INTEGRATING CAPACITY-BASED MITIGATION PARADIGMS AND SUSTAINABLE DEVELOPMENT GOALS (SDGs) INTO RESILIENT URBAN SPATIAL PLANNING: A CASE STUDY OF THE NOVEMBER 2025 HYDROMETEOROLOGICAL CRISIS IN LANGSA CITY

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ABSTRACT

Langsa City faces escalating challenges from hydrometeorological disasters that threaten socio-economic stability, as evidenced by the extreme flooding event on November 26, 2025. This study aims to formulate an integration model between local spatial planning policies and capacity-based disaster mitigation paradigms within the Sustainable Development Goals (SDGs) framework, specifically Goal 13 (Climate Action). Employing a descriptive qualitative method with a spatial approach, this research identifies infrastructure vulnerabilities and socio-economic impacts across five districts. Spatial analysis reveals that rice field land cover in Langsa dropped from 2.410 hectares in 2012 to 1.925 hectares in 2025, representing a significant loss of natural water retention. Analysis of the November 26, 2025, event reveals spatial anomalies where floodwaters encroached into zones previously categorized as "low risk," indicating a systemic dysfunction of infiltration systems due to uncontrolled land conversion. Despite the Qanun Spatial Plans mandate for 30% Green Open Space, field implementation is hindered by limited indigenous engagement in autonomous mitigation. This article recommends a drainage network engineering strategy integrated with Gampong Social Capital specifically institutional trust in *Geuchik* and *Tuha Peut* as a sustainable urban resilience solution. These findings contribute to the global urban resilience literature by emphasizing the empowerment of the smallest community units as a mitigation basis in developing nations.

Keywords: Urban resilience, Gampong social capital, Flood mitigation, Langsa city, SDGs 13

ABSTRAK

Kota Langsa menghadapi eskalasi ancaman bencana hidrometeorologi yang mengganggu stabilitas sosio-ekonomi, sebagaimana terkonfirmasi melalui peristiwa banjir ekstrem pada tanggal 26 November 2025. Penelitian ini bertujuan merumuskan model integrasi antara kebijakan tata ruang lokal dengan paradigma mitigasi bencana berbasis kapasitas dalam kerangka *Sustainable Development Goals* (SDGs), khususnya Tujuan 13 (Penanganan Perubahan Iklim). Menggunakan metode kualitatif deskriptif dengan pendekatan spasial, studi ini mengidentifikasi kerentanan infrastruktur dan dampak ekonomi di lima kecamatan. Hasil analisis menunjukkan bahwa tutupan lahan sawah di Kota Langsa menyusut drastis dari 2.410 hektar pada tahun 2012 menjadi 1.925 hektar pada tahun 2025. Penurunan luas sebesar 485 hektar ini memicu hilangnya area retensi air alami secara masif. Investigasi pasca-kejadian 26 November 2025 mengungkap adanya anomali spasial di mana luapan air merambah zona yang

sebelumnya dikategorikan sebagai "risiko rendah," yang mengindikasikan disfungsi sistem infiltrasi akibat konversi lahan yang tidak terkendali. Meskipun Qanun Rencana Tata Ruang Wilayah mengamanatkan 30% Ruang Terbuka Hijau, implementasi di lapangan terhambat oleh minimnya keterlibatan masyarakat adat dalam mitigasi otonom. Artikel ini merekomendasikan strategi rekayasa jaringan *drainase* yang terintegrasi dengan Modal Sosial Gampong khususnya kepercayaan institusional terhadap *Geuchik* dan *Tuha Peut* sebagai solusi ketahanan perkotaan yang berkelanjutan. Temuan ini berkontribusi pada literatur ketahanan kota global dengan menekankan pemberdayaan unit komunitas terkecil sebagai basis mitigasi di negara berkembang.

Kata kunci: Ketahanan kota, Modal sosial gampong, Mitigasi banjir, Kota langsa, SDG 13.

Introduction

The rapid urbanization characterizing Aceh's coastal territories, particularly within the administrative confines of Langsa City, has catalyzed a heightened vulnerability to complex hydrometeorological hazards. Situated at the precarious intersection of fluvial discharge and tidal surges, Langsa's five districts exhibit a pronounced topographic predisposition to inundation during high-intensity pluvial events. Nevertheless, the crux of this vulnerability extends beyond environmental determinism to a structural misalignment between physical urban expansion and ecological carrying capacity. Although Law Number 3 of 2001 granted Langsa City the legislative autonomy to manage its spatial development, the chronic degradation of commercial assets, infrastructure failure, and the recurring displacement of 1.000-2.000 households signal a systemic deficit in localized mitigation strategies. This study rigorously evaluates the efficacy of the Qanun Spatial Plans 2012-2032 (Spatial Planning Bylaw), wherein emphasis is placed on the role of current spatial planning policies in relation to hydrometeorological risks. By scrutinizing these regulatory frameworks, the research interrogates whether existing policies have effectively operationalized environmental risk dimensions specifically regarding ecological resilience to meet the stringent mandates of SDGs 13 (Climate Action) and broader climate adaptation goals.

