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GEOSPATIAL TECHNOLOGY APPLICATION FOR EVALUATING LAND USE CHANGE, FOREST COVER LOSS, AND URBAN EXPANSION IN DAVAO CITY

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ABSTRACT
Rapid urbanization in Davao City has significantly altered land use and land cover (LULC), leading to the loss of forests, agricultural lands, wetlands, and other ecologically sensitive areas. This study assesses LULC changes from 2013 to 2025 using remote sensing and GIS and evaluates their consistency with the Comprehensive Land Use Plan (CLUP). It maps urban expansion, vegetation loss, and land conversion while identifying priority areas for environmental management. The findings are expected to reveal increasing urban growth that has outpaced planning controls, highlighting gaps in monitoring and policy implementation. The study provides evidence-based recommendations to strengthen land use governance, improve future CLUP revisions, and support sustainable urban and environmental planning in Davao City.

Keywords:
Land Use and Land Cover (LULC); Geographic Information Systems (GIS); Remote Sensing; Davao City

INTRODUCTION

Rapid urbanization in the Philippines has accelerated land use and land cover (LULC) changes at an unprecedented rate, particularly in major regional centers like Davao City. As the largest city in the country by land area and the primary urban hub of Mindanao, Davao City has experienced significant spatial expansion driven by population growth, rural-to-urban migration, and economic development. These forces have increasingly converted agricultural,
forested, and ecologically sensitive lands into built-up areas, threatening biodiversity, watershed systems, and long-term environmental sustainability (Tinoy et al., 2019; Hotspot Cities Project, 2024).

Despite the adoption of successive Comprehensive Land Use Plans — most recently the CLUP 2019–2028 — Davao City continues to experience unmonitored and spatially uncontrolled land use change. Studies confirm that vegetation areas in District II alone declined from 80.32% in 2013 to 68.49% by 2023, while the city has lost 95% of its original wetland cover since 1944, from 471 hectares to only 24.46 hectares by 2021 (Masancay et al., 2025; Manalo, 2021). These changes directly undermine the city's natural flood buffering capacity and biodiversity systems. Yet a comprehensive, spatiotemporal LULC analysis covering all 182 barangays from 2013 to 2025 remains absent — a critical gap in spatial evidence that this study seeks to address through the application of geospatial technologies.

Despite successive CLUPs and environmental policies, Davao City continues to experience significant land use change, forest cover loss, wetland depletion, and urban expansion that threaten its ecological systems and long-term sustainability, largely due to inadequate monitoring, insufficient spatial data, and limited integration of geospatial technologies in environmental decision-making.

This study covers all 182 barangays of Davao City, Davao del Sur, Philippines, analyzing LULC changes from 2013 to 2025 across urban, peri-urban, and rural areas including ecologically sensitive zones. The study focuses on forest cover loss, urban expansion, wetland depletion, and agricultural land conversion, and evaluates these changes against the CLUP 2013–2022 and CLUP 2019–2028 zoning designations. The study does not cover chemical pollution indicators, detailed socioeconomic drivers, or other cities within the Davao Region.

The study is highly feasible from technical, data, and institutional perspectives. All required satellite imagery from USGS Earth Explorer and the ESA Copernicus Hub is freely accessible, and NDVI analysis are well-

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documented in peer-reviewed literature. The study aligns with the mandates of the Davao City CPDO, CENRO, and DENR Regional Office XI, ensuring institutional support and data accessibility within a realistic academic research timeline.

It aims to analyze and document spatial and temporal land use and land cover changes in Davao City from 2013 to 2025 using geospatial technologies, evaluate their consistency with the city's Comprehensive Land Use Plan, and generate evidence-based recommendations for spatial environmental management and planning.

Specifically, the study seeks to analyze and map LULC changes using multi-temporal satellite imagery; assess the extent of forest cover loss, built-up area expansion, and agricultural land conversion over the twelve-year period; evaluate spatial consistency between observed land use changes and the CLUP 2013–2022 and CLUP 2019–2028 zoning designations; identify critical environmental management zones requiring priority intervention; and recommend geospatial-based strategies and policy enhancements to strengthen spatial environmental governance and inform future CLUP revisions in Davao City.

