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Understanding the Patterns and Drivers of Landslides in the Urban Landscape of Yaoundé, Cameroon

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Abstract: Landslides are known to occur in many cities of Cameroon, particularly in Yaoundé, where rapid urban growth, changing weather patterns, and difficult terrain act as predisposing factors to landslides. Although several deadly landslides have been recorded in recent years, there has not been much detailed research on where and why these landslides occur. This paper examines the spatial distribution of landslides in Yaoundé's Mfoundi Division and the main drivers of these events. A mixed research method, including field surveys, GPS mapping, questionnaires with 250 residents from six subdivisions (Yaoundé II–VII), group discussions with community members, rainfall data from 2015 to 2024 (ONACC/CERES-NASA), and binary logistic regression analysis, was used. The results show that landslides have become more frequent, especially after 2019. Yearly rainfall varies (from 1,311 to 1,728 mm), and heavy rain in October and November often matches up with landslide events. Respondents identified the main causes of landslides to be rainfall (80%), poor land-use planning (62%), settlement growth (52%), and deforestation (50%). The statistical analysis showed that poor land-use planning (OR = 2.22, p = 0.013) and deforestation (OR = 2.21, p = 0.018) are significant anthropogenic drivers of landslides in Yaoundé. These results indicate that landslides in Yaoundé are shaped by heavy rain, unplanned settlement expansion, and weak government policies. To reduce the risk, there is an urgent need for better land-use planning, slope protection, and the use of modern early warning systems that involve the community.

Keywords: *Landslides; Urban Geohazards; Spatial Patterns; Anthropogenic Drivers; Yaoundé; Cameroon.*

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I. INTRODUCTION

Landslides are among the most destructive geohazards globally, resulting in substantial loss of life and economic damage each year, especially in mountainous and hilly regions of developing countries [1], [2]. Sub-Saharan Africa, particularly equatorial Africa, experiences increased risk due to the combination of steep topography, intense seasonal rainfall, deep weathering profiles, high population density, and increased vulnerability from rapid, largely unplanned urbanisation [3], [4]. In this case, Cameroon is one of the most frequently affected countries, with landslide occurrences documented along the Cameroon Volcanic Line, in the western highlands, and increasingly within major urban centres [5], [6].

Yaoundé which is the political and administrative capital, of Cameroon has recorded a number of catastrophic landslide episodes in recent years. These include the Ngousso landslide which occurred in November 2019, the Antenne Damas and Mimboman events of late 2022 (at least 14–17 fatalities combined), the Mbankolo tragic landslide of October 2023 (≥30 fatalities), and even another landslide in Mbankolo in March 2025. The city is characterised by a hilly plateau sitting at 750 m above sea level, with peaks exceeding 1,200 m. The city is also predominantly made up of ferralitic soils, bimodal rainfall patterns (1,500–2,000 mm yr^{-1}), and a dense drainage network which creates conditions inherently susceptible to slope instability [7], [8].

Natural vulnerabilities are worsened by rapid population growth. Yaoundé's population exceeded 4.6 million in 2024 and continues to expand at a rate greater than 3% per year [9]. This growth, driven by rural-to-urban migration and displacement resulting from the ongoing Anglophone socio-economic crisis, has led to the occupation of steep hillside zones by informal settlements, increased deforestation, and placed significant strain on inadequate drainage and urban planning infrastructure. Despite a national land-use planning orientation law enacted in 2011 and a National Land Use Planning and Sustainable Development plan validated in 2016, enforcement has

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remained weak, with communities continuing to expand into high-risk zones [10].

Previous research on landslides in Yaoundé and Cameroon at large has made important contributions through susceptibility mapping, geotechnical characterisation, and historical event documentation [11], [5], [12]. However, studies that incorporate spatial inventory analysis, temporal rainfall–landslide relationships, and quantitative assessment of the relative significance of multiple drivers within a single urban setting remain limited. Understanding the spatial and temporal drivers of landslides in Yaoundé is important for evidence-based disaster risk reduction.

This paper therefore addresses these gaps by addressing three specific objectives: (1) to document the spatial distribution and temporal trends of landslide occurrences in Yaoundé; (2) to identify and characterise the natural and anthropogenic drivers of landslides, and (3) to statistically test whether anthropogenic factors are significant triggers of landslide occurrence in Yaoundé. The findings contribute to the broader understanding of urban landslide dynamics in tropical African cities and provide actionable insights for planners, disaster managers, and policymakers.

II. MATERIALS AND METHODS

➢ *Study Area*

This study was carried out in Mfoundi Division of Yaoundé, focusing on six out of its seven subdivisions, that is, Yaoundé II, III, IV, V, VI, and VII (Fig. 1). The study area includes neighbourhoods with known landslide histories and those at risk, including Mbankolo, Antenne Damas, Ngousso, Mimboman, Oyom-Abang, Messa, Carrière, Nkolbisson, Akok-Ndoué, Febe, and Nkolafeme. Yaoundé I was left out because there have been no recorded landslide incidents and limited risk.

