

IMPACT OF DEVOLUTION ON LAND USE AND LAND COVER DYNAMICS IN SUNA EAST SUB COUNTY, KENYA: PATHWAYS TO SUSTAINABLE DEVELOPMENT

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Abstract

This study investigates how devolved governance, intended to empower local communities, is driving rapid and potentially harmful changes in land use and land cover in Suna East Sub County, Migori County. Employing a mixed-methods approach, the research integrates geospatial analysis of satellite imagery (ArcGIS, ERDAS Imagine) with quantitative data from household surveys (n=395) analyzed via SPSS, alongside qualitative insights from eight focus group discussions and fifteen key informant interviews. Inferential statistical tests, including chi-square and regression analyses, were employed to assess relationships between socio-demographic factors and perceptions of land use change. Spatial classification, change detection, and thematic content analysis further complement the methodological framework. The study compares land changes before (2008–2013) and after (2013–2018) devolution, revealing a pronounced expansion of built-up areas by 31% after devolution compared to just 1% before devolution. This is accompanied by a 36% decline in farmland, a 2% increase in bare land, and a significant slowdown in tree cover growth from 18% before devolution to 5% after. These transformations correspond with a 43% increase in county urban development expenditure (2014–2020), reflecting governance-driven urbanization and land fragmentation processes. While devolution has improved access to infrastructure and services, it has also introduced significant environmental challenges, including increased flooding, heat stress, and food security risks linked to agricultural land loss. Notably, gains in tree cover are spatially uneven and have failed to alleviate community concerns regarding ecological degradation. The findings underscore complex trade-offs between socio-economic development and environmental sustainability within decentralized governance frameworks. To foster resilient and equitable land governance, the study recommends enhanced LU/LC monitoring, capacity building, inclusive spatial planning, and the establishment of secure land tenure systems. Striking a balance between rapid infrastructure expansion, ecosystem conservation, and local participation is essential for sustainable development in devolved contexts.

Keywords: Devolution, Land Use Change, Urbanization, Environmental Governance, Sustainable Development, Spatial Planning

Introduction

Changes in land use and land cover (LU/LC) represent a major driver of global environmental transformation, with far-reaching implications for ecological integrity, socio-economic development,

and long-term sustainability. These transformations are frequently propelled by rapid urbanization, population growth, evolving agricultural practices, and institutional reforms. Collectively, these drivers can jeopardize biodiversity, disrupt food systems, and heighten vulnerability to climate change (Food

and Agriculture Organization [FAO], 2021; Lambin & Geist, 2021). Among the institutional reforms influencing LU/LC trajectories, devolution—a comprehensive form of decentralization, has emerged as a critical force, particularly through the transfer of governance authority from national to sub-national entities (Makanga & Musili, 2021).

Across Africa, Asia, and Latin America, the adoption of devolution has yielded diverse outcomes. While some countries have reported improvements in land tenure security and community participation, others continue to grapple with deforestation, land degradation, and institutional weaknesses (Mwangi & Wardell, 2021; Otieno et al., 2024). In the African context, Kenya, Uganda, and South Africa have embraced devolution with the aim of enhancing accountability, equitable resource distribution, and improved governance over natural resources (Boone et al., 2020; Njiru et al., 2021).

Kenya's 2010 Constitution marked a significant institutional shift by establishing devolution as a governance principle, delegating authority over land, natural resources, and spatial planning to 47 county governments (Government of Kenya, 2021). The reform was designed to redress historical disparities, foster inclusive development, and promote sustainable land governance. Nonetheless, empirical research assessing the spatial and environmental impacts of devolution remains limited. Preliminary evidence from counties such as Nairobi, Kisumu, and Mombasa suggests that devolution has accelerated land fragmentation and the conversion of agricultural land to urban use (Kageni, 2021; Ngugi & Mwangi, 2022), underscoring the inherent tension between development objectives and environmental sustainability.

Suna East Sub County in Migori County provides a particularly salient context for examining post-devolution LU/LC transformations. Traditionally agrarian, the sub-county has experienced rapid urban expansion, deforestation, and the conversion of farmland, changes driven by shifting policies, demographic pressures, and infrastructural investment (Migori County Government, 2022).

Although devolution has strengthened local governance institutions, the ecological and socio-economic outcomes of these LU/LC changes remain inadequately understood. The persistence of weak enforcement mechanisms, competing land interests, and data limitations continues to undermine the effectiveness of spatial planning in the region.