METHODOLOGY

Research Design

This study adopts a descriptive-analytical case study design to examine land use and land cover changes in Davao City from 2013 to 2025. It documents changes across all 182 barangays, evaluates their consistency with the Comprehensive Land Use Plan, and integrates GIS, remote sensing, and official planning documents to generate recommendations for improving spatial environmental governance.

Data Gathering and Procedure

The study utilizes two primary data sources to analyze land use and land cover (LULC) changes in Davao City from 2013 to 2025: high-resolution historical imagery from Google Earth and the official Davao City Zoning Map. Google Earth provides multi-temporal imagery that enables the visual identification and comparison of land use and land cover changes over time, while the Davao City Zoning Map serves as a reference for existing land use classifications and planned land use designations. Images and zoning data are examined for four reference years—2013, 2017, 2020, and 2025—to ensure a consistent temporal assessment of land use dynamics across the study period.

Secondary data are obtained from government agencies to support the spatial analysis, including the Davao City Comprehensive Land Use Plan (CLUP) zoning maps from the City Planning and Development Office (CPDO), forest cover and geohazard maps from the DENR, population data from the Philippine Statistics Authority (PSA), topographic maps from Geoportal PH, and disaster reports from the NDRRMC. All datasets are standardized and processed in a Geographic Information System (GIS) to facilitate land use classification, change detection, and comparison with the CLUP zoning designations.

Ethical Considerations and Limitations

All satellite imagery and spatial datasets are obtained from publicly available platforms under open-access licenses. The study acknowledges limitations related to the 10–30-meter spatial resolution of the satellite imagery, potential cloud cover during the dry season in some barangays, and the accuracy of the CPDO zoning shapefiles. These limitations are addressed through careful data validation, the use of multiple data sources, and iterative image classification and refinement to improve the reliability of spatial analysis.

RESULTS AND DISCUSSION

This section presents the findings on land use and land cover (LULC) changes in Davao City from 2013 to 2025 using data from the CLUP 2013–2022 and CLUP 2019–2028, MGB-XI hazard maps, PSA population records, NDRRMC disaster reports, and satellite-based studies. These datasets were integrated to assess land use changes, zoning compliance, and geohazard exposure across the city.

4.1 Land Use Inventory and Change, 2011–2022: The CLUP Baseline

Table 1 summarizes the city's official land use inventory as recorded in the CLUP 2013–2022, comparing the existing (actual) land use in 2011 against the areas proposed for the 2013–2022 planning horizon. Of the city's total land area of 244,000 hectares, the CLUP records a net increase of 38,379.66 hectares (+52.5%) in land classified for agricultural use, a net increase of 7,004.65 hectares (+83.6%) in residential use, and a net increase of 2,854.17 hectares (+334.6%) in industrial use, against a net decrease of 25,921.78 hectares (–64.9%) in land classified for forest use. The single largest reclassification, however, involves the 116,832.08-hectare "Grassland/Pasture" category, which is entirely absorbed into other categories — principally Agriculture and Conservation — between 2011 and 2022, alongside the complete phase-out of the 157.14-hectare Mining/Quarrying category.

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Land Use Category	Existing 2011 (ha)	Proposed 2022 (ha)	Change (ha)
Residential	8,382.38	15,387.03	+7,004.65
Commercial	1,583.32	2,624.26	+1,040.95
Industrial	853.02	3,707.19	+2,854.17
Infrastructure/Utilities	208.62	750.00	+541.38
Institutional	629.03	1,281.20	+652.17
Agriculture	73,086.30	111,465.96	+38,379.66
Forest and Forest Use	39,916.94	13,995.16	−25,921.78
Grassland/Pasture	116,832.08	0.00	−116,832.08
Mining/Quarrying	157.14	0.00	−157.14
Conservation	0.00	60,135.90	+60,135.90
Tourism Development	200.08	5,834.51	+5,634.43
Rural Settlement Area	0.00	5,464.85	+5,464.85
Floodway (Env. Mgt.)	0.00	6,696.55	+6,696.55
Landslide Mitigation (Env. Mgt.)	0.00	12,934.71	+12,934.71
Open Space	1,258.80	417.69	−841.11
Water Uses	243.27	69.58	−173.69
TOTAL	244,000.00	244,000.00	0.00

