidence exposes 33.173 hectares and 2,640 persons in 876 households across Daku, Poblacion 4, Tawin-tawin, Consuelo, Corazon, and Malinao, though its reported high-risk-area figure is internally inconsistent and excluded from quantitative use; erosion is mapped but lacks a complete barangay exposure table.

Multi-hazard barangay screening

Excluding erosion, documentary recurrence screening identifies Malinao as the most complex priority area, appearing across seven of the eight hazard lists (flood, rain-induced landslide, storm surge, tsunami, liquefaction, sea-level rise, and karst). Catangnan and Cabitoonan follow with five hazard signals each; Libertad and Tawin-tawin with four; Consuelo and Poblacion 5 with three; Magsaysay, Corazon, and Santa Fe with two; and Daku and Poblacion 4 with one. The pattern also reveals functional differences requiring distinct intervention logics: Malinao requires an integrated coastal-watershed-tourism package; Catangnan requires tourism-coastal-public-realm interventions; Cabitoonan requires mangrove-riparian-coastal measures; Consuelo and Corazon require watershed and slope interventions; Poblacion 5 requires urban waterfront and evacuation-compatible public-space interventions; and Tawin-tawin and Libertad require coastal-riparian and geologic-risk-sensitive land use controls.

Ecological-asset analysis and hazard-NbS matching

Four connected ecological systems structure the analysis: a coastal system (mangroves, beach forests, shoreline vegetation, seagrass, reefs); a riparian-drainage system (rivers, creeks, wetlands, permeable landscapes); an upland-watershed system (watersheds, strict protection and agroforestry areas, slopes); and an urban-tourism public-realm system (streets, parks, waterfronts, public facilities). These systems are functionally linked — upland vegetation and soil management influence downstream runoff and sediment, rivers and creeks connect upland drainage to coastal waters, and tourism development changes imperviousness, wastewater load, and land values — so intervention packages were matched to hazards at the system rather than the project-site level: riparian buffers, rain gardens, and watershed management for flooding and drainage congestion; mangrove and beach-forest protection, coastal buffers, and setbacks for storm surge, sea-level rise, and coastal erosion; watershed rehabilitation, agroforestry, and slope revegetation for rain-induced landslide and erosion; WSUD, bioretention, and constructed wetlands for tourism runoff and wastewater pressure; urban trees and green streets for heat and impervious growth; and setbacks, open-space retention, and geotechnical review as complementary (not preventive) responses to tsunami, liquefaction, and karst sensitivity.

Local MCA rankings

The baseline weighted local MCA scores rank the eight integrated NbS packages as follows: (1) the coastal mangrove-beach forest buffer and shoreline setback system, 4.75 (very high priority); (2) tourism-corridor green streets and permeable public realm, 4.25 (high); (3) riparian-waterway rehabilitation and sustainable drainage system, 4.10 (high); (4) water-sensitive tourism and wastewater-polishing landscapes, 3.95 (moderate-high); (5) ecological open space and evacuation-linked resilience nodes, 3.90 (moderate-high); (6) watershed-agroforestry and slope stabilization system, 3.85 (moderate-high); (7) low-impact development and open-space preservation in liquefaction- and karst-sensitive areas, 3.45 (moderate); and (8) island-barangay rainwater, coastal-vegetation, and open-space resilience, 3.30 (moderate). Sensitivity analysis across the equal-weight, risk-dominant, ecology-equity, and implementation-oriented scenarios shows that the coastal buffer package remains highest-ranked in every scenario (ranging 4.55–4.85), while tourism green streets and riparian SuDS remain within the leading group, tying under the risk-dominant scenario; middle-order packages shift modestly — watershed-agroforestry rises to 4.00 under the ecology-equity scenario — demonstrating that the local MCA responds to policy priorities without overturning the dominant finding that coastal, tourism-corridor, and riparian interventions warrant earliest planning attention. This is conditional ranking stability across five tested weight scenarios, not general robustness, since ratings, source data, and the additive model structure were held fixed.