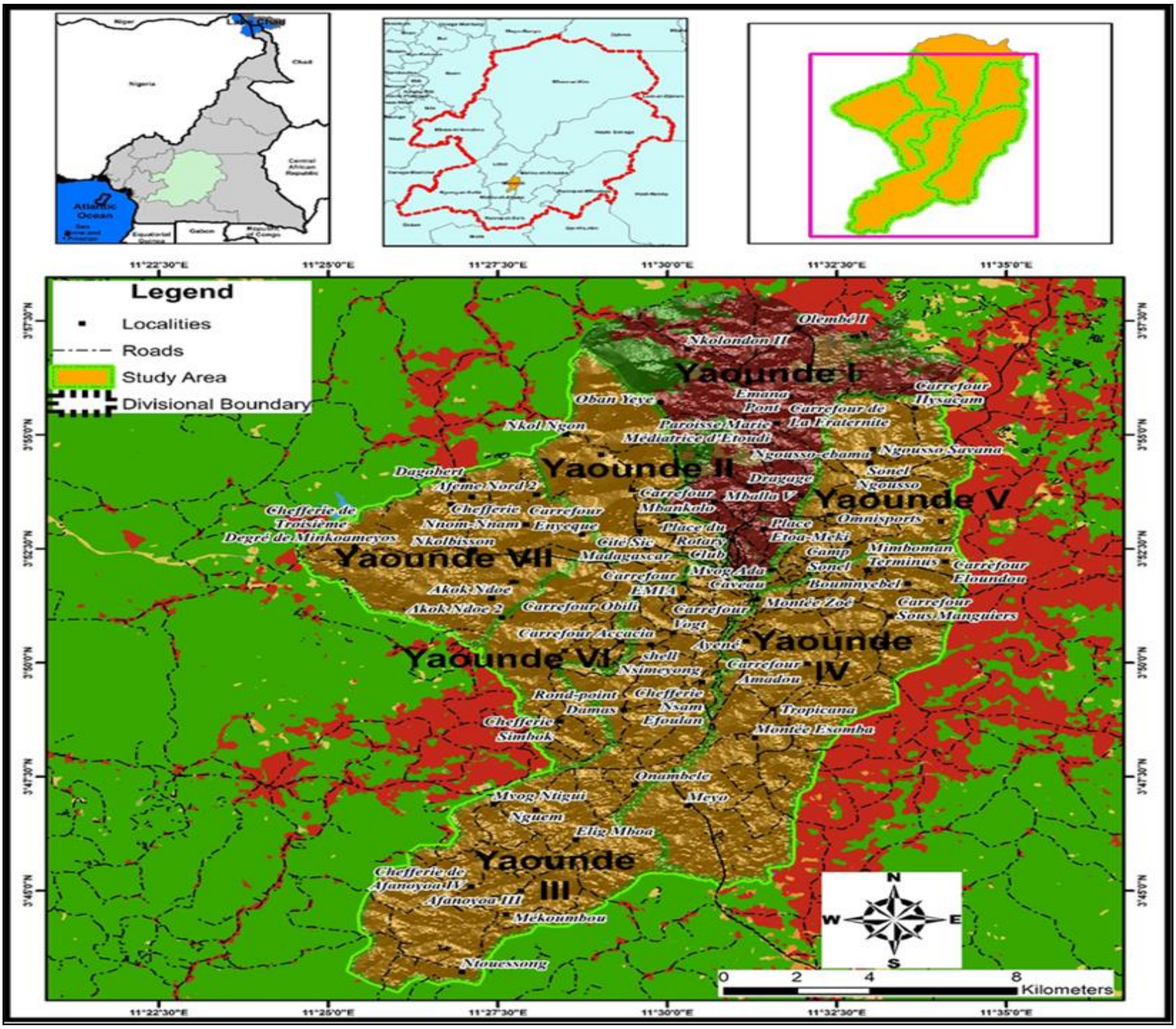

Fig 1 Location and Layout of Yaoundé.
Source: Kinyuy (2025)

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The city is located at approximately 3°52'N, 11°31'E, at an elevation of about 750 meters within the Congo Craton transition zone. The terrain features seven prominent hills, including Mont Mbankolo (1,098 m), Mont Febe (1,073 m), and Nkolondom (1,221 m), as well as steep slopes ranging from 15 to 70 degrees and a dense dendritic river network that drains into the Nyong and Sanaga basins.

The soils in the study are predominantly Ferralsols, Acrisols, and Andosols (highly weathered, clay-rich) types with poor drainage, which reduce slope stability under rainfall loading [7].

Fig. 2 shows a Digital Elevation Model (DEM) that highlights Yaoundé's complex topography across Mfoundi Division, providing a three-dimensional representation of the city's morphology. In the north and west, the DEM shows dense contour lines indicating steep slopes of 15-20 degrees. In contrast, the southern part of the area has fewer contours and gentler slopes. These sharp elevation changes over short distances lead to unstable slopes, making the city more prone to landslides.

