Carbon stock mapping and strategic analysis of Low-Carbon Development initiatives in North Konawe Regency, Indonesia

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Abstract. This study examines the implementation and challenges of Low-Carbon Development (LCD) initiatives in North Konawe Regency, Southeast Sulawesi, during the period 2019-2024. Integrating geospatial carbon stock mapping with SWOT and PESTLE analyses, the research evaluates land-use change and its implications for carbon sequestration capacity. Using Geographic Information System (GIS) tools and IPCC (2006) emission factors, carbon stock was quantified across multiple land-use categories. Results indicate a 13% increase in total carbon stock from 224.7 million tons CO_2 in 2019 to 254.4 million tons CO_2 in 2024, mainly driven by the expansion of tropical forests, which contribute over 94% of total carbon storage. Conversely, mangrove ecosystems experienced a critical decline of 80%, resulting in a carbon loss of 236,000 tons CO_2. SWOT analysis revealed significant strengths, including extensive forest cover and strong national policy support, while PESTLE analysis highlighted external challenges such as weak environmental enforcement, socioeconomic pressure, and limited regional financing. The integrated analytical framework underscores the need for a multi-stakeholder, ecosystem-based approach combining forest conservation, mangrove restoration, and sustainable land management to strengthen regional carbon resilience. These findings provide strategic insights for policymakers to design effective and sustainable mitigation programs aligned with Indonesia's national and global climate targets.

1 Introduction

Climate change is widely recognised as one of the most pressing global challenges of recent decades, with far-reaching implications for ecosystem integrity, human health, and socio-economic stability. The rising atmospheric concentration of greenhouse gases, particularly carbon dioxide (CO_2), continues to intensify climate risks and compound pressures on natural and human systems [1]. Among the major drivers of emissions, land-use change including deforestation and ecosystem conversion plays a critical role because it releases stored carbon while simultaneously reducing long-term sequestration capacity [2]. These dynamics contribute to biodiversity loss, habitat degradation, and greater vulnerability to climate

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extremes, including drought-related ecological instability and disruptions that can propagate through socio-ecological networks [3, 4].

In response, global climate governance has expanded through international agreements and the growing involvement of multiple actors beyond national governments. However, persistent gaps remain between stated commitments and the pace of implementation, reflecting constraints in governance coherence, coordination across sectors, and the ability to translate broad commitments into effective action on the ground [5, 6]. This implementation gap reinforces the need for mitigation strategies that are both scientifically robust and operationally feasible at multiple scales. Integrated land-based approaches particularly those centred on protecting and enhancing carbon stocks while strengthening resilience in ecosystems and communities are increasingly positioned as essential components of credible climate action pathways [7, 8].

For countries with carbon-dense ecosystems, land-based mitigation offers especially high leverage [9]. In the Indonesian context, forest conservation and reforestation are frequently emphasised as scalable options that can support emission reduction objectives while delivering broader sustainability co-benefits [10]. Yet, progress is often shaped by subnational realities where competing land-use priorities, capacity limitations, and implementation constraints influence the effectiveness and durability of mitigation outcomes [11, 12]. This makes subnational analysis particularly important: mitigation success depends not only on national policy intent, but also on how strategies align with local land-use dynamics and governance conditions.

North Konawe Regency in Southeast Sulawesi is a relevant case for assessing Low-Carbon Development (LCD) because it combines extensive tropical forests, coastal ecosystems, and productive land uses. Tropical forests function as major carbon sinks, and evidence from tropical regions shows that regeneration and sustained protection can deliver substantial sequestration benefits at landscape scale [13]. Mangrove ecosystems, although spatially limited, are highly carbon-dense and support both climate mitigation and coastal resilience. However, mangroves are particularly vulnerable to conversion and degradation, often generating disproportionate carbon losses relative to their area [14, 15]. Identifying where carbon gains and losses occur is therefore critical for designing spatially targeted, ecosystem-specific LCD strategies rather than uniform interventions.

Geospatial technologies, particularly remote sensing, and Geographic Information Systems (GIS), provide a practical foundation for monitoring land-use change and estimating carbon stock distribution with spatial specificity. Global evidence demonstrates that remotely sensed data can detect patterns of ecosystem loss including human-driven mangrove decline thereby strengthening the empirical basis for prioritising interventions and improving accountability [14]. However, spatial carbon information alone is insufficient for policy design without a parallel understanding of governance feasibility, socio-economic pressures, and enabling conditions that shape land-use decisions and implementation performance [5, 6]. For this reason, combining spatial carbon assessment with structured strategic analysis can improve the operational relevance of carbon mapping and support decision-making that is both evidence-based and implementation-ready.