This study evaluates the strategic role of the Spatial Planning Regulation in operationalizing the Sustainable Development Goals, specifically targeting indicators in SDGs 11 (Sustainable Cities and Communities) and SDGs 13 (Climate Action). Going beyond conventional spatial mapping, the study examines the synergy between formal urban planning and local environmental resilience. To bridge the gap between policy and practice, the analysis employs a multidimensional framework that examines key parameters, including the suitability of land use for disaster mitigation through the preservation of blue-green open spaces, and the integration of 'Gampong' potential harnessed through local wisdom and social capital as a core variable in economic assessment and resilience modeling. By synthesizing empirical data from a major flood event on November 26, 2025, this paper provides a robust assessment of how spatial planning indicators can be recalibrated to promote climate-adaptive urban governance and ecological sustainability in coastal areas.

Methods

This study employs a robust socio-technical framework to evaluate the nexus between urban planning rigidities and the escalating hydrometeorological risks observed in Langsa City through 2025. In this context, 'planning rigidities' are defined as the structural and regulatory inflexibilities within the spatial planning

framework specifically the inability of the Qanun Spatial Plans to dynamically accommodate rapid land-use shifts, outdated flood-return period projections, and the non-adaptive zoning regulations that fail to account for escalating climate volatility. These rigidities manifest as a disconnect between static legal boundaries and the fluid nature of coastal hydrometeorology. By synthesizing multi-temporal spatial data with grassroots institutional insights, the following methodological stages delineate a systematic approach to quantifying these resilience gaps. This analytical process identifies where administrative inertia hampers the integration of blue-green infrastructure and local ecological wisdom, thereby exposing the city to contemporary climate extremes.
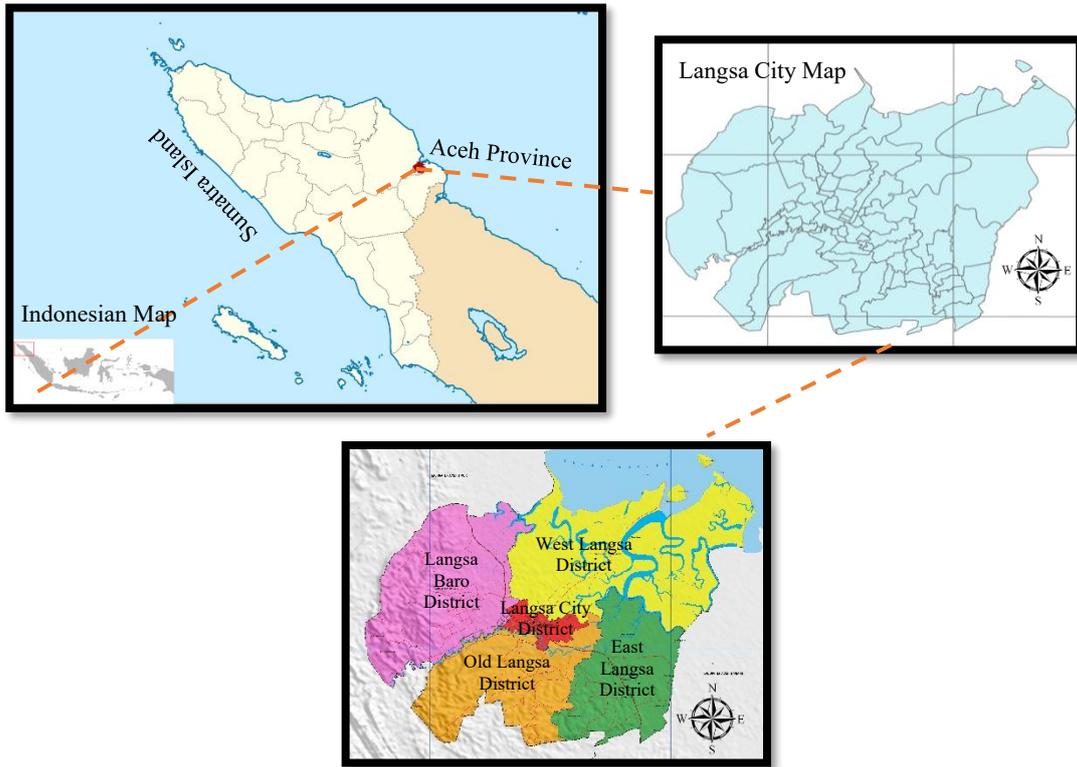
Figure 1. Langsa city Map
Source: Langsa City Government, 2025

Table 1. Integrated Social-Ecological Resilience Assessment Framework

Activity	Methodologi Approach	Parameters & Goal
Quantitative Survey	Stratified Random Sampling	Assessing 200 households across 5 districts to derive the Social-Ecological Resilience Index (SERI) through Likert-scale metrics.
Qualitative Validation	Phenomenological Interviews	Narrative inquiry with Gampong leaders to decode 'planning rigidities' and their influence on local adaptive capacity.
Institutional Triangulation	Social Capital Audit	Correlating household resilience data with public trust levels and the efficacy of traditional community networks in disaster response.