Table 1. Existing (2011) and Proposed (2013–2022) Land Use Areas, Davao City (Selected Categories)

Source: City Government of Davao, City Planning and Development Office, Comprehensive Land Use Plan 2013–2022, Table 1.3-4.

Although CLUP data indicate increases in agricultural and conservation areas, these changes largely reflect the reclassification of former grassland and pasture lands rather than actual expansion of vegetated areas. Remote sensing studies present a different trend. Masancay et al. (2025) reported that vegetation cover in District II declined from 80.32% in 2013 to 68.49% in 2023, accompanied by increasing built-up areas. Similarly, Manalo (2021) found that Davao City's urban wetlands decreased by 95%, from 471.87 hectares in 1944 to 24.46 hectares in 2021, mainly due to residential (51.6%) and commercial (33%) development. These findings suggest that despite the CLUP's reclassification of land into agricultural and conservation zones, vegetation and wetland loss continue in urbanized areas, indicating that land conversion remains a significant planning and environmental challenge.

4.2 Forest Cover Loss and Timberland Degradation

The CLUP identifies 13,995 hectares as forest land, primarily in Marilog, Paquibato, and Toril, while Global Forest Watch (2023) estimates approximately 96,000 hectares of remaining natural forest, much of which falls under conservation and ancestral domain areas. However, CLUP and DENR data reveal significant forest degradation: of the 116,039 hectares of GIS-classified timberland, only 25,759 hectares (22.2%) remain forested, while 71.9% have been converted to brushland or grassland and 5.87% to agricultural use. In Paquibato District, only 14.7% of ancestral domain lands remain forested, with most areas now classified as agricultural or grassland. These findings indicate that upland forest loss in Davao City is primarily driven by agricultural and agroforestry expansion, contributing to increased environmental risks such as flooding and landslides.

4.3 Agricultural Land Conversion and Grassland Reclassification

Agriculture is the single largest land use category in Davao City under both the 2011 baseline (73,086.30 hectares, 30.0% of city area) and the 2013–2022 CLUP (111,465.96 hectares, 45.66%). District narratives in the CLUP show this expansion is not uniform: in Baguio District, 1,118 hectares of agricultural land were reclassified to conservation to protect Mt. Apo Natural Park's aquifer recharge zones, a net conservation gain; in Bunawan District, agricultural land was instead reduced to 1,321 hectares to accommodate 2,625 hectares of proposed industrial expansion tied to port and banana-export logistics; and in Buhangin District, agricultural land was reduced to 2,395 hectares specifically to keep residential expansion out of the district's floodway. These cases show that "agricultural land" in the CLUP inventory functions partly as a holding category — land not yet converted to built-up use — rather than a protected productive-agriculture classification, which is consistent with the continuing net loss of vegetated cover documented by Masancay et al. (2025) even as the CLUP's agricultural hectarage nominally grows.

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4.4 Population Growth and the Pace of Urban Expansion

Table 2 traces Davao City's population across recent census years. The city grew from 1,632,991 in 2015 to 1,776,949 in 2020, an average annual growth rate of 1.79%, then to 1,848,947 by the 2024 Census of Population, a slower average annual growth rate of 0.96% for 2020–2024 (PSA, 2022, 2024, 2025). This deceleration is significant when read against the CLUP's own 2022 population projection of 1.925 million: the city's actual 2024 population of 1.849 million remained below the figure the 2013–2022 plan anticipated for 2022, even two years past the plan's own horizon.