This study integrates GIS-based carbon stock mapping with strategic assessment to evaluate opportunities and challenges for LCD implementation in North Konawe Regency. The objectives are to: (1) quantify carbon stocks across major land-use categories through spatial analysis; (2) assess internal conditions that support or constrain LCD implementation; and (3) examine external contextual drivers that influence feasibility and sustainability of LCD actions. The novelty of this research lies in explicitly linking quantified carbon gains and losses to implementation-oriented strategic priorities, thereby strengthening the policy usefulness of spatial carbon evidence, and offering a transferable framework for ecosystem-based Low-Carbon Development (LCD) planning in other tropical regions.

2 Research method

2.1 Research design and analytical framework

This study applies an integrated analytical approach that combines quantitative GIS-based carbon stock assessment with qualitative strategic analysis (SWOT-PESTLE) to examine the implementation conditions of Low-Carbon Development (LCD) in North Konawe Regency. The methodological framework combines: (1) GIS-based carbon stock mapping in ArcGIS 10.8 using Landsat 8 OLI/TIRS and Landsat 9 OLI-2 imagery (30 m resolution) to quantify spatial–temporal changes in land-based carbon storage between 2019 and 2024; and (2) SWOT and PESTLE analyses to assess internal capacities and external contextual drivers shaping LCD implementation. The integration of these components was intended to translate spatial carbon evidence into implementation-relevant strategic priorities. The overall analytical workflow is presented in Figure 1.

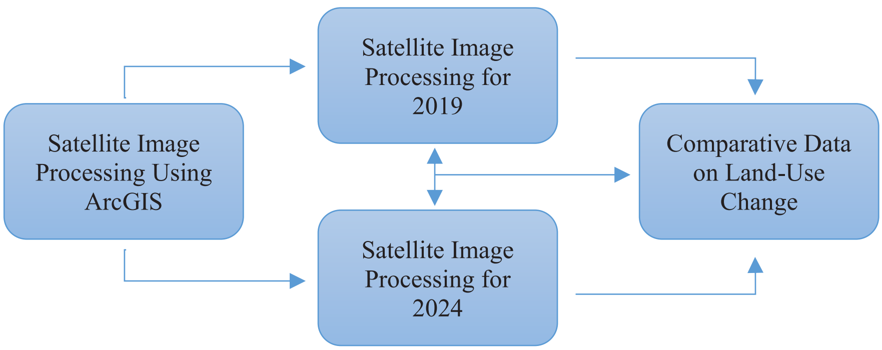


Fig. 1. Workflow of land-use data processing and carbon stock assessment for Low-Carbon Development analysis

2.2 Carbon stock mapping

Carbon stock mapping was conducted using GIS-based spatial analysis in ArcGIS 10.8. Land-use data for 2019 and 2024 were derived from satellite imagery and classified into major categories relevant to regional carbon dynamics, including tropical forest, mangrove forest, plantation/agriculture, shrub/grassland, settlement/built-up areas, and other land-use types. Carbon stock estimation followed an area-based calculation:

$$CS_i\,(t\,CO_2) = A_i\,(ha) \times EF_i\,(t\,CO_2\,ha^{-1}) \quad (1)$$

where CS_i denotes the carbon stock of land-use category i, A_i represents the land area in hectares, and EF_i refers to the carbon stock coefficient per hectare.

The spatial outputs enable comparison of carbon stock distribution between 2019 and 2024 and support identification of high-carbon ecosystems and areas experiencing significant carbon loss.

2.3 SWOT analysis

SWOT analysis was applied to identify internal strengths and weaknesses, and external opportunities and threats affecting LCD implementation. Strengths and weaknesses were derived from regional ecological characteristics, land-use structure, institutional arrangements, and existing low-carbon initiatives, supported by results from spatial analysis, regional planning documents, and stakeholder inputs. Opportunities and threats were assessed by examining policy directions, potential climate finance mechanisms, and socio-economic pressures associated with land-use change. The SWOT findings were then explicitly linked to prioritized strategic actions, namely strengthening forest protection in high-carbon areas, accelerating mangrove restoration in vulnerable coastal zones, improving monitoring-based land-use governance, and reinforcing institutional capacity for LCD implementation.