This study is framed within the Land Use Transition Theory (LUTT), which provides a useful lens for interpreting LU/LC changes as processes driven by interconnected political, ecological, and economic forces (Lambin & Meyfroidt, 2020). Governance reforms such as decentralization are instrumental in shaping the direction and pace of these transitions. Depending on the strength and coherence of institutional frameworks, decentralization may either promote sustainable land stewardship or accelerate degradation (Chepkwony, 2021). By applying LUTT, this study aims to elucidate the mechanisms through which devolved governance influences land cover dynamics and their broader environmental and socio-economic implications.

Decentralization broadly entails the redistribution of decision-making powers, responsibilities, and resources from central to local governments, based on the premise that local institutions, being closer to their environmental and social contexts, are better positioned to respond to ecological challenges and to foster participatory governance (Agrawal & Ribot, 2021). Devolution, as a more extensive and constitutionally anchored form of decentralization, grants counties substantive authority over land and resource management. However, the success of devolution hinges on the institutional capacity of local governments to implement policies, enforce regulations, and involve diverse stakeholders. Where such capacities are lacking, the intended benefits of decentralization may be compromised by weak governance and limited technical proficiency (Mwangi et al., 2022).

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) highlights that LU/LC changes significantly affect biodiversity, ecosystem services, and human well-being worldwide. In Sub-Saharan Africa,

development-driven land use transitions often generate short-term socio-economic gains at the expense of long-term ecological sustainability. For example, agricultural intensification in Malawi improved food security but intensified soil erosion and forest clearance (Chirwa et al., 2020). In Kenya, similar trade-offs are evident: while agricultural productivity has risen in Kiambu, it has been accompanied by land degradation (Maina et al., 2020); in Kisumu, wetland loss has diminished ecosystem services and negatively affected livelihoods in fishing and farming communities (Omondi et al., 2019). In Ruiru watershed, expanding agriculture and urban settlements have reduced water availability, exposing governance deficits in land and water resource management (Onyango et al., 2020).

Remote Sensing (RS) and Geographic Information Systems (GIS) technologies have proven indispensable in the monitoring and analysis of LU/LC changes, providing spatially explicit and temporally dynamic data that inform planning and policy. Globally, satellite imagery has been employed to track patterns of urbanization and forest change linked to governance reforms (Li et al., 2020; Silva et al., 2021). In Africa, RS/GIS analyses have illuminated trends in land degradation, deforestation, and urban expansion, often correlating with governance gaps (Adepoju et al., 2021; Gebremicael et al., 2020). In Kenya, such tools have documented forest decline in Mt. Kenya (Kageni, 2021), urban sprawl in Nairobi (Kathumo, 2021), and degradation in the Cherangany Hills (Rotich et al., 2022), highlighting their value for evidence-based land governance under devolution.

Although a growing body of literature explores devolution and LU/LC changes in Kenya, substantial gaps remain. Research has disproportionately focused on urban and coastal areas, with rural inland counties such as Suna East receiving limited scholarly attention. These regions face distinctive land pressures and governance challenges that merit closer analysis. Furthermore, while RS/GIS tools are widely applied, their integration with institutional and socio-economic analysis remains underutilized.

There is a pressing need to examine how county governments engage in land policy enforcement, tenure regulation, and participatory governance, especially in contexts marked by rapid land use transitions.

This study therefore aims to evaluate the influence of devolution on LU/LC dynamics in Suna East Sub County, Migori County, by analyzing spatial and socio-economic changes before and after devolution and to develop context-specific strategies for sustainable land management under a devolved governance system. Specifically, the study seeks to quantify the extent of LU/LC changes using RS and GIS tools, assess the socio-economic and environmental impacts of these changes, and recommend sustainable land governance strategies that align with the principles and realities of devolved governance. These objectives together address the critical need to understand how governance reforms translate into land use outcomes and inform policies that balance development with environmental stewardship.

Materials and Methods

This study employed a mixed-methods approach to investigate the impacts of devolved governance on land use and land cover (LU/LC) transformations in Suna East Sub County, Migori County, Kenya. Integrating quantitative geospatial analysis with qualitative data and socio-economic surveys enabled a comprehensive understanding of spatial changes alongside community perceptions and governance dynamics. The study period (2008–2018) was divided into two intervals, before devolution (2008–2013) and after devolution (2013–2018), to assess the effects of Kenya's 2010 constitutional reforms on land governance and LU/LC patterns.