Census Year	Total Population	Avg. Annual Growth Rate
2010	1,449,296 (implied by CLUP's cited Poblacion share of 10.79%)	—
2015	1,632,991	—
2020	1,776,949	1.79% (2015–2020)
2024	1,848,947	0.96% (2020–2024)

Table 2. Population of Davao City, Selected Census Years

Source: Philippine Statistics Authority, 2020 Census of Population and Housing; Highlights of the Region XI (Davao Region) Population, 2024 Census of Population (PSA, 2025); Davao City CLUP 2013–2022.

Residential land allocation in Davao City increased by 83.6%, from 8,382.38 to 15,387.03 hectares, despite population growth of only approximately 13% between 2011 and 2024. This trend indicates low-density horizontal expansion rather than population-driven vertical development, contributing to the conversion of peri-urban and environmentally sensitive areas (PSA, 2020, 2022, 2024; Tinoy et al., 2019). The CLUP 2019–2028 promotes vertical growth in Poblacion District due to its limited land area and floodway constraints, while Tugbok, Talomo, and Buhangin remain the primary districts for residential expansion, collectively accounting for more than 11,000 hectares of proposed residential land. These findings highlight the continued concentration of urban growth along the city's western and northern fringes and underscore the importance of implementing the CLUP's growth management strategies.

4.5 Landslide and Flood Susceptibility versus Land Use Allocation

The MGB-XI hazard maps and CLUP hazard inventory indicate that 101,006 hectares (41.56%) of Davao City are highly susceptible to landslides, while 7,546 hectares are highly flood-prone. However, only 19,631.26 hectares are designated as landslide and floodway mitigation zones under the CLUP, covering just 18% of identified hazard areas. This suggests that a substantial portion of hazard-prone land remains open to development, highlighting the need for stronger hazard-sensitive zoning and land use regulation (MGB-XI, 2007; CLUP 2019–2028).

District	Total Area (ha)	Dominant Hazard Pattern (MGB-XI Map)	CLUP Hazard-Restricted Zoning
Paquibato	65,240	Very high/high landslide susceptibility across most of the interior upland	1,158 ha landslide + floodway (combined)
Marilog	62,885	Very high/high landslide susceptibility across nearly the entire district except the Region XII boundary	9,548 ha landslide mitigation
Toril	29,685	High landslide susceptibility in the western upland; high-to-very-high flood susceptibility along the coastal fringe	1,434 ha landslide mitigation
Calinan	n/a (district straddles Davao & Talomo River watersheds)	High landslide susceptibility in the western upland; flood susceptibility along both river systems	3,783 ha conservation; floodway along flood-classified reaches
Tugbok	14,858	Flood corridor (high-to-	617 ha floodway; 146 ha

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		very-high) bisecting the district along the Talomo River; low-to-moderate landslide susceptibility in western hills	conservation
Talomo	8,558	Flood corridor (high-to-very-high) along the Talomo/Matina river systems toward the coast; landslide susceptibility inland, incl. Shrine Hills	954 ha floodway; 222.62 ha Urban Ecological Enhancement (Shrine Hills)
Poblacion	1,144	High-to-very-high flood susceptibility along the Davao River and southern/western riverside blocks	259 ha floodway
Agdao	530	Broad moderate-to-high flood susceptibility across roughly half the district, concentrated along the coast	No dedicated landslide/floodway allocation reported
Bunawan	6,393	High-to-very-high flood susceptibility along the entire coastal strip bordering Panabo City	Sited for heavy/medium industrial use despite coastal flood exposure
Baguio	n/a (8 barangays)	High landslide susceptibility across most of the district (Mt. Apo Natural Park slopes)	12,326 ha conservation

Table 3. Landslide and Flood Susceptibility Pattern versus Hazard-Restricted Zoning, by District

Source: Mines and Geosciences Bureau Regional Office XI, Detailed Landslide and Flood Susceptibility Maps by District, City of Davao (Terrain Analysis Study, 2007), scale 1:10,000; Davao City CLUP 2013–2022 district narratives.