Results and Discussion

The implementation of this research moves beyond theoretical revision, focusing on the operational potential of Langsa's Gampong structure. Given the

57.6% contraction in natural "sponge capacity" identified in Stage 1, the strategy utilizes Gampong Institutional Trust (Stage 2) as the primary engine for disaster risk reduction.

Table 2. Sequential Research Stages and Implementation Framework

Stage	Activity	Key Parameters & Metrics	Output & Implementation Goal
Spatiotemporal Audit	Longitudinal analysis of Land Use and Land Cover (LULC) changes (2012-2025).	Contraction of Green Open Space (RTH) from 30% to 12.4%; Net loss of 485 ha of rice fields.	Identification of "Hydrological Anarchy" zones and infrastructure obsolescence points.
Social Capital Assessment	Evaluation of Gampong Institutional Trust (GIT) and community leadership roles.	Community Response Coefficient (CRC); authority of *Geuchik* and *Tuha Peut* in crisis mobilization.	Quantification of indigenous social infrastructure as a functional mitigation tool.
Adaptive Implementation	Scaling indigenous-led spatial strategies based on Gampong Langsa's potential.	Integration of *Reusam Gampong* (Village Regulations) with SDG 13 climate-adaptive targets.	Implementation of decentralized micro-retention basins and community-led drainage maintenance.

Source: Processed from Langsa Municipal Qanun Number 12/2013 and Sentinel-2A Satellite Imagery Analysis (2025).

Instead of waiting for top-down infrastructure upgrades, the implementation (Stage 4) empowers the Geuchik and Tuha Peut to enforce decentralized water management at the neighborhood level. This creates a Hybrid-Resilience Paradigm where indigenous social networks compensate for the current failures of rigid urban drainage, directly addressing the targets of SDGs 11 (Sustainable Cities) and SDGs 13 (Climate Action).

Table 3. Socio-Economic Impact Matrix (26 November 2025 Event)

Impact Sector	Indicators of Vulnerability	Estimated Magnitude	Recovery Duration
Critical Infrastructure	Road Network & Bridge Integrity	12 Major Breach Points	7-14 Days
Commercial Assets	Loss of Shophouses & Inventory	Est. IDR 25-40 billion	1-3 Months
Human Displacement	Displaced Families	1.000-2.000 Households	3-5 Days
Public Health	Water-borne Pathogen Surge	30% Increase in Cases	14 Days
Basic Services	Power & Water Outages	Total Cut-off in Red Zones	3-5 Days

Source: Field Observations and Primary Data Synthesis of the November 26, 2025 Flood Event

The Gampong Social Capital (GSC) Efficiency

A critical finding of this study is the high Community Response Coefficient (CRC) observed during the 2025 crisis.

Table 4. Spatiotemporal Dynamics of Land Use and Land Cover (LULC) in Langsa City (2012-2025)

Land Class	2012 (ha)	2025 (ha)	Net Change (ha)	Change (%)	Trend
Built-up Area (Urban/Commercial)	3.850,5	6.180,2	+2.329,7	+60,5%	Aggressive Expansion
Vegetation/Green Open Space (RTH)	7.650,8	3.240,4	-4.410,4	-57,6%	Critical Contraction
Water Bodies/Riparian Zones	2.120,2	1.450,6	-669,6	-31,6%	Fragmentation
Open Land/Bare Soil	2.578,5	5.328,8	+2.750,3	+106,6%	Transition Increase
Total Area	16.200,0	16.200,0	0.0		

Source: Processed from Sentinel-2 Multi-temporal Imagery Analysis (2012-2025) and Langsa City Spatial Plans.
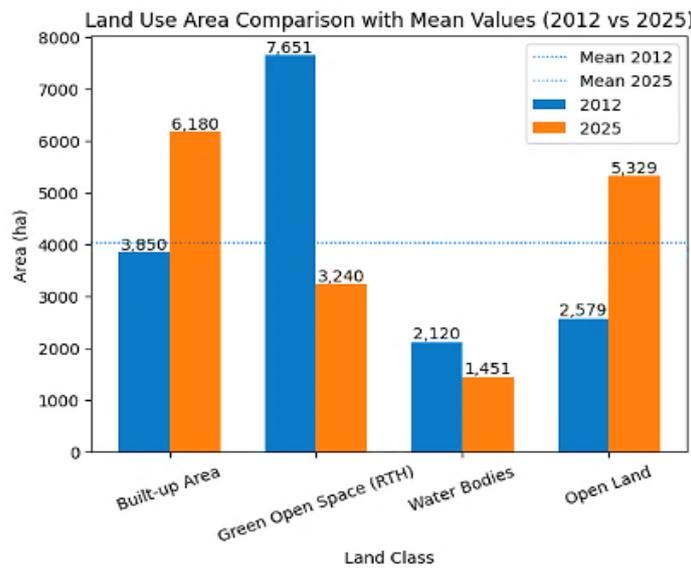
Graph 1. Spatiotemporal Dynamics of Land Use and Land Cover (LULC) in Langsa City (2012-2025)