Suna East Sub County, located in southwestern Kenya along the Tanzania border within the Lake Victoria Basin, is characterized by a mosaic of ecological zones including farmland, wetlands, shrublands, tree cover, and built-up areas. Rapid infrastructural growth and changing land tenure dynamics following devolution made it an ideal case

for examining governance-driven spatial transformations.

The sampling frame included 122,674 households from the 2019 Kenya Population and Housing Census (Kenya National Bureau of Statistics [KNBS], 2020). Using the Taro Yamane formula, a statistically representative sample of 400 households was selected via stratified random sampling across the four wards and their administrative sub-locations. Household heads were the primary respondents due to their central role in land use decisions and local governance participation.

Qualitative data collection employed purposive sampling to engage 15 key informants with specialized knowledge and decision-making roles in land governance and environmental management. These included county land officers, urban planners, environmental officers, agricultural extension agents, ward administrators, local chiefs, and respected community elders. Their insights were critical for understanding institutional frameworks, policy implementation, and historical land use changes. In addition, eight Focus Group Discussions (FGDs) were conducted, two per ward, each comprising 8 to 12 participants. These groups represented a cross-section of socio-economic actors, including smallholder farmers, women's group leaders, youth representatives, informal settlement dwellers, land vendors, and members of community-based organizations. The FGDs provided rich perspectives on grassroots experiences of land subdivision, real estate speculation, environmental degradation, and livelihood transformations in the post-devolution era.

Spatial data were generated from Landsat satellite imagery for 2008 (TM), 2013 (ETM+), and 2018 (OLI/TIRS), sourced from the Regional Centre for Mapping of Resources for Development. Images underwent pre-processing steps including atmospheric correction, mosaicking, and sub-setting. Land cover classification was performed using the Maximum Likelihood Classification (MLC) algorithm, categorizing five land cover types: built-up areas, farmland, shrubland, tree cover, and bare land. ArcGIS 10.8 was employed primarily for

classification, change detection, and spatial statistical analyses, while QGIS 3.22 was utilized for map production and visualization.

Quantitative household survey data were analyzed using SPSS Version 26. Descriptive statistics (means, frequencies, percentages) summarized land use trends and socio-economic indicators. Inferential statistical analyses were conducted to examine relationships and differences, including chi-square tests for independence (e.g., length of residence vs. perception of land use change), paired sample t-tests comparing LU/LC changes before and after devolution, and regression models assessing correlations between time periods and land use categories, as well as built-up area expansion and service access outcomes. These inferential methods provided rigorous evidence on the statistical significance and strength of observed patterns.

Qualitative data from FGDs and key informant interviews were analyzed thematically. Coding and clustering identified recurrent themes such as governance shifts, land tenure security, institutional coordination challenges, and environmental degradation. Triangulation of spatial, statistical, and qualitative evidence enhanced the validity and depth of the study's conclusions.

Ethical approval was granted by the National Commission for Science, Technology and Innovation (NACOSTI). Informed consent was obtained from all participants, and confidentiality was ensured through anonymization of data. Participants were informed of the study objectives and their voluntary participation rights.

Results and Discussion

Response Rate and Demographic Characteristics of Respondents

The study achieved a 98.75% response rate, with 395 of 400 questionnaires returned, enhancing data reliability and representativeness. Demographically, 57% of respondents were male and 43% female, with 38% aged 26–35, indicating a youthful, economically active population. Farming was the main occupation (42%), reflecting strong agricultural dependence.

Additionally, 46% had lived in Suna East for over 20 years, suggesting deep community roots and valuable local knowledge on land use changes. These demographics contextualize community perspectives on land transformations under devolution.

A chi-square test assessed the relationship between length of residence and perceptions of land use change, revealing a significant association ($\chi^2 = 13.57$, $df = 3$, $p < 0.01$). Long-term residents were more likely to report negative environmental impacts linked to built-up expansion. This suggests that extended residency may heighten awareness of urban development's environmental consequences.

Temporal Patterns in Land Use and Land Cover (LU/LC) Change

A temporal analysis of LU/LC dynamics over a 10-year period (2008–2018), segmented into two distinct phases, before devolution (2008–2013) and after devolution (2013–2018), to reflect governance shifts revealed substantial spatial transformations in Suna East Sub-County. As illustrated in Table 1 and Figure 1, built-up areas increased markedly from 1,379.76 ha (7%) in 2008 to 8,010.43 ha (39%) in 2018, indicating intense urbanization driven by decentralized governance.