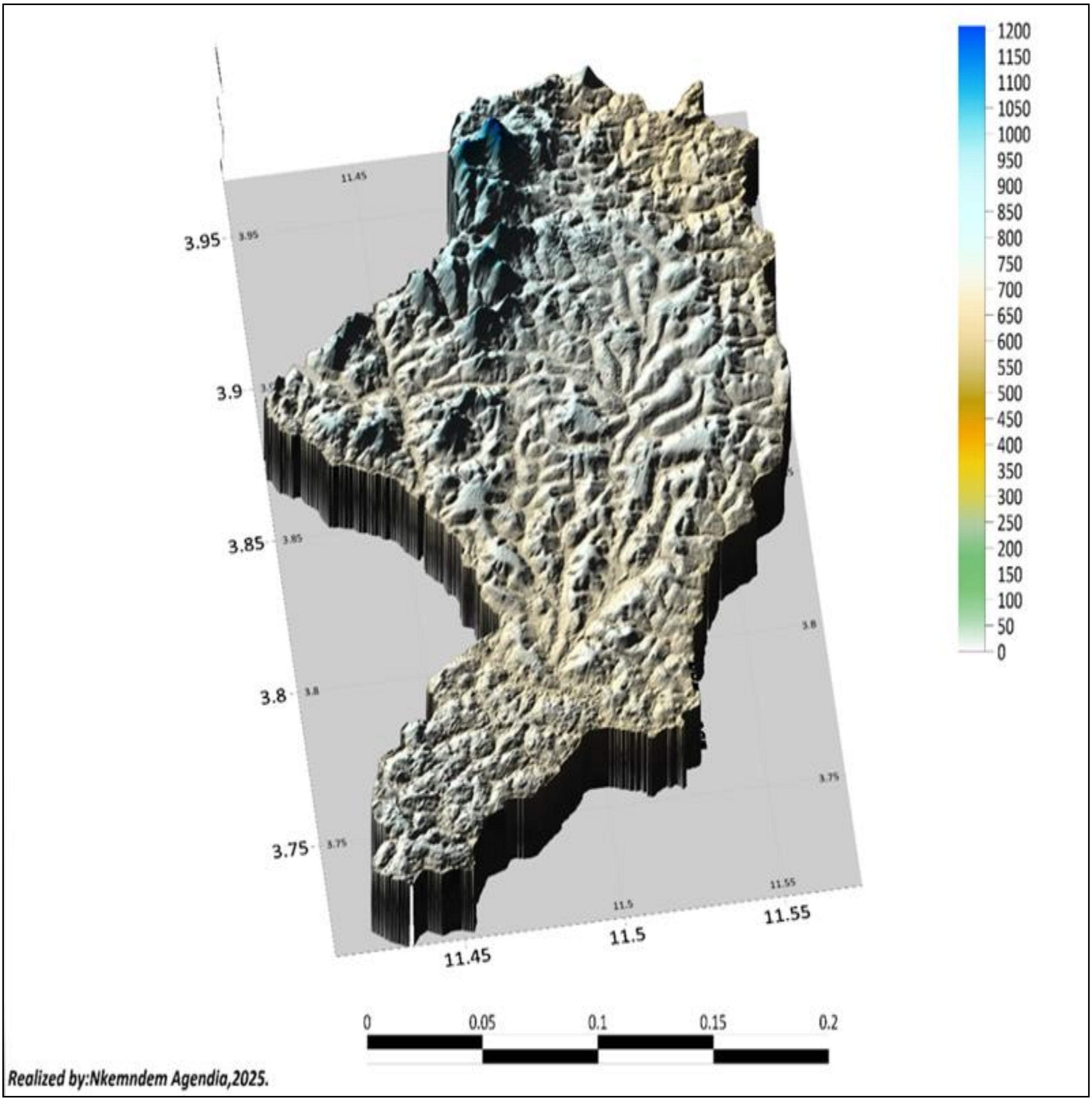

Fig 2 Three-Dimensional DEM Showing the General Morphology and Elevation Distribution of Yaoundé (650–1,225 m). Source: Nkemndem (2025)

➢ *Research Design*

This study employed a mixed-methods research design that combined quantitative and qualitative approaches. The methods included collecting primary data through household questionnaires, in-depth interviews, and focused group discussions. The researcher also mapped landslides in the field using GPS, analysed secondary data on rainfall and landslide events, and conducted spatial analyses using ArcGIS 10.8 and QGIS. The research covered the years 2015 to 2025, with primary data collected between January 2024 and March 2025.

➢ *Sampling and Data Collection*

A multi-stage sampling design was used for this study. Sites were chosen based on known landslide history and topographic risk, and grouped into four risk levels by slope angle using a 30-meter resolution ASTER Digital Elevation Model (DEM): very high risk (28 to 71 degrees: Febe), moderate risk (13 to 28 degrees: Mbankolo, Akok-Ndoué), low risk (8 to 19 degrees: Oyom-Abang, Nkolbisson, Nkolafeme), and minimal risk (0 to 13 degrees: Damas, Cradat). A total of 250 structured questionnaires were administered to household heads using systematic random sampling within each stratum (Table 1). Additionally, 10 focused group discussions and in-depth interviews were conducted with key stakeholders from relevant ministries (MINEPDED, MINHDU, MINEPAT, MINATD, MINTP) and NGOs (Cameroon Red Cross, IFRC, FAO).

The questionnaire measured awareness of landslides, how often people think they happen, and what causes them. It used closed-ended questions and a four-point Likert scale. To ensure the results were reliable and valid, we conducted a pilot test, offered the survey in both English and French, and conducted a supervisory review.

Table 1 Distribution of Questionnaires Across Study Sites

Study Site / Subdivision	Quarters Included	Questionnaires (n)
Yaoundé II	Mbankolo, Messa, Carrière, Febe	90
Yaoundé III	Damas	45
Yaoundé VI	Akok-Ndoué	30
Yaoundé VII	Nkolbisson, Oyom-Abang, Nkolafeme	85
Stakeholders	Ministries, Councils, NGOs	10
Total		250

Source: Fieldwork, 2025

➢ *Landslide Inventory and Rainfall Data Landslide*

Researchers created a GPS-based landslide inventory by systematically surveying all study sites. They recorded landslide coordinates with GPS Essentials and checked them against historical records from the Ministry of Territorial Administration (MINATD) and published studies. The inventory covers events from 1990 to March 2025. Landslide locations were mapped in ArcGIS 10.8 using an ASTER DEM to make the spatial inventory map.

Monthly and annual rainfall data for 2015–2024 were obtained from the Clouds and Earth's Radiant Energy System (CERES) satellite network operated by NASA, accessed through the National Observatory for Climate Change (ONACC). These data were analysed to explore temporal correspondence between precipitation anomalies and recorded landslide occurrences.

➢ *Land Use / Land Cover Change (LULC) Analysis*

LULC maps for 1985, 2005, and 2025 were generated from Landsat imagery using supervised classification in ArcGIS 10.8 and QGIS. Seven classes were identified: forest, agricultural/grassland, built-up, bare soil/rock, water bodies, wetlands, and shrub land. Change detection analysis was performed to quantify transitions, particularly forest loss and built-up expansion, as proxies for deforestation and settlement encroachment.

➢ *Statistical Analysis*

Binary logistic regression was used to test whether anthropogenic factors are statistically significant triggers of landslide occurrence (Hypothesis: H_0: anthropogenic factors are not significant triggers of landslides in Yaoundé; H_1: landslides in Yaoundé are significantly triggered by anthropogenic factors). The binary dependent variable was *landslide occurrence (presence = 1; absence = 0), derived* from the inventory dataset. Independent predictor variables representing potential drivers, such as rainfall, deforestation, settlement expansion, poor land-use planning, dam failure, road construction, agriculture, seismic activity, climate change, and cultural beliefs, were entered simultaneously into the model. Model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test (acceptable fit: $p > 0.05$). Results are reported as regression coefficients (B), Wald statistics, p-values, and odds ratios [Exp(B)] with 95% confidence intervals. All analyses were performed in SPSS v.26. Statistical significance was set at $\alpha = 0.05$.

III. RESULTS

➢ *Spatial Distribution and Occurrence of Landslides*

The landslide inventory mapped a total of 18 discrete events across the study area from 1990 to March 2025, with the majority concentrated in the northern and northwestern zones (Yaoundé II and V), corresponding to the highest-elevation quarters of Mbankolo, Ngousso, and Messa (Fig. 3). These areas are underlain by Andosols and Acrisols on slopes exceeding 15°, and their vulnerability is compounded by dense informal settlement. Mbankolo recorded the most events. Southern and eastern quarters (Damas, Oyom-Abang) recorded fewer events, consistent with their lower mean slopes (0–13°) and higher proportions of Ferralsol cover.