The findings show that upland districts such as Paquibato, Marilog, Toril, and Calinan experience the highest landslide susceptibility yet have relatively limited hazard-restricted zoning. In contrast, urban districts including Poblacion, Talomo, Agdao, Tugbok, and Bunawan are largely situated within high flood-risk areas along the city's major river systems. Notably, the 222.62-hectare Shrine Hills Urban Ecological Enhancement Zone in Talomo exemplifies the growing overlap between hazard-prone areas and residential development, consistent with assessments identifying Davao City's central and coastal barangays as highly vulnerable to flooding, sea-level rise, and storm surges (UN-Habitat and World Food Programme).

The CLUP 2019–2028 establishes strict regulations for hazard-prone areas, including development restrictions in landslide zones and mandatory flood mitigation measures in flood-prone areas. However, nearly 80% of identified high-risk areas remain outside designated hazard overlay zones, indicating that the main issue lies in incomplete hazard mapping and zoning coverage rather than weak ordinance provisions.

Provision	Key Development Regulation	Ordinance Section
High Risk to Landslide Overlay Zone (HR-LSD-OZ)	No new structures or fences permitted; only tree and vetiver-grass planting for slope stabilization is allowed; existing structures barred from expansion and required to retrofit.	Sec. 13.1.1
Moderate Risk to Landslide Overlay Zone	Maximum 30% site occupancy (MAPSO) of the identified hazard area; remaining 70% reserved for greening; unpaved surface area of 60–70% required; further subdivision of the 30% portion prohibited.	Sec. 13.1.2

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High Risk to Flood Overlay Zone	Development allowed only where engineering mitigation is demonstrated adequate; functional wetlands, easements, and buffer areas to be preserved within the zone.	Sec. 13.2.1
Moderate Risk to Flood Overlay Zone	Mandatory flood-proofing: finished floor line at or above the DPWH-determined Flood Protection Elevation, evacuation-capable roof decks, and utility connections elevated above the FPE.	Sec. 13.2.2
Davao River Easement	30-meter easement on both banks from the river mouth to Ma-a Bridge (10 m developed as river promenade, 20 m as road right-of-way).	Sec. 12.6.14(1)
Matina River Easement	30-meter easement on both banks from the river mouth to C.P. Garcia Highway.	Sec. 12.6.14(2)
Talomo River Easement	30-meter easement on both banks from the river mouth to McArthur Highway.	Sec. 12.6.14(3)
Other Rivers and Creeks Easement	5-meter easement (urban areas), 20-meter easement (agricultural areas), 40-meter easement (forest areas), on both banks.	Sec. 12.6.14(4)
Wetlands Sub-Zone	No structures or buildings permitted within the wetland area; no landfilling or other activity that alters the area's natural character.	Sec. 12.5.1.3
Mangrove Sub-Zone	No permanent buildings or structures; allowable activity limited to mangrove plantation, limited ecotourism, and scientific/educational study.	Sec. 12.5.1.1
Agricultural Land Reclassification Cap	Reclassification of agricultural land to non-agricultural use capped at 15% of the city's total agricultural land area; irrigated, agrarian-reform, and CARP-covered land exempted outright.	Sec. 32
Non-Conforming Structures in Protection Forest	Immediate demolition order upon confirmation of structures or land development introduced within Protection Forest, plus a violator-funded reforestation program for the disturbed site.	Sec. 51(15)

***Table 4. Overlay Zone, Easement, and Protective Sub-Zone Regulations, CLUP 2019–2028* Comprehensive Zoning Ordinance** *Source: City Government of Davao, Comprehensive Zoning Ordinance 2019–2028 (CLUP Volume 2), Sections 12.5.1, 12.6.14, 13.1, 13.2, and 32.*

4.6 Disaster Occurrence in Davao City and the Davao Region, 2013–2025

Table 4 compiles the major flood, landslide, and earthquake events affecting Davao City and the wider Davao Region across the 2013–2025 study period, drawn from NDRRMC situation reports and contemporaneous news coverage.