2.4 PESTLE analysis

To complement the SWOT assessment, a PESTLE framework was used to evaluate external contextual factors shaping LCD effectiveness and sustainability. The analysis covered: (1) Political factors (policy alignment and governance coherence), (2) Economic factors (financing access, market incentives, and budget constraints), (3) Social factors (public awareness, livelihood dependence, and participation), (4) Technological factors (availability and use of GIS/remote sensing for monitoring), (5) Legal factors (regulatory framework and enforcement capacity), and (6) Environmental factors (ecosystem vulnerability, carbon potential, and climate-related hazards). This approach provides a structured basis for assessing enabling conditions and constraints beyond the direct control of local implementing agencies.

2.5 Data sources and validation

Primary data were obtained through field surveys, stakeholder consultations, and interpretation of remote sensing imagery. Secondary data were collected from regional land-use plans, national climate policy documents, and peer-reviewed scientific literature. Land-use classification results and carbon coefficients were cross-validated to enhance the reliability and consistency of carbon stock estimates.

2.6 Analytical procedure and SWOT-PESTLE integration

Analysis proceeded in three stages. First, spatial analysis was used to map land-use change and carbon stock distribution for 2019 and 2024. Second, SWOT and PESTLE analyses were conducted to identify internal capacities, external drivers, and implementation constraints affecting LCD performance. Third, both outputs were integrated analytically to link quantified carbon trends with prioritized strategic actions, particularly forest protection in high-carbon areas, mangrove restoration in vulnerable coastal zones, strengthened land-use governance, and improved technical and financing readiness. The conceptualintegration applied in this study is shown in Figure 2.

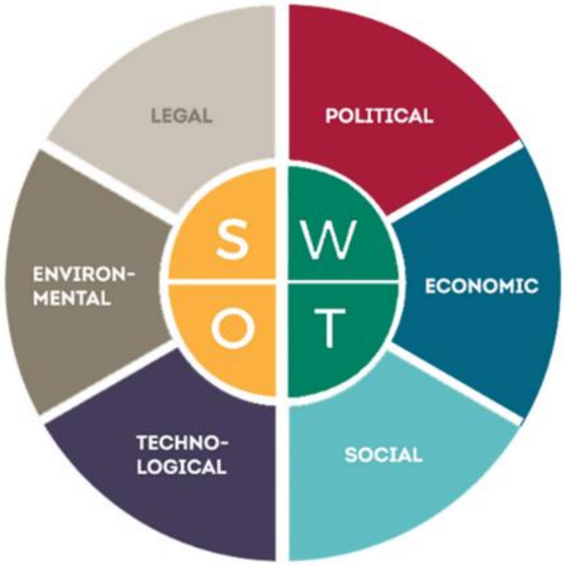


Fig. 2. Integrated SWOT-PESTLE analytical framework for Low-Carbon Development implementation

3 Results

3.1 Carbon stock distribution and dynamics in North Konawe Regency

3.1.1 Changes in total carbon stock

The analysis indicates an estimated net increase of approximately 13% in total carbon stock, rising from 224.7 million tons CO_2 in 2019 to 254.4 million tons CO_2 in 2024. This trend suggests an improvement in land-based mitigation outcomes in North Konawe Regency over the study period, largely reflecting the dominance and expansion of forested landscapes. However, these values should be interpreted as spatially derived estimates rather than exact absolute measurements, as they depend on land-use classification results and IPCC-based carbon coefficients, which may introduce uncertainty related to image interpretation, class boundaries, and generalized emission factors. Despite these limitations, the direction of change remains analytically meaningful and indicates that tropical forests continue to function as the principal carbon asset in the regency. Evidence from tropical contexts further suggests that forest protection and regeneration can deliver substantial sequestration benefits when maintained consistently over time[13]. In this sense, North Konawe's trajectory reinforces the strategic role of forest-dominated regions as core mitigation assets within subnational Low-Carbon Development (LCD) pathways. Carbon stock distribution by land-use category

Carbon storage is highly uneven across land-use types, with natural forest ecosystems accounting for most of the total stock. Table 1 presents the distribution of carbon stocks and land-use areas for 2019 and 2024.