Ranked priority packages

The coastal buffer package ranks first because it responds to recurrent coastal hazards, protects mangroves and beach forests together with shoreline vegetation and easements, supports fisheries and tourism, and translates readily into zoning controls, while remaining understood as a complement to, not a substitute for, evacuation, early warning, and site-specific coastal engineering (Narayan et al., 2016). Tourism-corridor green streets rank second because the Malinao–Santa Cruz corridor concentrates coastal exposure, roads, wastewater pressure, and pedestrian activity, where native shade trees, permeable surfaces, and stormwater planters can reduce runoff and heat while improving destination resilience — provided implementation uses continuous street segments and regulated private development rather than isolated decorative landscaping. Riparian-waterway rehabilitation with SuDS ranks third given flooding's broad population exposure and the connected hydrological role of rivers, creeks, and drainage corridors, though General Luna's limestone and karst conditions require controlled rather than indiscriminate infiltration (Huang et al., 2020; Ferreira et al., 2020). Water-sensitive tourism and wastewater-polishing landscapes, ecological open space and evacuation-linked resilience nodes, and the watershed-agroforestry and slope stabilization system form a moderate-high-priority group whose value lies respectively in reducing tourism-related runoff and groundwater pressure, in combining daily public-space and emergency functions with high equity value, and in providing downstream runoff and erosion benefits for Consuelo, Corazon, and Malinao that rise in importance under an ecology-equity weighting. Low-impact development in liquefaction- and karst-sensitive areas and the island-barangay resilience package receive moderate priority precisely because NbS cannot prevent liquefaction, karst subsidence, or island freshwater scarcity; their role is to reduce exposure through open-space retention, controlled infiltration, and site-specific validation rather than to imply that landscaping renders geologically unsuitable land safe for intensive development.

Six strategic priority areas emerge from combining the package and barangay analyses: Malinao as the principal integrated coastal-watershed-tourism area; Catangnan as the principal tourism-coastal-public-realm area; Cabitoonan as the principal mangrove-riparian-coastal corridor; Poblacion 5 as the principal urban-waterfront and resilience-node area; the Consuelo-Corazon-Malinao watershed and slope-resilience system; and the Libertad-Santa Fe-Tawin-tawin coastal exposure-management and low-impact-development cluster. These are planning geographies for coordinated policy, investment, and design rather than rigid project boundaries; project delineation requires subsequent parcel, easement, hydrological, ecological, and community validation, since the recovered research record did not include validated georeferenced hazard, ecological-condition, cadastral, or ownership layers sufficient to produce defensible derived GIS maps.

Multi-functionality and context dependence

The findings support the literature's characterization of NbS as multifunctional (Raymond et al., 2017): the leading coastal package addresses several hazards while producing biodiversity, fisheries, tourism, and public-access benefits. Hazard count alone is nonetheless insufficient — watershed-agroforestry remains strategically important despite lower immediate exposure scores, and open-space resilience remains important for its equity and evacuation functions. The ranking also reinforces that NbS performance is context-dependent (Chausson et al., 2020; Seddon et al., 2020): mangroves are appropriate where tidal hydrology supports them, infiltration systems only where karst and groundwater conditions permit, and agroforestry only where land use and livelihoods can sustain long-term vegetation cover, rejecting generic project replication.

Hybrid infrastructure, tourism equity, and ranking stability

The study confirms that NbS must operate within a hybrid risk-governance system: flood and drainage interventions still require engineering capacity and maintenance, coastal interventions still require setbacks and evacuation planning, wastewater-polishing landscapes still require formal treatment systems, and geologic hazards still require technical investigation. Tourism relevance simultaneously increases the urgency and financing potential of NbS and creates equity risk, since waterfront improvement, green streets, and mangrove ecotourism may raise land values or restrict livelihood access, supporting the justice safeguards emphasized by Anguelovski and Corbera (2023), Kabisch et al. (2022), and Kiss et al. (2022); public access, fisherfolk use, and non-displacement must therefore be treated as design and governance criteria rather than post-project considerations. Across the five tested weight scenarios, the coastal buffer remains first while middle-order changes reveal legitimate policy sensitivity — an ecology-equity emphasis raises watershed-agroforestry, while an implementation emphasis favors packages with clearer regulatory pathways — making value choices visible without determining IUCN integrity.