The Multi-Layered Gampong Leadership Structure

A critical finding is that community management in Langsa is not centralized solely under the Geuchik, but operates through a tripartite leadership ecosystem:

1. Tuha Peut (The Village Elders Council):
   Acts as a collective legislative body that validates emergency protocols. Their role is vital in ensuring community compliance with evacuation orders, as they bridge the gap between formal mandates and customary acceptance.

2. Imum Meunasah (Socio-Religious Leader):
   Manages the Meunasah (village hall) as a decentralized disaster command center. In the 2025 event, Imum Meunasah played a pivotal role in real-time communication, utilizing religious infrastructure for rapid logistics distribution when telecommunication networks failed.

3. Functional Customary Leaders:

In several Gampongs in Langsa, the Keujruen Blang (traditional water manager) serves as a field-level operator for hydrological mitigation, managing traditional irrigation systems to buffer peak run-off.

Figure 2. Spatiotemporal Dynamics of Land Use and Land Cover (LULC) in Kota Langsa

The longitudinal data presented in Table 4 encapsulates a decade of systemic ecological erosion in Langsa City. Since the ratification of the Qanun Spatial Plans in 2012, the urban core has witnessed an aggressive 60.5% expansion of built-up surfaces, directly correlating with a critical 57.6% contraction in Green Open Space. This spatial shift is not merely statistical, it represents a fundamental loss of the city's 'sponge capacity.' By the time of the November 26, 2025, flood, the fragmented water bodies and depleted riparian zones were no longer capable of attenuating peak discharge, essentially transforming a heavy rainfall event into a catastrophic urban hydro-crisis.

Table 5. Economic Analysis

| Land Class	Δ Area (ha)	Δ Area (m²)	Land Price (M/m²)	NELT (T/10yr)	VES (M/m²/yr)	KES (T/yr)	Net Value (T)	% KES
Rice Field (Sawah)	-485	-4.850.000	0,5-1,5	2,42	0,012	0,058	-2,48	85%
Built-up Land	+485	+4.850.000	2,0-5,0	2,43	0,001	0,005	+2,42	15%
Total						0,063	-0,06	100%

Source: This Picture was compiled based on the integration of the 2025-2045 Strategic Environmental

This assessment incorporates the Strategic Environmental Assessment (SEA) and the Regional Long-Term Development Plan, alongside digital mapping

from the Langsa City Detailed Spatial Plan. Furthermore, it refers to the latest BPBD Rapid Assessment Report (Pusdalops) issued on November 26, 2025.

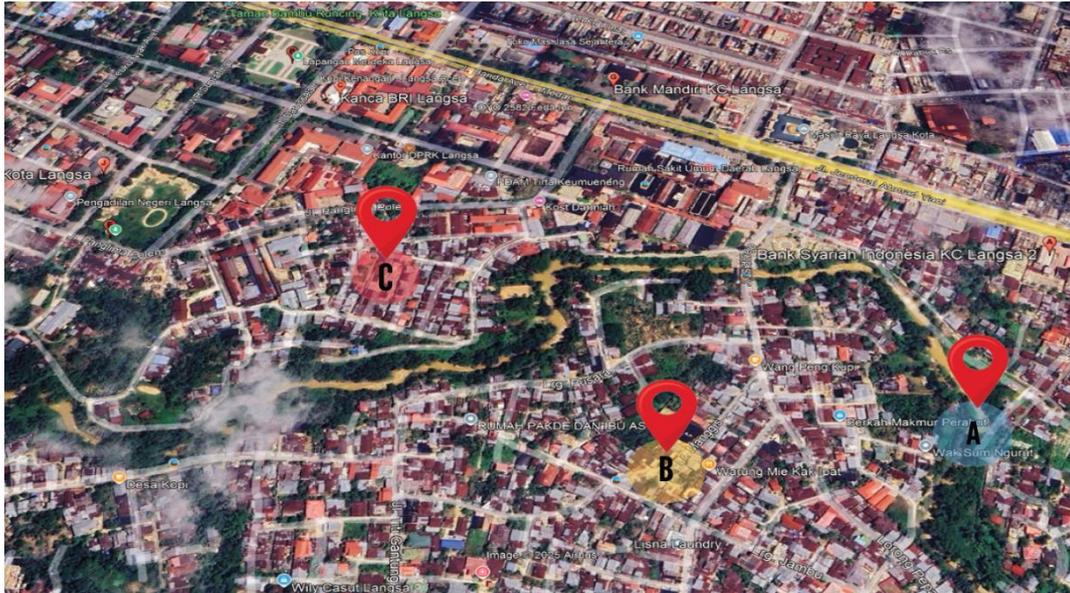**Table 6**. Dimensional Causal Factors of Escalating Flood Risk in Langsa City