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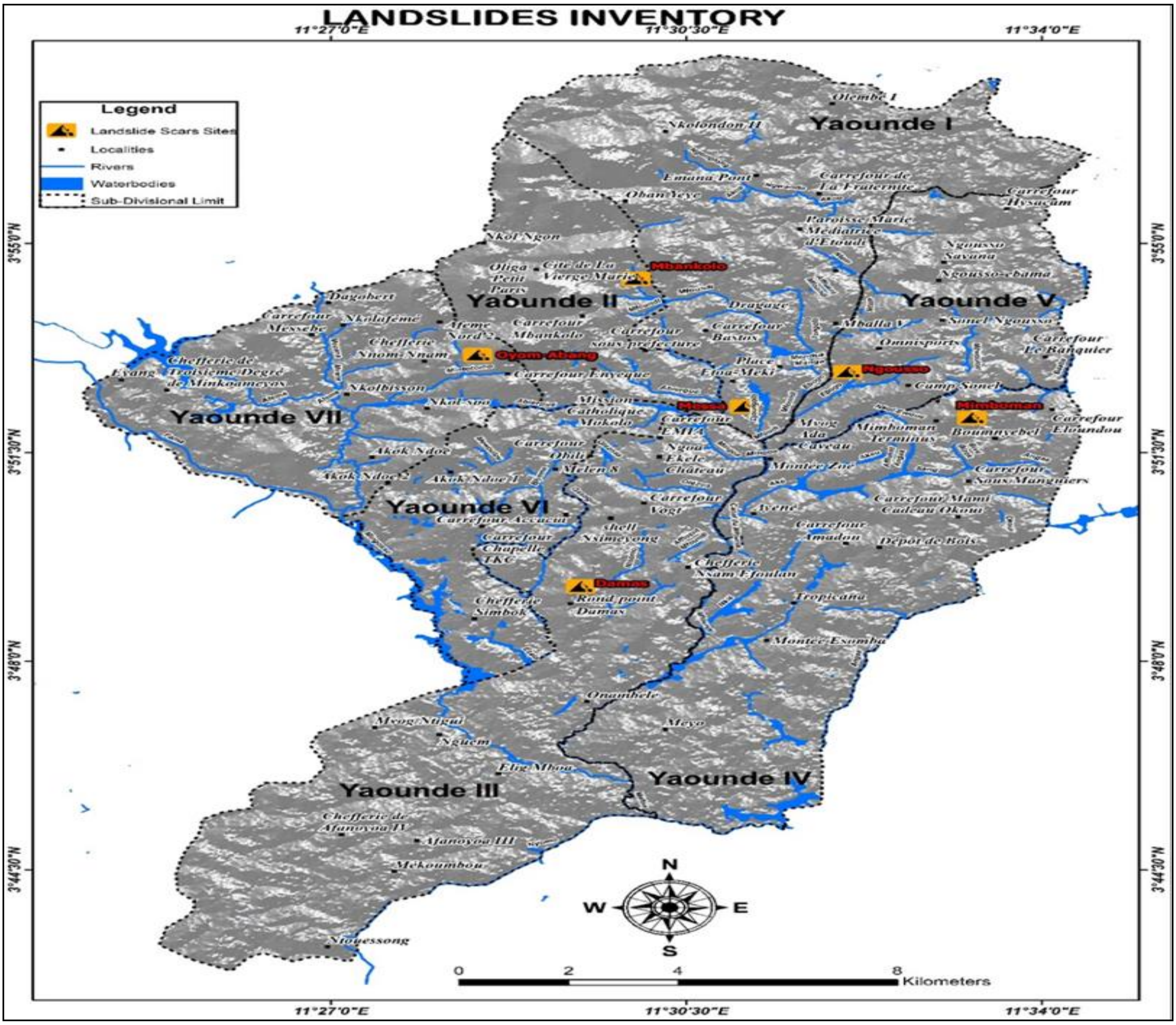

Fig 3 Landslide Inventory Map of Yaoundé (1990–2025).
Source: Kinyuy (2025)

Most people in the community were aware of the risk of landslides. Of 250 respondents, 82% (206 people) reported being aware of landslides in Mfoundi Division. Of these, 29% had seen a landslide in their own area, and 53% knew of landslides in nearby areas (Table 2). Only 13% said they were not aware of any landslides.

Table 2 Respondents' Awareness of Landslides in Yaoundé

Awareness Category	Landslide in own quarter (n)	No event in own quarter (n)	Total (%)
Aware of landslides	73 (29%)	133 (53%)	206 (82%)
Unaware of landslides	11 (4%)	22 (9%)	33 (13%)
Total	84 (34%)	155 (62%)	239 (96%)

Source: Fieldwork, 2025

- *Temporal Trends*

Temporal analysis indicates an irregular yet generally increasing trend in landslide frequency. No landslide events were recorded between 2015 and 2018. In 2019, a single event occurred in Ngousso (November), coinciding with an annual rainfall of 1,311 mm, the lowest in the ten-year dataset, but following an exceptionally wet October (348.68 mm). No events were documented in 2020 or 2021. In 2022, two events were recorded (Damas and Mimboman), corresponding with an elevated annual rainfall of approximately 1,700 mm and November precipitation of 198.90 mm. In 2023, one event was documented in Mbankolo, with 249.49 mm of rainfall recorded in October 2023. No events were recorded in 2024 (Fig. 4).

Among respondents, 76% (n = 82 of 108) perceived an increasing trend in landslide frequency, whereas 24% reported a decreasing trend. These perceptions are consistent with existing literature, which indicates intensifying hydrometeorological extremes due to climate change [13]. In addition, an estimated median of about 2 landslides per community over the past decade (range: 0–10) was recorded based on respondents' responses. Mbankolo and Nkolafeme had the highest medians (2.5), while Akok-Ndoué had the lowest (median 1.0; Table 3). These differences align with the spatial inventory and reflect the influence of slope gradient, soil type, and settlement density.

Table 3 Reported Landslide Frequency Per Community (Past 10 Years)

Community	n	Median	Mean	Max
Mbankolo	26	2.5	2.46	5
Nkolafeme	10	2.5	2.30	4
Messa	9	2.0	2.56	10
Febe	17	2.0	2.24	4
Oyom-Abang	11	2.0	2.00	3
Carrière	14	2.0	1.93	3
Nkolbisson	9	2.0	1.67	3
Damas	25	2.0	1.64	5
Akok-Ndoué	20	1.0	1.35	3
Overall	141	2.0	1.98	10

Source: Fieldwork, 2025

➢ *Rainfall Analysis–Landslide Relationships*

During the study period, annual rainfall ranged from 1,311 mm in 2019 to 1,728 mm in 2020, with a decadal average of about 1,500-1,600 mm per year. There was a general link between higher-than-average rainfall and more frequent landslides. The years with the most landslides, 2022 and 2019, had annual rainfall totals of 1,600-1,700 mm. Still, no landslides occurred in 2020 and 2021, even though those years also had relatively high rainfall. This suggests that annual rainfall alone does not fully explain when landslides occur.