Concurrently, farmland declined sharply from 13,300.45 ha (64%) to 3,512.70 ha (17%), suggesting that agricultural land was increasingly repurposed for residential and infrastructural developments. In contrast, tree cover expanded significantly from 1,228.57 ha (6%) to 6,007.39 ha (29%), reflecting active afforestation initiatives, agroforestry adoption, and conservation efforts.

Table 1

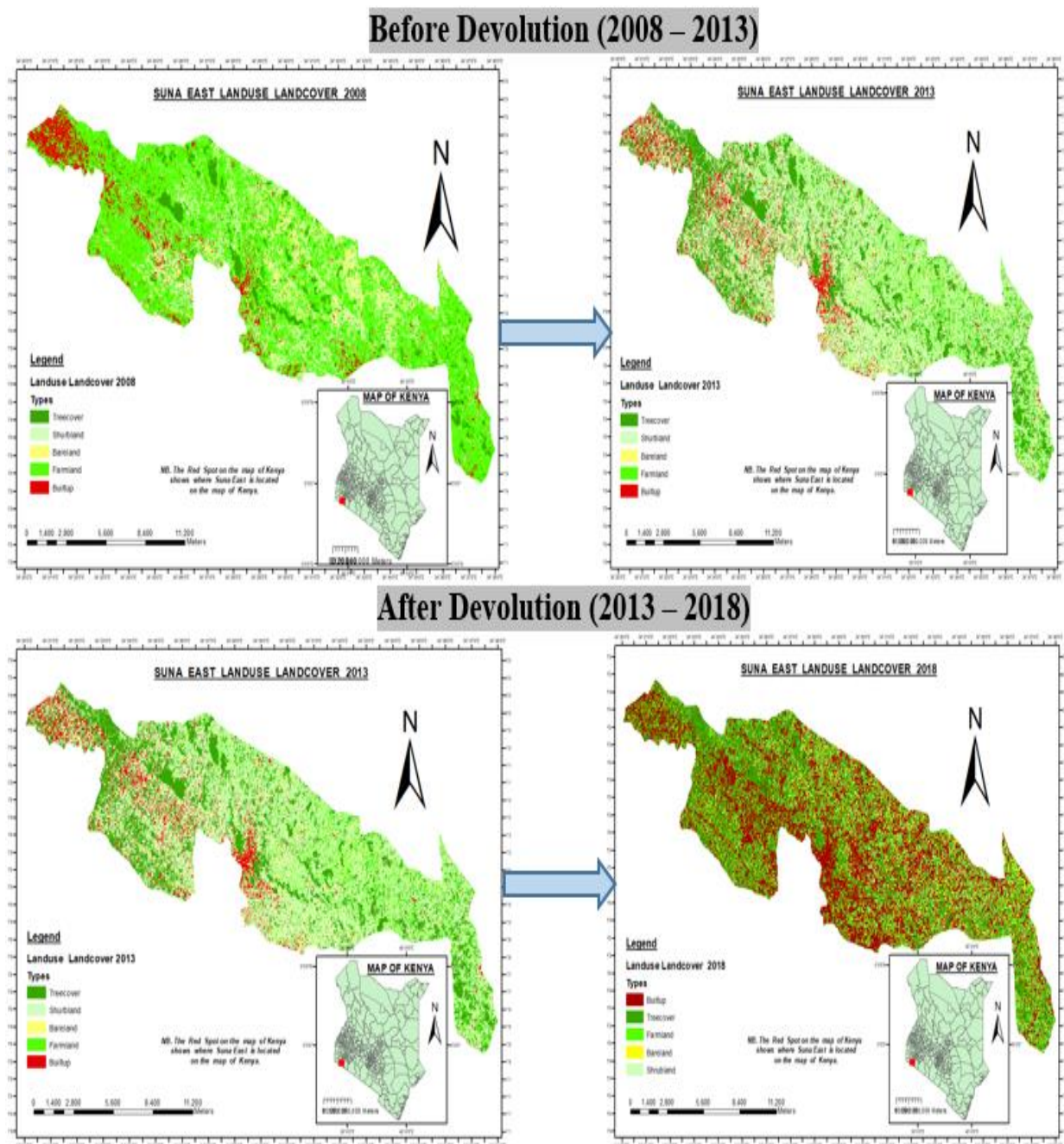
Trend of LU/LC changes Suna- East over 10 - year period