Date	Event	Reported Impact
Jan 2014	Low-pressure-area-induced landslides and flash floods, Davao Region	14 fatalities regionwide; thousands evacuated in Compostela Valley and Davao del Norte (Inquirer.net, 2014)
2016–2021 (cumulative)	Recurrent flooding and landslide damage, Davao Region	₱11 billion in cumulative damages (avg. ₱1.8 billion/year); Davao del Norte hardest-hit at ₱10.8 billion (Earth Journalism Network, 2024)
Feb 7, 2021	M6.0 Davao del Sur earthquake (Makilala-Malungon Fault)	14 injured; 25 buildings damaged; month-long aftershock sequence felt across southern Mindanao
Aug 12, 2021	M7.1 Davao Oriental earthquake (Philippine Trench)	1 fatality; tsunami advisory issued; felt at Intensity IV in Davao City
Feb 1, 2023	M6.0 earthquake, Davao de	Felt strongly across Davao City

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	Oro/Davao City area	
Jan 16–31, 2024	Shear-line/low-pressure-area flooding and landslides, Davao Region	At least 21 fatalities and over 670,000 displaced regionwide (NDRRMC, 2024); in Davao City, ~7,000 residents in 10 barangays affected; 23 barangays later placed under a state of calamity, with ₱84.35 million released from the Quick Response Fund (SunStar Davao, 2024; Manila Bulletin, 2024)
Jan 4, 2025	Flash flooding along the Matina River system, Davao City	617 families (2,211 persons) displaced in Matina Pangi, Matina Crossing, and Matina Aplaya; 5 homes destroyed (Inquirer.net, 2025)
Oct 10, 2025	M7.4 Davao Oriental earthquake (Philippine Trench)	10 fatalities and 1,027 injuries regionwide; ₱2.26 billion in damage; 30 cm tsunami recorded; strongly felt across Davao City, with an extended aftershock sequence

Table 5. Timeline of Major Disaster Events, Davao City and Davao Region, 2013–2025

Source: NDRRMC situation reports as cited in Earth Journalism Network (2024) and NDRRMC (2024); Inquirer.net (2014, 2025); SunStar Davao (2024); Manila Bulletin (2024); GMA News Online (2024); Wikipedia earthquake summaries corroborated against PHIVOLCS/USGS parameters.

Two patterns stand out. First, flooding recurs in the same barangays: Matina Pangi, Matina Crossing, and Matina Aplaya were flooded in the January 2024 event and again in the January 2025 event, exactly the corridor the MGB-XI hazard map classifies as high-to-very-high flood susceptibility along the Talomo/Matina river system (Section 4.5, Table 3). This recurrence in the same locations across consecutive years indicates that the CLUP's floodway and easement provisions for this corridor — 954 hectares designated Floodway in Talomo District alone — have not yet translated into effective on-the-ground flood-risk reduction, echoing the Statement of Facts' finding that weak monitoring and enforcement allow encroachment into protected zones to persist. Second, the frequency and magnitude of seismic events increased markedly toward the end of the study period, culminating in the M7.4 Davao Oriental earthquake of October 2025 — the strongest and most damaging event in the twelve-year window — a reminder that Davao City's land use and disaster-risk planning must account for compound seismic and hydrometeorological hazards rather than flooding and landslides alone.

4.7 Consistency with the CLUP 2013–2022 and CLUP 2019–2028 Zoning Designations

The CLUP 2013–2022 reported that only about 13,000 hectares of the 36,916.74 hectares allocated for urban development had been utilized by 2011, leaving over 23,000 hectares available for future growth. This suggests that much of Davao City's recent urban expansion could have been accommodated within already designated urban areas if land use monitoring and development controls had been more effectively implemented.

In response to emerging land use evidence, the CLUP 2019–2028 introduced stronger environmental protections, including dedicated Wetlands and Mangrove Sub-Zones that prohibit land reclamation and permanent structures. These provisions address documented wetland loss and demonstrate how geospatial evidence can inform policy, highlighting the importance of integrating continuous satellite-based monitoring into future CLUP updates (Manalo, 2021).