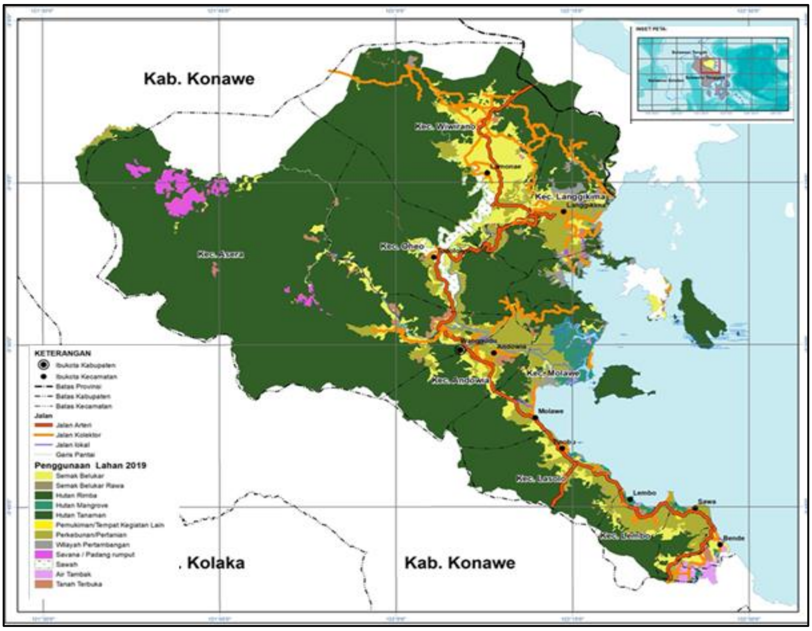
Table 1. Carbon stock distribution by land-use type in North Konawe Regency

Land-use type	Area 2019 (ha)	Carbon stock 2019 (tons CO_2)	Area 2024 (ha)	Carbon stock 2024 (tons CO_2)
Tropical forest	295,416.38	211,848,403.59	336,432.70	241,261,944.96
Mangrove forest	470.02	293,245.48	91.16	56,874.72
Plantation/agriculture	37,477.59	8,665,193.58	45,032.40	10,411,941.20
Shrub/grassland	33,492.45	3,687,518.75	23,227.94	2,557,396.19
Paddy field	5,375.24	39,454.26	1,132.53	8,312.77
Bare land	5,722.35	52,502.56	966.37	8,866.44
Savanna/grass savanna	4,621.75	76,328.20	8.71	143.85
Swamp shrub	61.07	6,723.81	0.00	0.00
Settlement/built-up area	1,277.60	23,443.96	2,491.31	45,715.54
Mining area	4,586.41	0.00	7,168.66	0.00
Aquaculture ponds	2,158.82	0.00	1,613.60	0.00
Swamp water	0.00	0.00	706.93	4,202.98
Lake/reservoir	0.00	0.00	39.76	0.00
Fishponds	0.00	0.00	108.94	0.00
River	0.00	0.00	2,484.70	0.00
Port	0.00	0.00	12.18	0.00
Inland sand dunes	0.00	0.00	137.47	0.00
Coastal sand dunes	0.00	0.00	123.21	0.00
Total	**390,679.38**	**224,697,441.33**	**421,778.57**	**254,355,398.66**

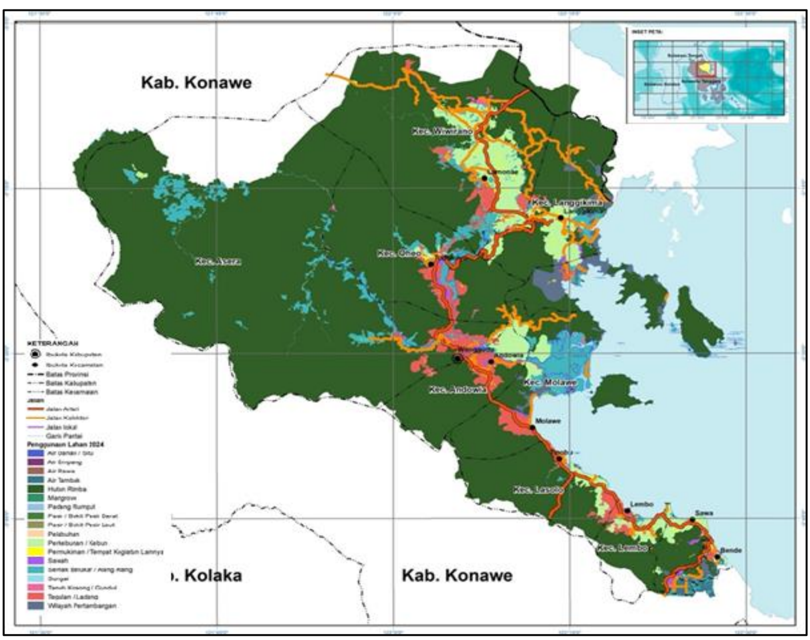
As shown in Table 1, carbon storage in North Konawe Regency is overwhelmingly dominated by tropical forests, which contributed more than 94% of total stocks in both 2019 and 2024. Forest expansion added approximately 29.4 million tons CO_2, reinforcing forests as the primary regional carbon sink. In contrast, mangrove area declined by around 80%, resulting in a loss of 236,370 tons CO_2 and indicating a critical vulnerability in coastal carbon retention, while plantation and agricultural lands exhibited only modest carbon gains.