LULC	2008		2013		2018	
	Sum_Area (Ha)	%	Sum_Area (Ha)	%	Sum_Area (Ha)	%
Bare land	1190.48810	6	1000.54739	5	1393.35113	7
Farmland	13300.4548	64	10882.9089	53	3512.69816	17
Built up	1379.76224	7	1654.63404	8	8010.42906	39
Shrub land	3553.32138	17	2189.28938	10	1728.90038	8
Tree cover	1228.57419	6	4925.41482	24	6007.38856	29

Source: Field Data, 2025

To evaluate the strength of the relationship between the time period (before devolution versus after devolution) and various land use categories, a regression model was fitted with land use type as the dependent variable and time period as the independent variable. The results demonstrated that built-up area expansion exhibited the strongest positive correlation with the time variable ($R^2 = 0.82$, $p < 0.001$), indicating a substantial increase in

urban development following devolution. In contrast, farmland showed a statistically significant negative correlation with time ($R^2 = -0.75$, $p < 0.01$), suggesting a notable decline in agricultural land over the same period. These findings underscore a marked shift in land use patterns associated with the post-devolution era, characterized by accelerated urbanization and a corresponding reduction in agricultural space.

Figure 1*LU/LC changes before and after Devolution in Suna East Sub County**Source: Field Data, 2025*

These trends align with findings from related empirical studies. For example, in Kibwezi West, Kenya, spatio-temporal LU/LC analyses revealed similar trajectories of agricultural loss and urban expansion in dryland contexts (Mwang'ombe et al.,

2024). In Gauteng, South Africa, Dube et al. (2023) documented comparable built-up growth following decentralization. Likewise, peri-urban villages in Tamil Nadu, India, experienced a 25–30% reduction

in farmland following governance devolution (Ramanathan & Prasad, 2022).

Land Use and Land Cover Transitions Before and After Devolution

A comparative evaluation of LU/LC changes before devolution (2008–2013) and after its implementation (2013–2018) provides a clearer understanding of the impacts of governance

reforms. Before devolution period, land use changes were relatively modest: built-up area increased by only 275 ha (1%), and tree cover expanded by 3,697 ha (18%). However, following the full implementation of devolution, built-up area expanded dramatically by 6,356 ha (31%), while farmland contracted sharply by 7,370 ha (36%), as shown in Table 2.

Table 2

LU/LC changes before and after Devolution in Suna East Sub County

LU/LC	Change in LU/LC (2008-2013)		Change in LU/LC (2013-2018)	
	(Ha)	(%)	(Ha)	(%)
Bare land	-189.94	-1	+392.80	+2
Farmland	-2,417.55	-11	-7,370.21	-36
Built up	+274.87	+1	+6,355.80	+31
Shrub land	-1,364.03	-7	-460.39	-2
Tree Cover	+3,696.84	+18	+1,081.97	+5

Source: Field Data, 2025

Paired sample t-tests reveal statistically significant differences in land use patterns before and after devolution, with p-values less than 0.01 for both built-up areas and farmland. These results indicate that the observed changes are unlikely due to chance and instead reflect a structural impact of the policy shift toward decentralized governance. This suggests that devolution has fundamentally altered land allocation and use, driving notable spatial and functional changes. Importantly, the transformation was asymmetric: built-up areas expanded substantially, reflecting increased urbanization and infrastructure development, while farmland contracted significantly. This imbalance highlights the prioritization of non-agricultural uses over agricultural productivity, with serious implications for local food security, rural livelihoods, and land management.

This pattern is consistent with recent continental findings. Musiega et al. (2025), for instance, demonstrated that land governance reforms in Kenya's agropastoral regions triggered nonlinear, category-specific land cover transitions, including accelerated urban growth and farmland loss. Their

study supports the interpretation that decentralization policies often lead to uneven land use outcomes, reinforcing the view that structural policy interventions can reshape land systems in complex and asymmetric ways.