IUCN Second-Edition integrity implications

The 27-indicator crosswalk confirms that the manuscript is strongest as an ex ante planning and systems framework: 3 indicators are documented at planning-framework level (problem definition and systems/cross-sector integration) and 13 are partially evidenced, while 8 are not evidenced in the current record — including stakeholder-led prioritization, measurable biodiversity baselines, alternatives-based economic justification, secured finance, and agreed grievance processes — and 3 (periodic safeguard review, monitoring-based testing of assumptions, and implemented adaptive management) are not yet assessable before implementation. This result does not invalidate the package rankings; it limits their meaning. The rankings identify where municipal planning attention should begin, not that the packages already constitute high-integrity NbS. For publication and implementation, the local MCA ranking and IUCN integrity status are accordingly reported side by side: relative priority is a comparative planning result, while integrity status is a stage-dependent evidence finding, and neither substitutes for the other.

Proposed CDRA-to-NbS mainstreaming framework

Chapter-level findings are translated into an eight-stage operational framework — evidence consolidation and problem framing; barangay recurrence and ecological screening; NbS theory of change and alternatives; IUCN integrity screening; local MCA, uncertainty, and validation; planning, regulatory, and investment decision; implementation, finance, maintenance, and safeguards; and monitoring, evaluation, learning, and adaptation — in which each stage produces an auditable output for the next and an adaptive-learning loop returns monitoring evidence to problem framing. The eight operational stages are numerically coincidental with, but conceptually distinct from, the eight IUCN criteria, whose 27 indicators apply cross-cuttingly across the entire cycle rather than to a single stage.

Each priority package is assigned a distinct spatial and policy pathway and a corresponding proposed overlay: a Coastal Green-Blue Buffer Overlay for the coastal buffer package; a Water-Sensitive Tourism Overlay for the tourism-corridor package; a Riparian and Waterway Resilience Overlay for the SuDS package; an Ecological Open Space and Resilience Node Overlay for public-realm and evacuation functions; a Slope and Watershed Protection Overlay for the Consuelo-Corazon-Malinao system; a Low-Impact Geologic-Risk Overlay for liquefaction- and karst-sensitive areas; and an Island Community Resilience Overlay for Daku, La Januza, Anajawan, and Suyangan. These overlays are proposed for CLUP recognition of green-blue infrastructure as resilience infrastructure and ZO translation into enforceable development controls, complemented by a Local Urban Design Guide providing site- and street-level standards; corresponding investment translation would convert each package into an LDIP/AIP-programmed PPA — including a Coastal Green-Blue Buffer Mapping and Management Program, a Municipal Mangrove and Beach-Forest Protection and Restoration Program, a Malinao-Santa Cruz Water-Sensitive Tourism Corridor Program, a Municipal Creek, Riparian, and SuDS Program, a Tourism Wastewater and Stormwater Compliance Program, an Ecological Open Space and Resilience Node Program, a Consuelo-Corazon-Malinao Watershed and Agroforestry Program, a Geologic-Risk-Sensitive Development Review Program, an Island Water and Public-Facility Resilience Program, and a Local Urban Design Guide Preparation Project — with defined problem, location, responsible office, cost class, funding strategy, maintenance plan, and performance indicators appraised against green, gray, hybrid, and no-action alternatives before budget commitment.

Institutional mainstreaming requires an interoffice NbS and Resilient Urban Design Technical Working Group, since no single office controls risk assessment, ecosystems, engineering, tourism, zoning, safeguards, and monitoring: indicatively, the Municipal Planning and Development Office (MPDO) leads framework integration; the Municipal Disaster Risk Reduction and Management Office

(MDRRMO) interprets and updates CDRA evidence; the Municipal Environment and Natural Resources Office (MENRO) leads ecological programs and safeguards; the Municipal Engineering Office (MEO) leads drainage and SuDS engineering; the Zoning Office applies overlay provisions; the Tourism Office integrates tourism standards; the Municipal Agriculture Office (MAO) implements agroforestry and climate-resilient farming support; the Municipal Social Welfare and Development Office and Municipal Health Office review vulnerability and inclusive-consultation safeguards; budget offices program financing; the Sangguniang Bayan adopts policy; and barangay governments validate sites and sustain stewardship, with national agencies, academe, and civil society providing technical assistance and co-financing. Potential financing sources include regular LGU appropriations, eligible disaster-risk-reduction expenditures, national programs, grants, climate-finance facilities, and private-sector compliance, but these remain financing options rather than secured mechanisms, and funding availability does not substitute for the prior risk, ecological, equity, and feasibility tests.