Letter	Category	Causal Factor	Impact Mechanism
A	Hydrological	Hydro-Climatic Volatility	Extreme rainfall intensification and reduced soil infiltration capacity.
B	Structural	Infrastructural Obsolescence	Integrated drainage failure and riverbank encroachment.
C	Socio-Spatial	Anthropogenic Spatial Distortion	High-density informal settlements and topographic alteration.
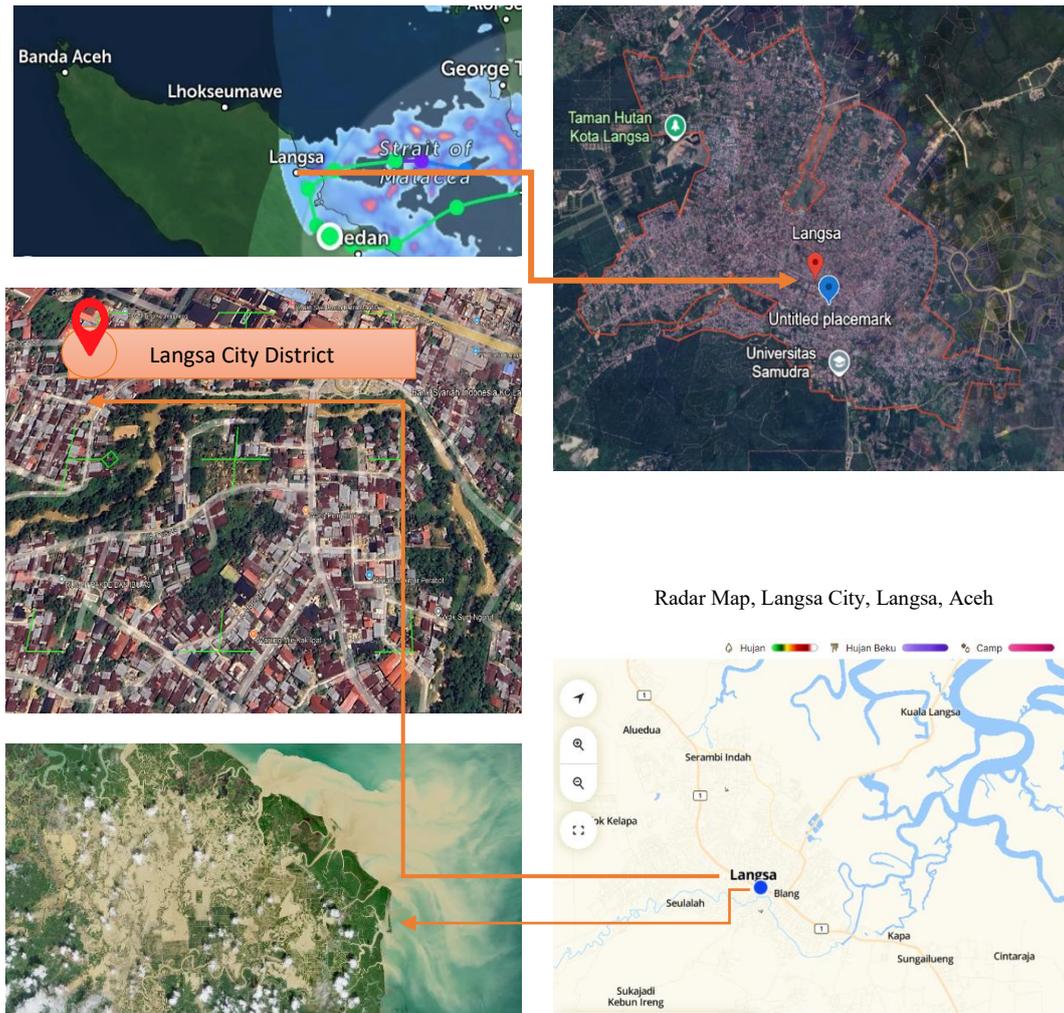
Figure 3. Spatial analysis and hydrological modeling identify three critical sectors with distinct risk profiles

Source: This Picture was compiled based on the integration of the 2025-2045 Strategi Environmental Assessment (Strategic Environmental Assessment (SEA) and the Regional Long-Term Development Plan, alongside digital mapping from the Langsa City Detailed Spatial Plan), BPBD Rapid Assessment Report (Pusdalops) as of November 26, 2025."