3.1.2 Spatial patterns of carbon stock distribution

Spatial mapping indicates a clear inland–coastal contrast: carbon stocks are concentrated in inland areas dominated by tropical forest, whereas coastal zones show stronger carbon depletion associated with mangrove loss.



(A). Carbon stock map of North Konawe Regency in 2019



(B). Carbon stock map of North Konawe Regency in 2024

Fig. 3. Spatial distribution of carbon stocks in North Konawe Regency, 2019 and 2024

3.2 SWOT analysis of low-carbon development implementation

The SWOT analysis translates spatial carbon evidence into implementation-relevant factors by identifying internal strengths and weaknesses as well as external opportunities and threats that shape LCD performance in North Konawe Regency.

3.2.1 Strengths

North Konawe's strengths are primarily anchored in its ecological carbon base and monitoring capability. The dominance of tropical forest carbon stocks provides a strong mitigation foundation, while GIS and remote sensing support systematic monitoring of land-use dynamics, which is important for planning and accountability.

Table 2. Key strengths supporting Low-Carbon Development in North Konawe Regency

Strength aspect	Description	References
High carbon sequestration potential	Extensive tropical forests contributing ~94% of total regional carbon stock	[13]
Geospatial monitoring capacity	GIS/remote sensing enables mapping of land-use change and carbon stock distribution	[14]
Institutional environment for mitigation	Multi-actor climate governance trends support broader engagement and implementation pathways	[5]

3.2.2 Weaknesses

The major weakness is severe mangrove degradation, which reduces blue-carbon stocks and weakens coastal resilience. Additional constraints include limited local capacity to sustain large-scale mitigation interventions and difficulties translating broad climate ambition into consistent on-the-ground implementation.

Table 3. Key weaknesses constraining Low-Carbon Development implementation

Weakness aspect	Description	References
Mangrove ecosystem degradation	~80% decline in mangrove area, causing disproportionate carbon loss	[14, 15]
Implementation capacity constraints	Challenges in converting commitments into durable implementation at subnational level	[6]

3.2.3 Opportunities

External momentum for climate action creates opportunities to strengthen ecosystem-based mitigation, particularly through forest protection and coastal restoration. Broader engagement by non-state actors can also support implementation through partnerships, financing facilitation, and program delivery.

Table 4. Key opportunities for enhancing Low-Carbon Development

Opportunity aspect	Description	References
Ecosystem-based mitigation agenda	Increasing emphasis on land-based pathways for mitigation and resilience	[7,8]
Multi-actor engagement	Non-state action and partnerships can expand delivery capacity	[5]

3.2.4 Threats

LCD implementation faces threats from continuing land-use pressures and climate-related risks. Climate extremes can destabilise ecosystems and amplify ecological stress, while drought-related instability can propagate through socio-ecological networks.

Table 5. Key threats to Low-Carbon Development implementation

Threat aspect	Description	References
Climate-related ecological stress	Increasing exposure to extreme events and ecological disruptions	[3, 4]
Governance-implementation gap	Persistent gaps between commitments and implementation undermine durability	[6]

Overall, SWOT results suggest that North Konawe has strong mitigation potential due to its forest carbon assets and monitoring capability, but coastal mangrove loss and implementation capacity constraints pose significant risks. These findings provide a basis for the PESTLE analysis by clarifying the external context that can enable or hinder action.