Every priority project should identify affected stakeholders and rights-holders, document accessible participation, assess livelihood, access, tenure, and benefit-distribution effects, disclose criteria and decisions, and establish an agreed, accessible grievance mechanism before enforcement of easements, setbacks, or protection rules proceeds, consistent with applicable law, due process, and coordinated housing and social-protection measures where required. Monitoring should assess both implementation outputs and outcomes for people and nature across risk/hydrology, coastal/ecological condition, water quality/security, land-use/regulatory performance, public realm/access, equity/participation, investment/institutionalization, biodiversity/ecosystem integrity, economic/financial viability, governance/safeguards, and assumptions/adaptive-management domains, phased across an immediate 0–12-month stage (technical working group, data reconciliation, site validation, pilot PPAs), a Years 1–3 stage (policy adoption, Local Urban Design Guide, pilot implementation, baselines), a Years 4–6 stage (scaling, institutionalized compliance, integrated monitoring), and a Year 7-onward stage aligned with the next CLUP cycle (performance review, updated overlays, secured long-term financing).

Municipal NbS priority agenda

The analysis converges on a ten-point municipal agenda: establishing a connected Coastal Green-Blue Buffer System; adopting water-sensitive tourism-development standards for the Malinao-Santa Cruz corridor; rehabilitating rivers, creeks, and flood-prone drainage through a municipal SuDS and waterway program; protecting the Consuelo-Corazon-Malinao watershed system; developing green streets and permeable public spaces in Catangnan and the Poblacion barangays; establishing evacuation-compatible ecological open spaces; applying low-impact-development and geotechnical-review requirements in liquefaction- and karst-sensitive areas; implementing island-specific rainwater and open-space resilience measures; integrating the priority packages into the CLUP, ZO, Local Urban Design Guide, LDIP, AIP, PPAs, institutional responsibilities, and monitoring system; and applying the IUCN Second-Edition integrity screen throughout project preparation, closing each indicator-specific evidence gap, and using the official Self-Assessment Tool only once the required evidence exists.

CONCLUSION

Eight conclusions follow from this study. First, General Luna requires a multi-hazard rather than single-hazard planning approach, with barangay-level priorities indicated by documentary recurrence together with source-described coastal, tourism, settlement, and upstream-downstream contexts, subject to subsequent GIS and field validation. Second, NbS is a suitable planning response where an intervention has a demonstrated functional relationship to the hazard and is compatible with local ecology and land use; it is strongest for flooding, runoff, erosion, coastal degradation, water-quality pressure, heat, and long-term coastal adaptation, and complementary rather than sufficient for tsunami, liquefaction, and karst subsidence. Third, ecological assets become effective NbS only when their function is protected, restored, connected, maintained, and incorporated into development control — they should be treated as components of municipal resilience infrastructure rather than residual land. Fourth, the coastal mangrove-beach forest buffer and shoreline setback system is the leading municipal priority, followed by tourism-corridor green streets and permeable public realm and riparian-waterway rehabilitation with SuDS. Fifth, risk reduction in General Luna requires a hybrid approach coordinating NbS with conventional drainage, wastewater treatment, geotechnical investigation, evacuation systems, and infrastructure maintenance; representing NbS as a substitute for these measures would overstate its capacity. Sixth, social equity is a substantive criterion of NbS suitability, not an afterthought: an intervention that reduces physical risk while restricting customary access or displacing vulnerable households cannot be considered fully suitable without safeguards. Seventh, CDRA-guided prioritization is most useful when linked to formal planning and implementation instruments, for which the proposed eight-stage framework provides a defensible pathway from evidence to CLUP policy, zoning and design standards, investment programming, institutional responsibility, and adaptive review. Eighth, the local MCA rankings and IUCN integrity status must remain analytically separate: the rankings are defensible as conditional planning priorities but do not themselves establish high-integrity NbS or conformity with the IUCN Standard, which requires indicator-specific evidence generated through stakeholder participation, ecological and economic assessment, financing, implementation, monitoring, and corrective action.