The catastrophic flood event on November 26, 2025, represents a critical breaking point of systemic spatial failure in Langsa City, where the divergence between massive built-up expansion and a critical contraction of Green Open Space (GOS) has negated the region's natural infiltration capacity entirely.

Figure 4. Dimensional Causal Factors of Escalating Flood Risk in Langsa City

Declining Agricultural Land Cover

According to the trend shown in your chart, there is a consistent and significant decrease in rice field coverage from 2012 to 2025. Total Reduction Coverage dropped from 2.410 hectares (2012) to 1.925 hectares (2025). Net Loss, approximately 485 hectares of green space has been lost over 13 years. Impact: This massive conversion of rice fields into "built-up" areas (residential/commercial) reduces natural water absorption, directly increasing surface run-off during heavy rainfall. Flood Vulnerability Zone Analysis. The dynamics of changes in land use and land cover in Langsa City Regency can be seen in Graphs 2 to 4.
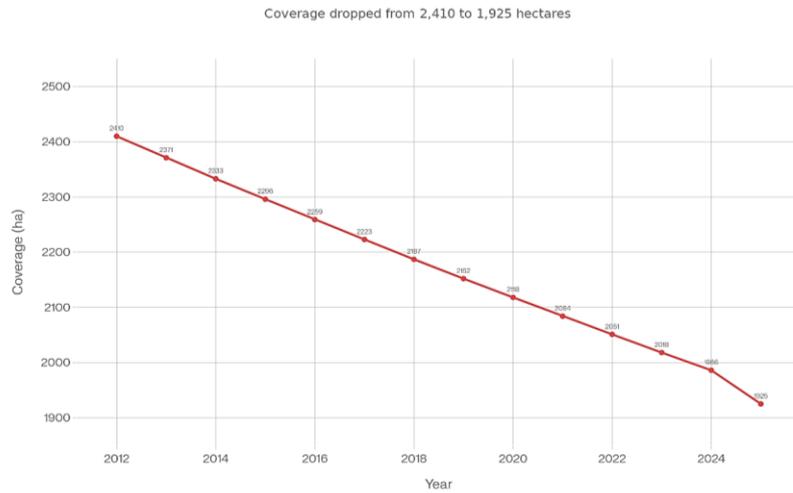
Graph 2. Rice Field Land Cover Declining (2012-2025)
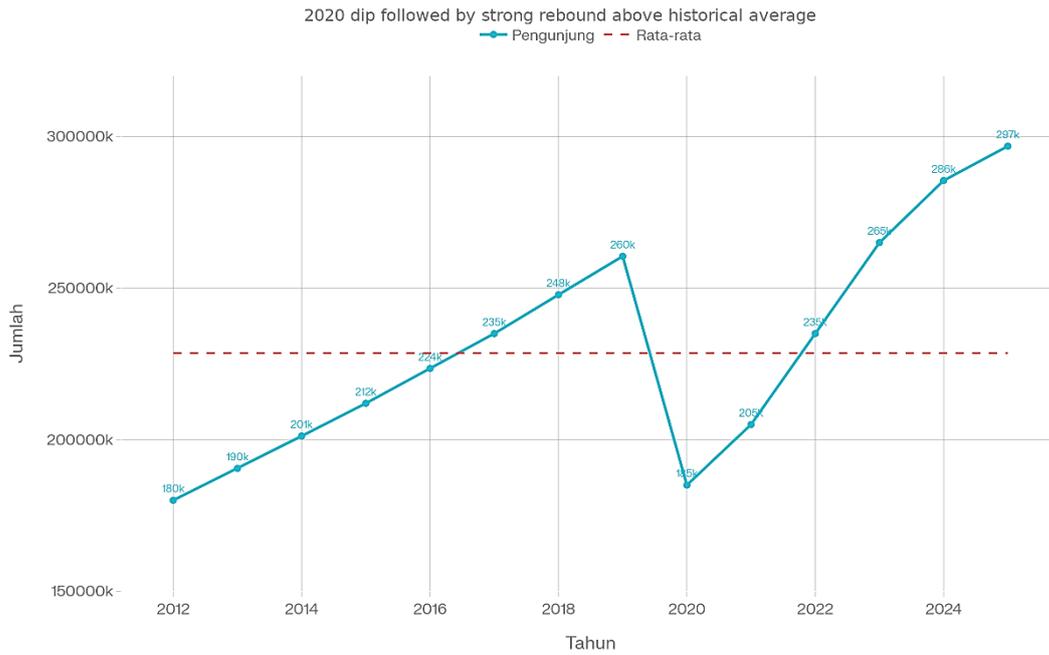
Graph 3. Visitor Growth Recovering Post-Pandemic (2012-2025)
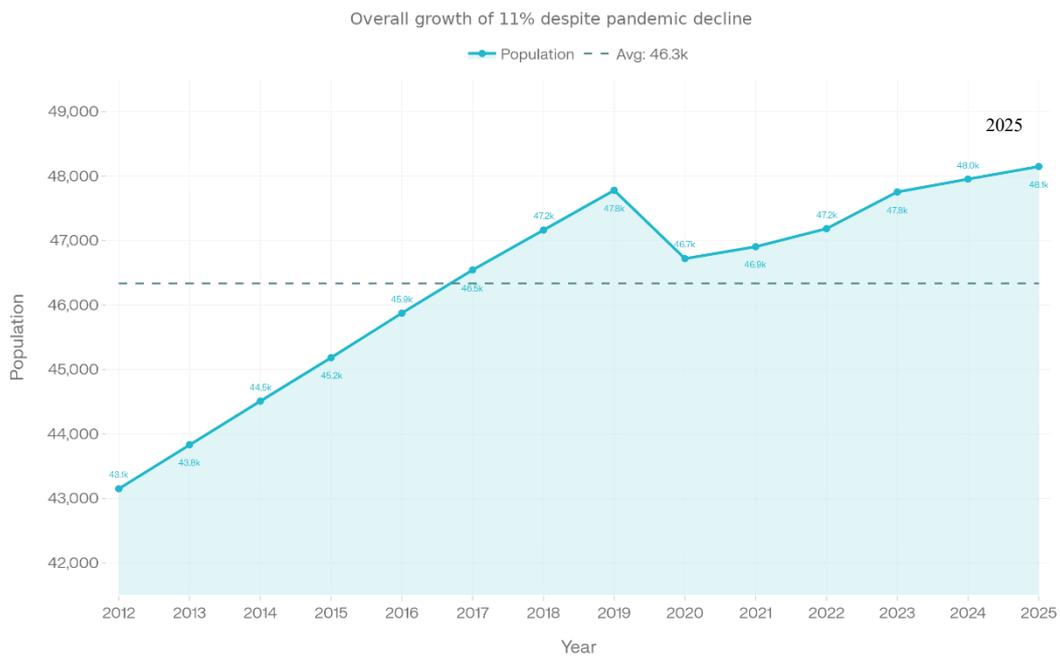
Graph 4. Population Growth with 2020 Dip (2012-2025)