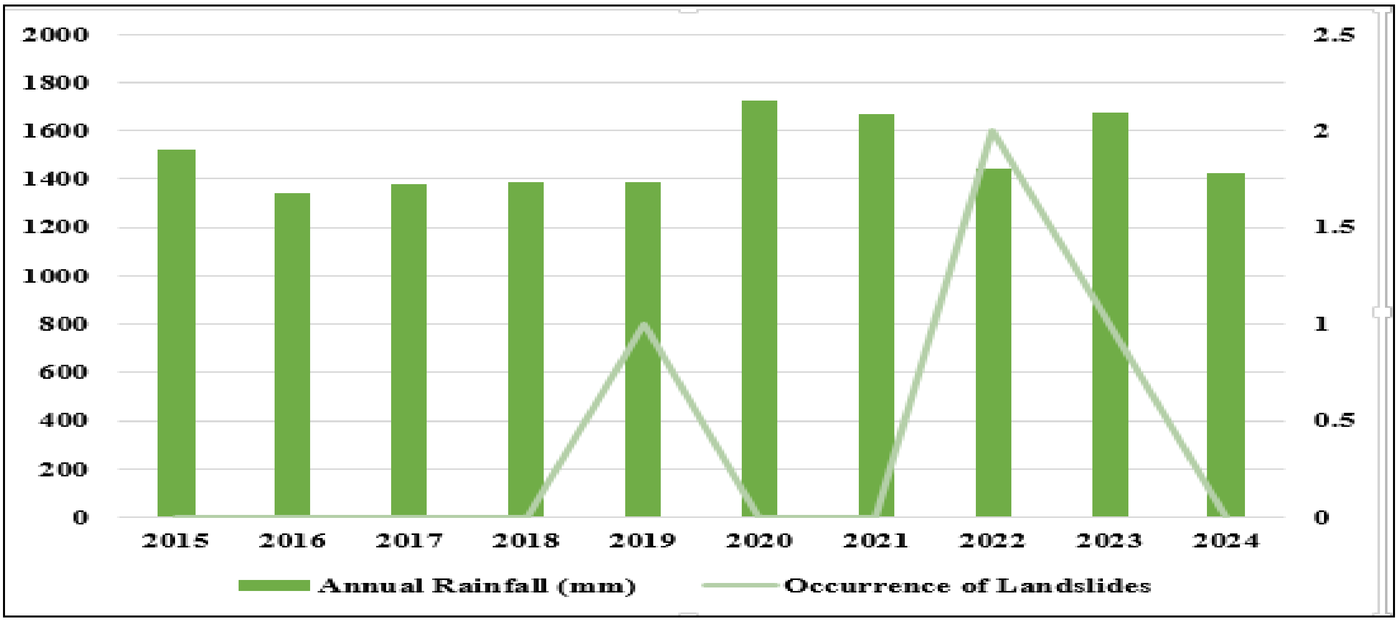

Fig 4 Annual Rainfall (mm) and Landslide Events in Yaoundé, 2015 to 2024.
Source: ONACC and MINATD, 2025

Monthly data reveal that October, with an average of 313 mm, and November, with 157 mm, are the wettest months. This matches the end of the long rainy season from September to November in Yaoundé's bimodal rainfall pattern. All three major events studied (2019, 2022, and 2023) happened in October or November. These findings suggest that heavy rainfall during the wet season, soil already saturated with water, and weaker clay-rich soils are the main climatic triggers, rather than the total annual rainfall.

➢ *Land Use and Land Cover Change*

LULC analysis revealed significant landscape changes over the past forty years. In 1985, forests predominated in Yaoundé I, III, and IV, while built-up areas were primarily concentrated in central Yaoundé II. By 2005, forest cover had declined dramatically, particularly in Yaoundé II, V,

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and VI, as agricultural land and urban development expanded around Mbankolo, Nkolbisson, and Mimboman. By 2025, built-up areas extended across all subdivisions, with forests restricted to higher slopes and protected reserves. Bare soil and rock areas increased in the northern region, indicating ongoing deforestation and land clearing. The expansion of settlements into areas with slopes exceeding 15 to 20 degrees, notably in Mbankolo, Febe, and Carrière, closely corresponds to locations where landslides have been documented.

Fig. 5 presents the LULC map of Yaoundé for 1985, revealing a landscape that was predominantly natural and largely undisturbed by large-scale urban development. At this time, dense forest cover dominated across most of the study area, particularly in Yaoundé I, III, and IV, where contiguous green canopy extended across both valley floors and hillside slopes. Built-up areas were minimal and largely confined to the central administrative core of Yaoundé II, reflecting the city's relatively contained urban footprint at the time. Agricultural and grassland patches were scattered across the southern periphery, while bare soil and rock exposures were rare, indicating that vegetation cover was largely intact across the hilly terrain. Wetlands and water bodies remained undisturbed along the major drainage channels. This baseline landscape, characterised by extensive forest cover and deep-rooting vegetation across steep slopes, provided natural slope protection through root reinforcement, interception of rainfall, and regulation of subsurface drainage.

Fig 5 LULC Map of Yaoundé (1985).
Source: Kinyuy (2025)

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Fig. 6 illustrates the significant landscape transformation by 2005, reflecting two decades of accelerating urban growth and land use change. Forest cover declined, especially in Yaoundé II, V, and VI, where vegetation was cleared to make way for expanding residential and agricultural land around the Mbankolo, Nkolbisson, and Mimboman neighbourhoods. Built-up areas expanded beyond the central urban core, reaching hillsides and valley margins. Bare soil and rock surfaces increased towards the northern zones, showing active deforestation and land clearing for construction. Water bodies became more fragmented as urban development encroached on riparian corridors, characterize by natural drainage.