3.3 PESTLE analysis

The PESTLE analysis assesses external political, economic, social, technological, legal, and environmental factors that influence the effectiveness, scalability, and sustainability of LCD implementation, complementing the internal focus of the SWOT analysis.

Table 6. PESTLE analysis of external factors influencing Low-Carbon Development in North Konawe Regency

Dimension	Key aspect	Description	References
Political	National climate commitment	Indonesia's emission reduction targets under international climate governance provide a strong policy mandate for subnational LCD action.	[6, 9]
	Policy coherence	Alignment between climate commitments and development planning supports vertical policy integration, although implementation gaps remain.	[5, 6]
Economic	Climate finance access	Land-based mitigation and ecosystem protection offer entry points for climate finance and results-based mechanisms.	[7, 8]
	Ecosystem-based value	Forest conservation and reforestation can generate mitigation benefits alongside development co-benefits.	[10]
Social	Public awareness and participation	Limited climate literacy and uneven engagement constrain community participation in mitigation initiatives.	[3, 4]
Technological	Geospatial monitoring capacity	Remote sensing and GIS enable spatially explicit monitoring of land-use change and carbon stocks.	[14]
Environmental	Ecosystem vulnerability	Mangrove and coastal ecosystems face high vulnerability, where small-area losses lead to large carbon impacts.	[14, 15]
Legal	Governance and enforcement	Climate governance frameworks exist, but weak enforcement can undermine land-use control and mitigation durability.	[5, 6]

Overall, the PESTLE analysis shows that LCD implementation in North Konawe Regency benefits from political commitment and geospatial capacity but is constrained by economic limitations, weak public engagement, governance gaps, and high ecosystem vulnerability, particularly in mangrove areas, underscoring the need for stronger governance coherence and ecosystem-specific prioritisation.

3.4 Integrated SWOT–PESTLE analysis and policy implications

Integrating SWOT and PESTLE analyses provides a comprehensive framework for linking internal capacities with external contextual drivers shaping LCD implementation. While SWOT captures ecological, institutional, and technical strengths and weaknesses, PESTLE situates these factors within broader political, economic, social, technological, legal, and environmental conditions. In North Konawe Regency, the integrated SWOT–PESTLE matrix (Table 7) aligns carbon stock evidence with governance and development contexts, enabling the identification of strategic leverage points and critical constraints that inform targeted policy responses.

Table 7. Integrated SWOT-PESTLE analysis for Low-Carbon Development in North Konawe Regency

Dimension	Internal factors	Impact	External factors	Impact
Political	Alignment with national LCD and climate commitments	+	Strong national policy mandate and international climate targets	+
	Weak local enforcement capacity	–	Limited consistency in translating national policies to local implementation	–
Economic	High-value Forest and mangrove carbon assets	+	Access to international climate finance and carbon markets	+
	Limited regional budget and financial readiness	–	Economic pressures from land-based development	–
Social	Potential for community-based conservation initiatives	+	Growing awareness of climate risks	+
	Dependence on land-based livelihoods	–	Inequitable distribution of LCD benefits	–
Technological	Availability of GIS-based carbon mapping	+	Advancing global monitoring technologies	+
	Limited technical expertise at local level	–	High cost of advanced technology adoption	–
Legal	Existence of national regulatory frameworks (e.g. RAN-GRK)	+	International pressure for regulatory compliance	+
	Weak enforcement of land-use regulations	–	Limited capacity for regulatory adaptation	–
Environmental	Extensive tropical forest carbon stock	+	Global emphasis on ecosystem restoration	+
	Severe mangrove degradation	–	Increasing climate-related hazards	–

The integrated SWOT–PESTLE analysis shows that North Konawe Regency has strong potential for Low-Carbon Development, supported by extensive forest carbon stocks and alignment with national climate commitments. These strengths are reinforced by external political momentum for ecosystem-based mitigation. However, weak land-use enforcement and socio-economic pressures, especially in coastal zones, have driven significant mangrove degradation and blue-carbon losses. Despite opportunities for climate finance and community-based initiatives, limited institutional capacity and monitoring readiness constrain implementation. Overall, effective LCD requires prioritising forest protection, accelerating mangrove restoration, strengthening governance, and improving data integration, as reflected in the conceptual framework in Figure 4.