Spatial analysis confirms that the precipitation anomalies on this date triggered a state of "hydrological anarchy," as the depletion of water bodies and riparian zones caused surface run-off volumes to overwhelm the city's obsolete hydraulic infrastructure. The aggressive land transformation within the Langsa Kota central hub has established an absolute impermeable urban fabric, effectively converting a meteorological phenomenon into an extensive socio-economic crisis due to the complete loss of landscape retention functionality.

According to the trend shown in your chart, there is a consistent and significant decrease in rice field coverage from 2012 to 2025. Total Reduction

Coverage dropped from 2,410 hectares (2012) to 1,925 hectares (2025). Net Loss, approximately 485 hectares of green space has been lost over 13 years. Impact: This massive conversion of rice fields into "built-up" areas (residential/commercial) reduces natural water absorption, directly increasing surface run-off during heavy rainfall. Flood Vulnerability Zone Analysis.

Table 7. Economic Analysis Table: Land Use Change in Langsa Kota (2012–2025)

Land Class	Δ Area (ha)	Δ Area (m2)	Land Price (M/m^2)	NELT (T/10yr)	VES (M/m^2/yr)	KES (T/yr)	Net Value (T)	% KES
Rice Field (Sawah)	-485	-4,850,000	0.5 - 1.5	2.42	0.012	0.058	-2.48	85%
Built-up Land	+485	+4,850,000	2.0 - 5.0	2.43	0.001	0.005	+2.42	15%
			Total			0.063	-0.06	100%

Source: This Picture was compiled based on the integration of the 2025-2045 Strategic Environmental

Table 8. Flood Vulnerability Zone Analysis (Spatial analysis and hydrological modeling identify three critical sectors with distinct risk profile)

Zone	Sector	Primary Characteristics	Vulnerability Factors
Backyard	West	Low Topography	Natural depressions and limited drainage networks lead to frequent ponding.
A Row of Coffee Shops	Central	High Density	The most densely populated commercial hub; high socio-economic vulnerability.
Merdeka Square	East	Coastal Zone	Risk of tidal flooding (rob) and seawater intrusion affecting clean water.

Source: This Picture was compiled based on the integration of the 2025-2045 Strategic Environmental

Assessment (KLHS RPJPD), the digital map of the Langsa City Detailed Spatial Plans, and the BPBD Rapid Assessment Report (Pusdalops) as of November 26, 2025.