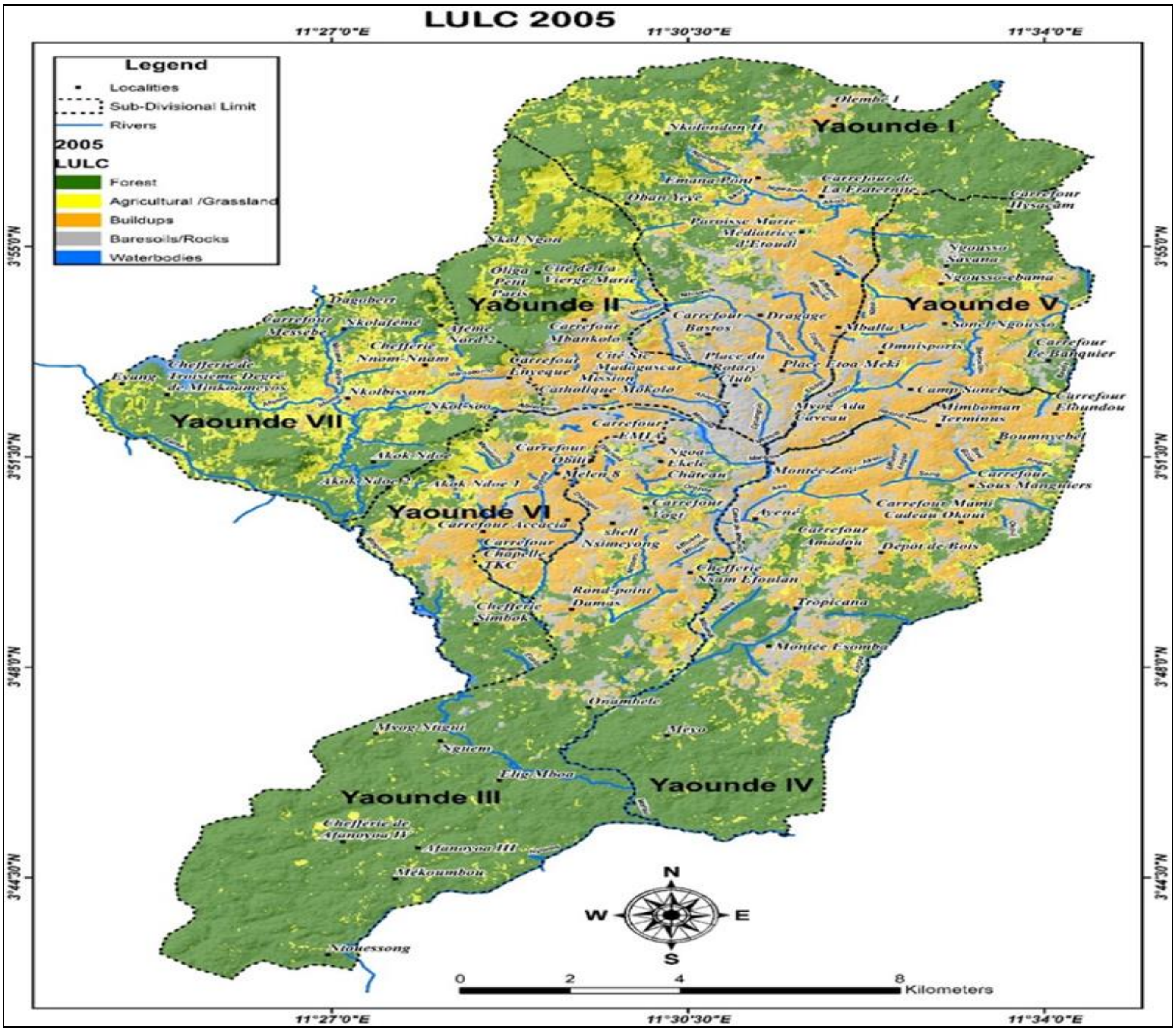

Fig 6 LULC Map of Yaoundé (2005).
Source: Kinyuy (2025)

Fig. 7 reveals Yaoundé's land use and land cover changes by 2025 over the past forty years. Forests have been heavily reduced in almost all areas, remaining only on the steepest slopes and in a few protected reserves. Built-up areas now cover most of the region, extending into the northern and north-western uplands of Yaoundé II and VI. Neighbourhoods like Mbankolo, Febe, Carrière, and Nkolbisson, which were mostly forest in 1985, are now developed. Moreover, more bare soil is observed in the northern zones, indicating ongoing deforestation and construction on unstable slopes. This tremendous loss of forest is challenging as these areas have slopes steeper than 15 to 20 degrees, clay-rich soils, thoroughly weathered materials, and a higher risk of landslides during heavy rain. The overlap between newly built-up areas and landslide locations recorded from 2015 to 2025 shows that ongoing deforestation and unregulated settlement are the main drivers of the increased risk of disasters in these naturally risky areas.