4.8 Critical Environmental Management Zones Requiring Priority Intervention

Synthesizing the land use, hazard, and disaster evidence above, five zones emerge as priorities for intervention:

Matina–Talomo River corridor (Matina Pangi, Matina Crossing, Matina Aplaya, Talomo Proper). Repeated flooding in 2024 and 2025 within a mapped high-to-very-high flood susceptibility zone; the 954-hectare Floodway designation for Talomo District requires active easement enforcement rather than nominal zoning.

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Marilog–Paquibato upland landslide belt. Contiguous very-high/high landslide susceptibility across the bulk of both districts, overlapping expanding agroforestry and rural settlement areas; only a small fraction of this exposure (9,548 ha in Marilog; 1,158 ha in Paquibato) carries formal development restriction.
Shrine Hills Urban Ecological Enhancement Zone. A 222.62-hectare landslide-susceptible hill fully enclosed by dense residential development on both the Ma-a and Matina Pangi sides; requires slope-stability management rather than further residential infill.
Coastal industrial-flood overlap, Bunawan–Lasang. Heavy and medium industrial zoning (2,625 ha proposed) sited directly within a coastal strip mapped as high-to-very-high flood susceptibility; floodwater contact with industrial or chemical operations poses compounded environmental and public-safety risk.
Degraded Timberland, Marilog–Paquibato. 83,435 hectares (71.9%) of GIS-calculated Timberland already reduced to brushland or grassland; the largest single reforestation and watershed-recharge opportunity identified in the CLUP's own data.

4.9 Synthesis

Overall, the findings suggest that Davao City's land use changes from 2013 to 2025 were influenced not by a lack of planning policies, but by challenges in implementing and enforcing them. Although hazard maps and the CLUP had already identified flood- and landslide-prone areas, urban expansion, vegetation loss, wetland decline, and recurring flooding continued in many of these locations. The updated CLUP 2019–2028 addressed some of these issues by strengthening wetland protection and integrating disaster risk reduction, climate change adaptation, and environmental conservation into its zoning policies. These improvements demonstrate how geospatial evidence can support better planning decisions. However, continued use of satellite-derived land use and land cover (LULC) data and GIS-based monitoring is still needed to strengthen zoning enforcement and improve the protection of flood- and landslide-prone areas.

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CONCLUSION

The most appropriate course of action is the institutionalization of a GIS-based Land Use Monitoring and Decision Support System under the City Planning and Development Office (CPDO). This system should integrate satellite imagery, CLUP 2019–2028 zoning layers, hazard maps, and field validation data to regularly monitor land use changes, particularly in environmentally sensitive and hazard-prone areas. Priority monitoring should focus on the Matina–Talomo flood corridor, the Marilog–Paquibato conservation belt, Bunawan's coastal zone, and other districts experiencing rapid urban expansion. Regular spatial assessments will enable the city to detect unauthorized land conversion, strengthen zoning enforcement, and support evidence-based planning decisions.
In parallel, the City Government should strengthen the implementation of the CLUP 2019–2028 by expanding hazard-sensitive zoning regulations and enhancing inter-agency coordination among the CPDO, CENRO, DENR, and the Local Disaster Risk Reduction and Management Office (LDRRMO). Development permits in high-risk landslide and flood-prone areas should undergo stricter geospatial and environmental assessments, while conservation and watershed areas should be prioritized for restoration and protection initiatives. Public awareness campaigns and stakeholder engagement activities should also be conducted to improve compliance with zoning regulations and promote sustainable land use practices.
Finally, the findings of this study should inform future CLUP reviews and revisions by incorporating geospatial technologies as a standard planning and monitoring tool. The integration of real-time spatial data into local governance will improve environmental management, reduce disaster risks, and ensure that Davao City's urban growth remains consistent with its long-term sustainability and resilience objectives.