The Municipality of General Luna should adopt a phased CDRA-to-NbS process beginning with data reconciliation and site validation and proceeding through policy, regulatory, investment, and institutional measures: recognizing green-blue infrastructure in the CLUP and CDRA; developing legally reviewed coastal, riparian, watershed, tourism, open-space, geologic-risk, and island overlay provisions in the Zoning Ordinance; preparing a Local Urban Design Guide; programming the eight priority packages into the LDIP, AIP, and PPAs with maintenance and monitoring budgets; constituting an interoffice NbS and Resilient Urban Design Technical Working Group; conducting technical validation (GIS, hydrological, ecological, geotechnical, ownership, and engineering review) before site-specific adoption; requiring water-sensitive design and public-access safeguards from tourism and private development through permits and standards; institutionalizing stakeholder mapping, inclusive consultation, and non-displacement safeguards; establishing monitoring baselines reviewed annually and at each CLUP/CDRA/LCCAP/LDRRMP update; and maintaining a 27-indicator IUCN evidence register, applying the official Self-Assessment Tool only when the required evidence has matured. Implementation should begin with the highest-risk and most institutionally ready actions — coastal buffer mapping, protection of existing mangroves and waterways, geologic-risk data validation, and tourism wastewater compliance — while restoration and construction proceed only after site-specific assessment and community consultation, and public funds should prioritize ecological function and exposure reduction over visibility alone.

The study contributes to local planning practice by providing General Luna a structured method for interpreting its CLUP/CDRA as an intervention-selection and investment-prioritization tool; methodologically, by developing a transparent CDRA-to-NbS analytical sequence combining documentary hazard recurrence, ecological-asset assessment, hazard-NbS functional matching, a separate IUCN integrity screen, weighted local suitability scoring, and bounded weight-sensitivity analysis that exposes its own bases, assumptions, and limits; to Philippine NbS policy application, by operationalizing the DHSUD resilient urban design guidance in a coastal-tourism municipality and contributing a stage-sensitive IUCN Second-Edition crosswalk that does not treat missing implementation evidence as conformity; and to transferability, since the framework may be adapted — with local recalibration of hazards, ecosystems, land use, institutions, and community priorities — by similarly situated coastal tourism municipalities possessing CLUP/CDRA and sectoral data.

The study's limitations are stage-specific rather than incidental. It relies on the available CLUP/CDRA, Sectoral Studies, and DHSUD Guidelines, some of whose internal tables contain reconciled or qualified inconsistencies; it is planning-level and does not conduct hydrodynamic, hydraulic, geotechnical, or structural analysis, nor a complete ecological field inventory; its local MCA contains researcher judgment within a compensatory additive structure whose five weight scenarios test only selected weight uncertainty and not rating, data, criterion-dependence, or model-form uncertainty; and in the IUCN crosswalk, only 3 of 27 indicators are documented at planning-framework level, 13 are partially evidenced, 8 are not evidenced in the current record, and 3 are not yet assessable before implementation, so formal adoption requires stakeholder deliberation, ecological baselines, alternatives-based economic appraisal, agreed grievance and safeguard procedures, site validation, and project-level analysis that this documentary, single-case design cannot itself supply.

Future research should pursue a fully georeferenced multi-hazard and NbS suitability model using validated LGU and national-agency shapefiles; ecological field research on mangrove hydrology, beach-forest suitability, riparian vegetation, and coral/seagrass condition; hydrological and coastal studies quantifying intervention performance under relevant rainfall, storm-surge, and sea-level-rise scenarios; economic research comparing life-cycle costs and financing arrangements for gray, green, and hybrid alternatives; social research on community preferences, tenure, and willingness to participate in stewardship; legal and institutional research testing the proposed overlays against national laws, protected-area regulations, and local legislative authority; and longitudinal research evaluating implemented NbS against ecological, hydrological, social, economic, and regulatory indicators, testing project assumptions, and applying the current IUCN Self-Assessment Tool only once the required implementation evidence exists.

General Luna's resilience depends on managing tourism growth, settlements, infrastructure, ecosystems, and hazard exposure as one interconnected planning system. The municipality already possesses substantial risk and planning evidence; the critical requirement is to convert that evidence into spatial priorities, enforceable policies, appropriate designs, programmed investments, capable institutions, community safeguards, and measurable outcomes. Nature-based Solutions can contribute materially to this task when they are guided by CDRA evidence, matched with ecological and land-use conditions, compared transparently through local multi-hazard and equity criteria, screened against the non-compensatory integrity requirements of the IUCN Global Standard, combined with necessary conventional measures, and mainstreamed into the instruments through which local development is regulated and funded. Only with stakeholder participation, biodiversity and social baselines, economic and financial justification, safeguards, monitoring, and corrective action can the proposed packages progress from planning priorities toward demonstrably high-integrity NbS.

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