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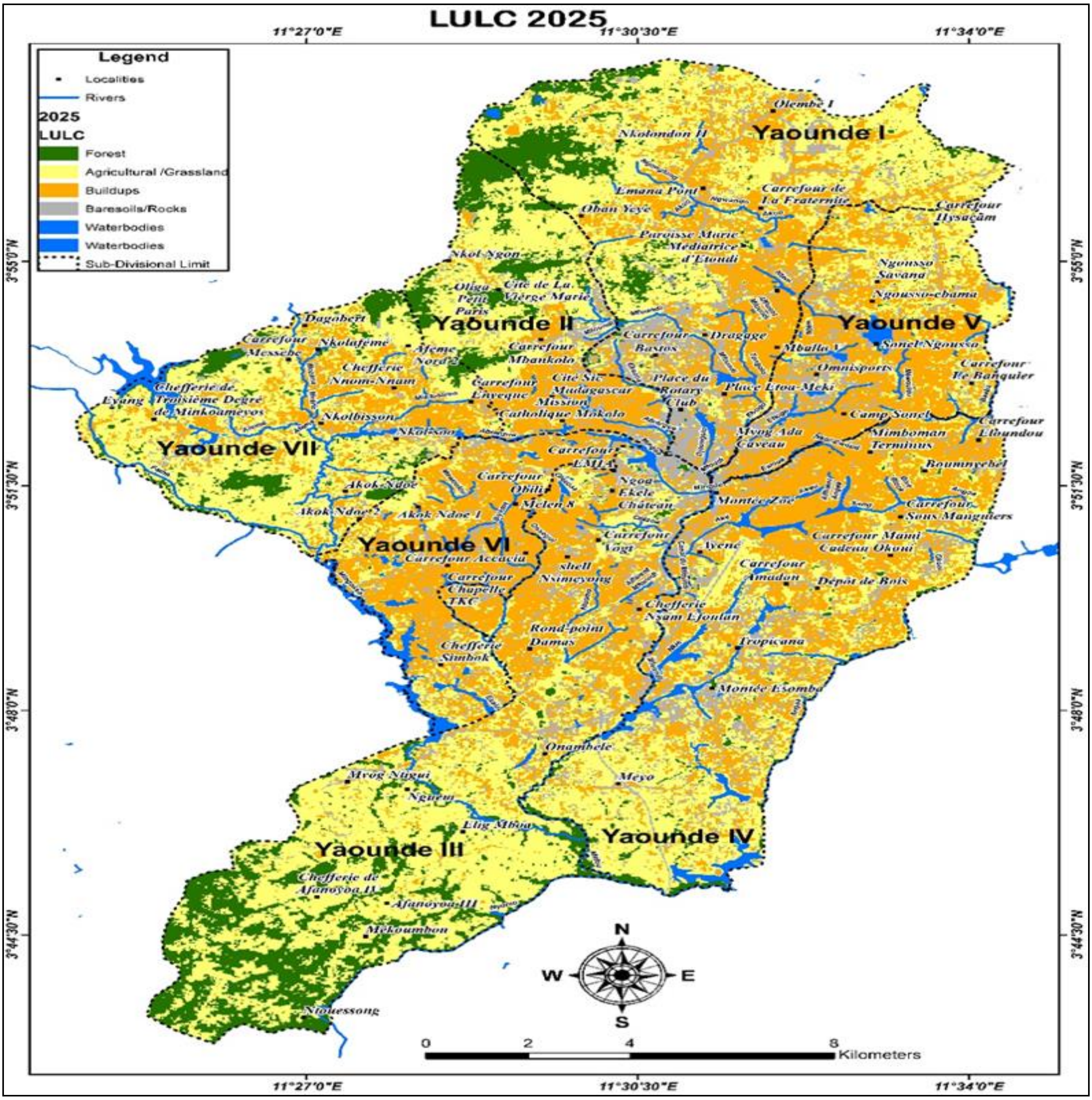

Fig 7 LULC Map of Yaoundé (2025).
Source: Kinyuy (2025)

Figures 5, 6, and 7 together show that stabilizing forest cover has been steadily replaced by informal built-up land on Yaoundé's most at-risk slopes over the past forty years. This clearly demonstrates that human-driven land use changes have made landslides more likely across the study area.

➢ *Perceived Drivers of Landslides*

Rainfall was identified by respondents as the primary trigger of landslides (80%), followed by poor land-use planning (62%), settlement expansion (52%), deforestation (50%), climate change (46%), dam failure (36%), road construction (34%), seismic activity (27%), agriculture (23%), and cultural beliefs (15%). The predominance of anthropogenic factors among these drivers, with six out of ten being human-induced, highlights the socially constructed nature of landslide risk in Yaoundé.

Qualitative evidence from interviews and focus group discussions supported these perceptions. A senior MINHDU official reported that a programme intended to deliver 10,000 residential units produced fewer than 4,000, resulting in overcrowding and informal hillside settlements. A Greenpeace Africa representative also described the

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Mbankolo tragedy as predictable, citing ineffective enforcement of existing land-use legislation. Field observations recorded houses built on slopes over 20°, structures with cracked foundations, pit latrines near streams, and active quarrying next to residential areas.

The dam failure observed during the 2023 Mbankolo event was significant. Testimonies from locals and field documentation confirm that the 100-year-old colonial-era Nkol Etam Dam overtopped during heavy rainfall, releasing a destructive wave that destabilised the hillside and swept through dense informal settlements below.

- *Statistical Test of Anthropogenic Drivers*

Table 4 presents the binary logistic regression results. The Hosmer-Lemeshow goodness-of-fit test yielded χ^2 (8) = 23.41, p = 0.064, indicating the model is well calibrated. Poor land-use planning (B = 0.799, Wald = 6.218, p = 0.013, OR = 2.22, 95% CI: 1.19–4.16) and deforestation (B = 0.793, Wald = 5.611, p = 0.018, OR = 2.21, 95% CI: 1.15–4.26) were statistically significant anthropogenic factors ($p < 0.05$), each more than doubling the odds of a landslide. Other human factors, including settlement expansion (p = 0.568), agriculture (p = 0.279), road construction (p = 0.345), dam failure (p = 0.987), and cultural beliefs (p = 0.417), were not significant. Natural triggers such as rainfall (p = 0.523), climate change (p = 0.107), and seismic activity (p = 0.940) were also not significant. These findings support rejecting the null hypothesis (H_0: anthropogenic factors are not significant triggers of landslides in Yaoundé).

Table 4 Binary Logistics Results (Predictors of Landslide Occurrence in Yaoundé)

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Rainfall	0.270	0.423	0.407	1	0.523	1.310	0.571	3.004
Deforestation	**0.793**	**0.335**	**5.611**	**1**	**0.018**	**2.210**	**1.147**	**4.260**
Settlement expansion	0.171	0.299	0.326	1	0.568	1.186	0.660	2.132
Dam failure	0.005	0.306	0.000	1	0.987	1.005	0.552	1.830
Cultural Belief	-0.456	0.561	0.660	1	0.417	0.634	0.211	1.905
Climate Change	-0.505	0.313	2.597	1	0.107	0.604	0.327	1.115
Agriculture	0.402	0.371	1.173	1	0.279	1.495	0.722	3.095
Road Construction	0.300	0.318	0.890	1	0.345	1.350	0.724	2.516
Poor land use planning	**0.799**	**0.320**	**6.218**	**1**	**0.013**	**2.222**	**1.186**	**4.163**
Seismic Activities	-0.026	0.337	0.006	1	0.940	0.975	0.504	1.885
Constant	0.099	0.590	0.028	1	0.867	1.104		

Statistically Significant ($p < 0.05$). Hosmer–Lemeshow Test: χ^2 (8) = 23.41, p = 0.064. Source: Fieldwork, 2025

IV. DISCUSSION

- *Spatial Patterns and Their Determinants*

Landslides in Yaoundé's northern and northwestern uplands, especially in Mbankolo, Ngousso, Messa, Febe, correspond to areas with predisposing physical conditions. These neighbourhoods are located at the highest elevations (800–1,100 m) on steep slopes (13–71°), where Andosols and Acrisols have low shear strength when saturated and poor drainage. This pattern is consistent with broader findings from equatorial Africa, where steep terrain and clay-rich soils increase intrinsic susceptibility [3], [14].