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https://ijetrm.com/

REFERENCES

1) DENR-FMB. (2022). Philippine Forest Reference Level document. UNFCCC REDD+ Web Platform. https://redd.unfccc.int/files/philippine_frl_document_final_6dec2022.pdf
2) Earth Journalism Network. (2024). Seven things data tell us about deforestation and the devastating floods in Davao Region. https://earthjournalism.net
3) European Space Agency. (2023). Copernicus Open Access Hub — Sentinel-2 imagery. https://scihub.copernicus.eu
4) Global Forest Watch. (2023). Davao City, Philippines — Deforestation rates and statistics. World Resources Institute. https://www.globalforestwatch.org
5) Hotspot Cities Project. (2024). Davao, Philippines — Environmental profile. https://hotspotcitiesproject.com/cities/davao.html
6) Ijetrm. (2025). Assessing urban resilience and land use planning: A SWOT analysis of the Davao City CLUP (2019–2028). International Journal of Engineering Technology Research and Management. https://ijetrm.com
7) Manalo, L. (2021). Land use change of urban wetlands in Davao City, Philippines. IDIS / Academia.edu. https://www.academia.edu/125216102
8) Masancay, F. D., Arizobal, A. E., Pascua, V. T., & Petalcorin, I. G. D. (2025). Urban sprawl mapping based on LULC time-series in District II of Davao City, Philippines. Davao Research Journal, 16(1), 72–88. https://davaoresearchjournal.ph/index.php/main/article/view/305
9) NDRRMC. (2024). Situational report on flooding and landslides in Davao Region. National Disaster Risk Reduction and Management Council. https://www.ndrrmc.gov.ph
10) Philippine Information Agency. (2024, February 19). Loss of urban wetland caused flooding in Davao City. https://pia.gov.ph
11) ScienceDirect. (2023). Determination of future land use changes using remote sensing and ANN: A case study of Davao City, Philippines. https://www.sciencedirect.com/science/article/pii/S2666544123000254
12) Tinoy, M., et al. (2019). Reviewing city limits: The risk of rapid urbanization in Davao City. International Journal of Scientific Research and Engineering Development, 2(1). https://ijsred.com
13) United States Geological Survey. (2023). Landsat 8/9 OLI imagery — Earth Explorer. https://earthexplorer.usgs.gov
14) City Government of Davao, City Planning and Development Office. (2013). Comprehensive Land Use Plan 2013–2022: Davao City.
15) City Government of Davao, City Planning and Development Office. (2019). Comprehensive Land Use Plan 2019–2028: Davao City [Interactive zoning map]. https://gismap.davaocity.gov.ph/Zoning/
16) Earth Journalism Network. (2024, October 31). 7 things data tell us about deforestation and the devastating floods in Davao Region. https://earthjournalism.net/stories/seven-things-data-tell-us-about-the-deforestation-and-devastating-floods-in-davao-region
17) Hotspot Cities Project. (2024). Davao City urban growth and land use monitoring report.
18) Manalo, L. (2021). Land use change of urban wetlands in Davao City, Philippines. Interfacing Development Interventions for Sustainability (IDIS).
19) Masancay, F. D., Arizobal, A. E., Pascua, V. T., & Petalcorin, I. G. D. (2025). Urban sprawl mapping based on Land Use and Land Cover (LULC) time-series in District II of Davao City, Philippines. Davao Research Journal, 16(1), 72–88. https://doi.org/10.59120/drj.v16i1.305
20) National Disaster Risk Reduction and Management Council. (2024). Situational report on the effects of the shear line/low-pressure area in Davao Region.
21) Philippine Statistics Authority. (2025, August 1). Highlights of the Region XI (Davao Region) population 2024 Census of Population (2024 POPCEN). https://psa.gov.ph/statistics/population-and-housing/node/1684078106
22) Tinoy, M. M., Novero, A. U., Landicho, K. P., Baloloy, A. B., & Blanco, A. C. (2019). Urban effects on land surface temperature in Davao City, Philippines. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W19, 433–440. https://doi.org/10.5194/isprs-archives-XLII-4-W19-433-201