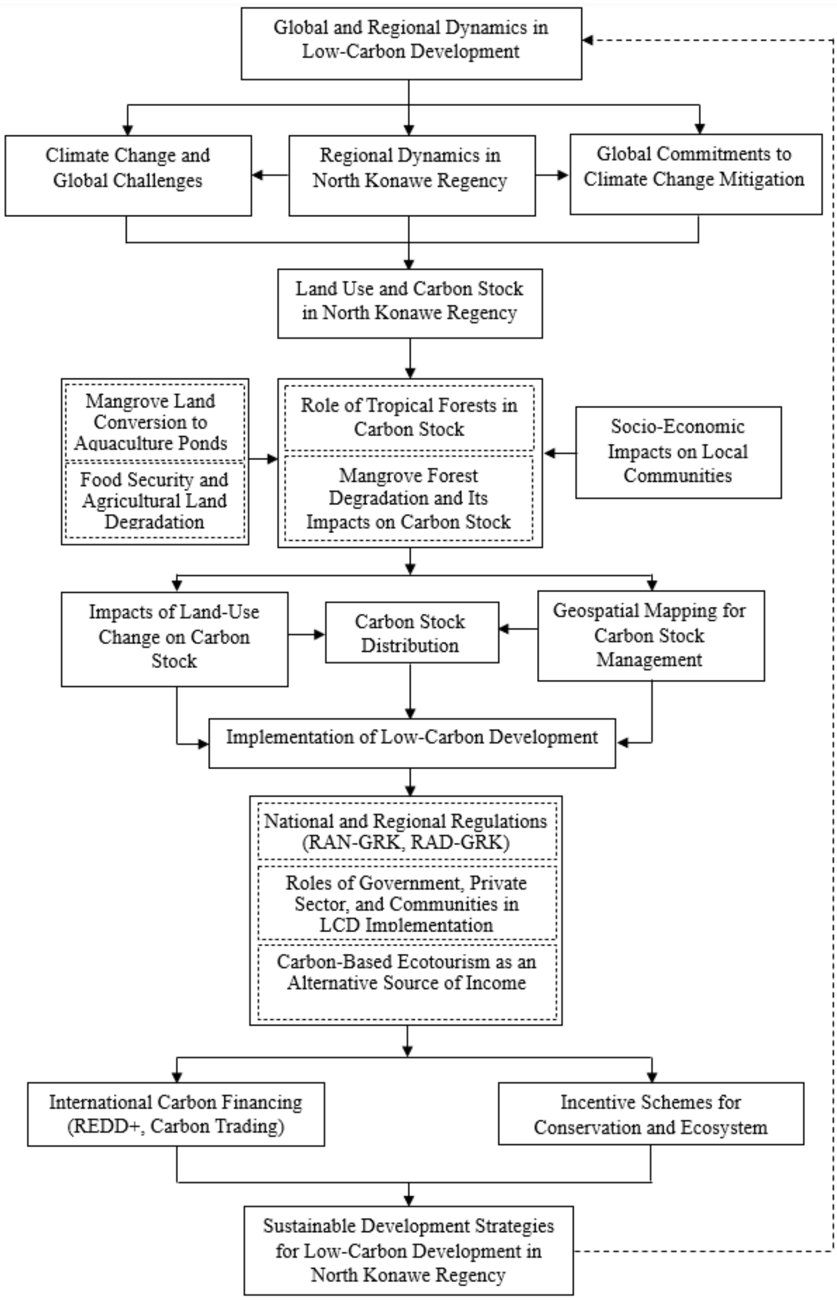


Fig. 4. Conceptual policy framework for sustainable Low-Carbon Development and carbon stock management in North Konawe Regency

4 Discussion

This study demonstrates the value of an integrated, ecosystem-based approach to Low-Carbon Development (LCD) at the subnational level by linking spatial carbon stock evidence with strategic governance assessment. The results show that North Konawe Regency experienced a net increase in carbon stocks between 2019 and 2024, mainly associated with the expansion of tropical forest cover. This pattern supports evidence that forest protection and regeneration can deliver substantial sequestration benefits at landscape scale when maintained over time [13].

The dominance of tropical forests accounting for more than 94% of total regional carbon stocks confirms that forest-based mitigation remains the backbone of LCD strategies in forest-rich tropical regions. In this context, the observed increase in forest area indicates that land-based interventions can translate into measurable carbon gains, reinforcing the role of forests as high-leverage mitigation assets for climate action pathways [13].