However, the spatial pattern is shaped by more than just physical geography. LULC analysis shows that the highest-risk areas have seen the most significant change from forest cover to informal built-up zones between 1985 and 2025. For example, Mbankolo changed from mostly forested hillside in 1985 to densely packed informal housing by 2025. This pattern is similar to what Dille et al. [15] found in other African cities, where building houses and roads changes both surface and underground water flow, which affects slope stability. Settlements near stream channels, as shown in the drainage network map, face an even greater risk because channel incision and bank erosion weaken the base of slopes.

- *Rainfall as a Triggering Factor (Intensity over Annual Totals*

The temporal analysis reveals an important distinction in the rainfall–landslide relationship. While years with elevated annual totals broadly correspond to higher event frequency, the strongest predictors of individual events are concentrated monthly rainfall during October–November and antecedent soil saturation. The 2019 Ngousso event occurred in a year of below-average annual rainfall (1,311 mm), following an exceptionally wet October (348.68 mm); the 2022 Damas event followed November precipitation of 198.90 mm; and the 2023 Mbankolo event coincided with October rainfall of 249.49 mm. This pattern is consistent with findings by Alsubal et al. [16] and Zhao et al. [17] who emphasise that reductions in matric suction and increases in

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pore-water pressure during intense short-duration rainfall are more critical mechanisms than annual precipitation totals.

The fact that there were no landslides in 2020 and 2021, despite high annual rainfall totals, suggests that rainfall intensity, prior conditions, and local human changes interact in complex ways to trigger landslides. This means that early warning systems should focus on short bursts of rainfall rather than on total rainfall over a season.

- *Anthropogenic Drivers (Statistical Evidence and Mechanisms)*

The binary logistic regression results confirm that poor land-use planning and deforestation each significantly increase the likelihood of landslides in Yaoundé (OR > 2.2 for both, $p < 0.05$), after accounting for other factors such as rainfall. This result aligns with established mechanisms: deforestation removes root reinforcement that stabilizes regolith [18], [19], while poor land-use planning enables settlement on slopes, disrupts natural drainage, leads to excavation at slope bases, and increases runoff from impervious surfaces [20], [15].

The lack of statistical significance for factors such as settlement expansion, road construction, and agriculture in the logistic model should be interpreted with caution. These factors remain important, but may be collinear with land-use planning, which includes regulatory failures across construction activities, or their effects may be mediated by deforestation. Qualitative and observational data confirm their influence: surveyors observed construction on slopes over 20°, road cuts without drainage, agricultural clearing on hillsides, and residential expansion near mining sites. These are clear examples of unregulated human activity that the Pressure and Release (PAR) model describes as dynamic pressures transforming root causes into unsafe conditions [21].

Although the dam failure did not achieve statistical significance as a predictor, it warrants particular attention due to its causal role in the 2023 Mbankolo landslide. The collapse of the Nkol Etam Dam during torrential rainfall illustrates what the PAR model defines as an unsafe condition: ageing infrastructure located near high-hazard informal settlements, maintained by poor governance and inadequate resources for inspection and remediation. This observation aligns with that of Depicker et al. [22], who identify ageing infrastructure as a significant yet frequently overlooked driver of urban slope instability.

- *Theoretical and Policy Implications*

Collectively, these findings indicate that landslides in Yaoundé are primarily socially constructed disasters, as defined by the Pressure and Release model [21] and the Theory of Vulnerability and Adaptation to Disaster [23]. At the same time, natural triggers such as intense rainfall and steep topography are necessary but not sufficient to cause disasters. Instead, these triggers become disasters due to the cumulative effects of poverty-driven informal settlements on hazardous slopes, inadequate enforcement of land-use regulations, and ongoing deforestation that diminishes vegetation's protective capacity.

The policy implications are clear. First, enforcement of existing land-use legislation, including the 2011 orientation law and the 2016 National Land Use Planning Plan, must be strengthened, with particular emphasis on prohibiting construction on slopes exceeding 15 degrees. Secondly, targeted reforestation programs on denuded hillsides in Mbankolo, Febe, and Nkolbisson are recommended to reduce landslide risk by restoring root reinforcement and interception capacity. Third, early warning systems based on short-duration rainfall thresholds during October and November should be prioritised and integrated with community-based evacuation strategies. Finally, the inventory of ageing infrastructure, particularly colonial-era water retention structures, must be urgently updated, and critical facilities should be either repaired or decommissioned.

V. CONCLUSION

A comprehensive analysis of spatial patterns, temporal trends, and multi-factorial drivers of landslides in Yaoundé, Cameroon, was conducted using GPS-based inventory mapping, community surveys, rainfall data analysis, LULC detection, and binary logistic regression. The principal findings are as follows: (1) landslides are spatially concentrated in the high-elevation, steep-slope northwestern quarters (Mbankolo and Febe), where forest conversion to informal settlement has been most intensive over the past four decades; (2) concentrated October–November rainfall, rather than annual precipitation totals, serves as the primary climatic trigger; (3) 76% of residents perceive an increase in landslide frequency; and (4) poor land-use planning and deforestation are statistically significant anthropogenic drivers, each more than doubling the odds of landslide occurrence.

The findings indicate that landslides in Yaoundé result from the interaction between physical susceptibilities and socially constructed vulnerabilities, rather than being solely natural events. Effective risk reduction necessitates a dual approach: mitigating anthropogenic factors that increase susceptibility through improved land-use governance and targeted reforestation, and investing in meteorological early warning systems calibrated to short-duration rainfall thresholds.

Future research should utilize high-resolution rainfall data at sub-daily intervals to enhance threshold modelling, employ satellite-based deformation monitoring to identify slow-moving slope movements prior to catastrophic failure, and implement longitudinal socio-economic tracking to assess how vulnerability changes with ongoing urbanization. Applying this framework to other rapidly expanding tropical African cities with comparable geomorphological and socio-economic characteristics would strengthen the evidence base for regional disaster risk reduction policy.

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