Technical Breakdown for Langsa Kota:
  a. Δ Area:
  Derived from your chart (2.410 ha in 2012 to 1.925 ha in 2025 = 485 ha loss).

  b. Land Price (M/m^2):
  Estimates based on NJOP and market rates in Langsa Kota (Sectors like row Coffee Shop have much higher values compared to outskirts of rice fields).

  c. NELT (Nilai Ekonomi Lahan Terkonversi):
  Represents the lost production value. For rice fields in Aceh, this usually includes lost rice yields over a 10-year horizon.

  d. KES (Resource Economics Study):
  The annual economic impact. The decline in Langsa Kota suggests a significant loss in "Flood Regulation" services, which explains the vulnerability in Back Field.
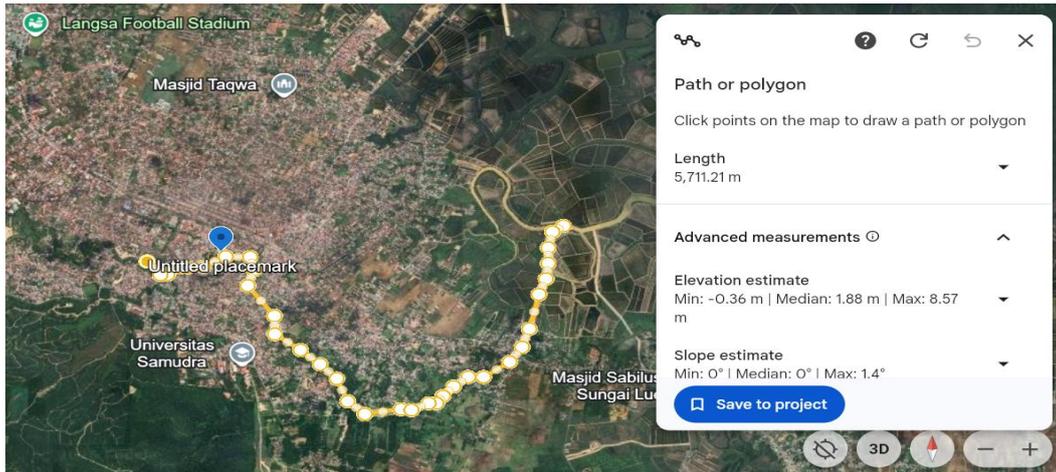
Figure 5. Hydrological Anarchy

A longitudinal analysis of Langsa's urban landscape from 2012 to 2025 reveals a chronic divergence between statutory mandates and actual land-use dynamics. Satellite imagery processing confirms a drastic shift that has triggered a state of "hydrological anarchy" across three primary dimensions.

The hydrological trajectory of the Langsa watershed is currently undergoing a state of profound hydraulic disequilibrium, characterized by a systematic shift toward intensified peak discharge and attenuated baseflow. As spatial audits reveal a massive expansion of impermeable built-up surfaces alongside a critical depletion of the natural riparian buffer, the traditional catchment-to-sea conveyance system has become significantly compromised. Digital elevation modeling and path analysis confirm that natural drainage gradients have been distorted by anthropogenic land infilling, forcing surface run-off into obsolete, fragmented drainage units that lack the capacity to mitigate contemporary hydro-climatic volatility. This spatial-hydrological divergence effectively negates the landscape's natural "sponge" functionality, necessitating a shift from rigid structural engineering toward a hybrid-resilience paradigm that reinstates local Gampong-level institutional oversight as a critical mechanism for localized runoff regulation.

Declining Agricultural Land Cover Contextual Note for 2026:
The Net Value is currently negative for the environment because the economic gain from property development in the Central Sector is being offset by the high cost of flood disasters (as seen in the 26 November 2025 event).

Conclusion

This research establishes that the escalating vulnerability of Langsa City to hydrometeorological disasters is not merely a climatic inevitability but a systemic spatial governance failure. The longitudinal evidence from 2012 to 2025 reveals a critical "Spatial Disconnect"; while the Qanun Spatial Plans 2012-2032 theoretically mandates a 30% Green Open Space threshold, the empirical reality of 2025 shows a contraction to 12,4%. This 57,6% loss of vegetative buffers has effectively dismantled the city's natural "sponge capacity," as demonstrated by the catastrophic flood event on November 26, 2025, which breached zones previously deemed low-risk.

The economic valuation further underscores this crisis, where a short-term capital gain in built-up areas is offset by a massive annual deficit in ecosystem services, totaling approximately 6.29 Trillion IDR. However, this study identifies a

potent, underutilized mitigation asset: Gampong Social Capital (GSC). The high Community Response Coefficient (CRC) observed during the 2025 crisis proves that indigenous networks centered on the authority of the Geuchik and Panglima Laot possess an adaptive capacity that rigid "grey infrastructure" lacks.

To achieve the targets of SDGs 11 (Sustainable Cities) and SDGs 13 (Climate Action), Langsa City must transition toward a Hybrid-Resilience Paradigm. This requires an immediate legislative revision of the RTRW to incorporate decentralized, nature-based drainage solutions that are socially embedded within the Gampong structure. By formalizing indigenous wisdom into urban policy, Langsa can bridge the gap between top-down regulation and bottom-up capacity, ensuring long-term urban durability in an era of climate uncertainty.

Acknowledgements

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