However, the results also reveal an imbalance in the regional mitigation trajectory. While terrestrial forest carbon stocks increased, mangrove ecosystems declined sharply, producing a substantial loss of blue carbon. This contrast is policy-relevant because mangroves are among the most carbon-dense ecosystems, especially due to their large belowground carbon pools and sediment storage [15]. The scale of loss is consistent with global evidence of human-driven mangrove decline, which often produces disproportionate carbon impacts relative to the small spatial extent of mangrove ecosystems [14]. These findings underscore that LCD strategies focused primarily on terrestrial forests risk overlooking high-impact coastal mitigation opportunities and vulnerabilities.

Carbon gains in plantation and agricultural land suggest incremental mitigation potential through improved land management, although the magnitude remains far lower than that of natural forest systems. In practical terms, this implies that sustainable agriculture should be framed as a complementary pathway that supports livelihoods and land productivity, rather than a substitute for conserving high-carbon ecosystems.

From a governance perspective, the integrated SWOT and PESTLE results help explain why carbon gains and losses occur unevenly across ecosystems. External enabling conditions such as expanding global climate governance and multi-actor climate action can support local implementation, yet persistent coordination and delivery gaps remain common, particularly where implementation capacity is limited [5, 6]. In North Konawe, these constraints are most visible in coastal zones, where mangrove conversion reflects interacting socio-economic pressures and weak land-use control. These pressures align with broader evidence that land-use change remains a critical emissions driver because it releases stored carbon while reducing sequestration capacity [2].

These findings further indicate that climate risks can amplify ecosystem vulnerability and undermine the durability of Low-Carbon Development outcomes. Ecological instability associated with drought and other climate extremes increases uncertainty in long-term carbon retention [3], while broader climate-change fingerprints observed across ecological records reinforce the need for adaptive and resilience-oriented mitigation planning [4]. Accordingly, LCD strategies should integrate mitigation objectives with ecosystem resilience, particularly in climate-sensitive coastal zones and forest-edge landscapes.

This study also demonstrates the policy value of spatially explicit carbon evidence. GIS-based carbon mapping enables intervention prioritisation based on carbon magnitude and vulnerability, while strategic frameworks support translation of spatial data into governance and financing decisions. Together, these approaches facilitate spatially differentiated LCD strategies that protect high-carbon forests, prioritise mangrove restoration, and strengthen local implementation capacity.

5 Conclusions and recommendations

5.1 Conclusions

This study integrates GIS-based carbon stock mapping with SWOT and PESTLE analyses to evaluate Low-Carbon Development (LCD) implementation in North Konawe Regency during 2019-2024. The results indicate a 13% increase in total carbon stock, from 224.7 million tons CO_2 in 2019 to 254.4 million tons CO_2 in 2024. This increase was primarily driven by the expansion of tropical forest cover, which consistently accounts for more than 94% of total regional carbon storage. The findings confirm that tropical forests remain the dominant mitigation asset in the regency and that land-based conservation measures can deliver measurable improvements in regional carbon sequestration.

At the same time, the study identifies a critical vulnerability in the regional mitigation pathway. Mangrove ecosystems declined by approximately 80% over the study period, resulting in a carbon loss of 236,370 tons CO_2. This contrast between inland forest gains and coastal blue-carbon losses highlights an uneven mitigation outcome across ecosystems and underscores the need to reposition mangrove protection and restoration as a strategic priority within LCD planning. The integrated strategic assessment further shows that while policy alignment and the availability of geospatial monitoring tools provide enabling conditions, LCD effectiveness remains constrained by weak land-use enforcement, limited local financing and technical capacity, and increasing exposure to climate-related risks.

5.2 Recommendations

To strengthen LCD implementation, North Konawe Regency should prioritise the protection of high-carbon forest ecosystems to maintain recent gains in carbon stocks, while simultaneously accelerating mangrove protection and restoration as a high-impact coastal mitigation and resilience strategy. These ecosystem priorities should be supported by strengthened regulatory enforcement and institutional capacity at the local level, particularly to manage land conversion pressures and improve compliance in ecologically sensitive areas. The regency should also enhance monitoring and reporting systems to improve programme credibility and facilitate access to climate finance mechanisms. Finally, LCD interventions should be designed to increase community participation and benefit-sharing, aligning conservation and restoration objectives with local livelihood needs to ensure long-term sustainability and social legitimacy of mitigation actions.

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