Built-Up Area Expansion: Development Benefits and Ecological Costs

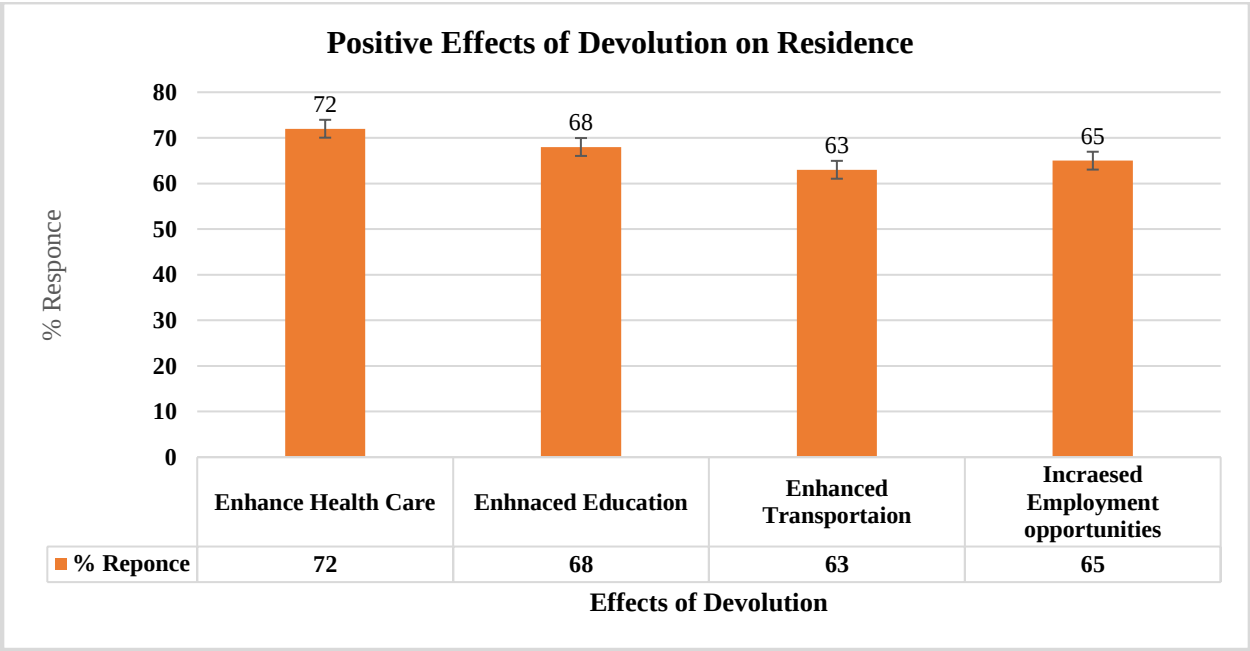
The post-devolution expansion of built-up areas in Suna East Sub-County represents the most significant LU/LC transformation observed during the study period. Between 2013 and 2018, built-up land increased by over 6,356 hectares, an expansion exceeding 2,200% compared to the modest 1% growth recorded in the before devolution period. This dramatic growth is largely attributable to local government investments in infrastructure such as roads, markets, schools, and administrative buildings, as confirmed through Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). A county planner noted that devolution empowered local authorities to allocate funds for infrastructure previously neglected by the central government.

Survey data reveal notable improvements in access to essential services among respondents as shown in Figure 2. Specifically, 72% reported enhanced access to healthcare, reflecting the critical importance of medical services to community well-being. Access to education also showed significant improvement, with 68% of respondents indicating better availability of educational resources. Transportation services, while slightly lower, still saw a majority of 63% reporting improved access, underscoring progress in mobility and connectivity. Alongside these service improvements, 65% of respondents identified new employment or business opportunities emerging particularly in the construction, trade, and transport sectors,

highlighting the positive economic impact associated with these developments.

Regression analysis further supports these findings, demonstrating that the growth of built-up areas significantly predicts improved access to these services ($\beta = 0.67, p < 0.01$). This suggests that urban expansion and infrastructure development are key drivers in enhancing service availability for the population. However, it is worth noting that the same growth is only marginally correlated with improved environmental outcomes ($\beta = 0.21, p = 0.08$), indicating that while economic and service benefits are clear, environmental improvements may require additional focused efforts.

Figure 2
Effects of Devolution on Residents of Suna- East



Source: Field Data, 2025

These findings align with international comparisons. For instance, in Pune, India, Koparde and Chalke (2025) reported that a 12% increase in built-up land was associated with a 34% decline in carbon sequestration and a 13% reduction in flood mitigation capacity. Similarly, in Nigeria, Ota et al. (2021) documented direct vegetation loss due to urban expansion.

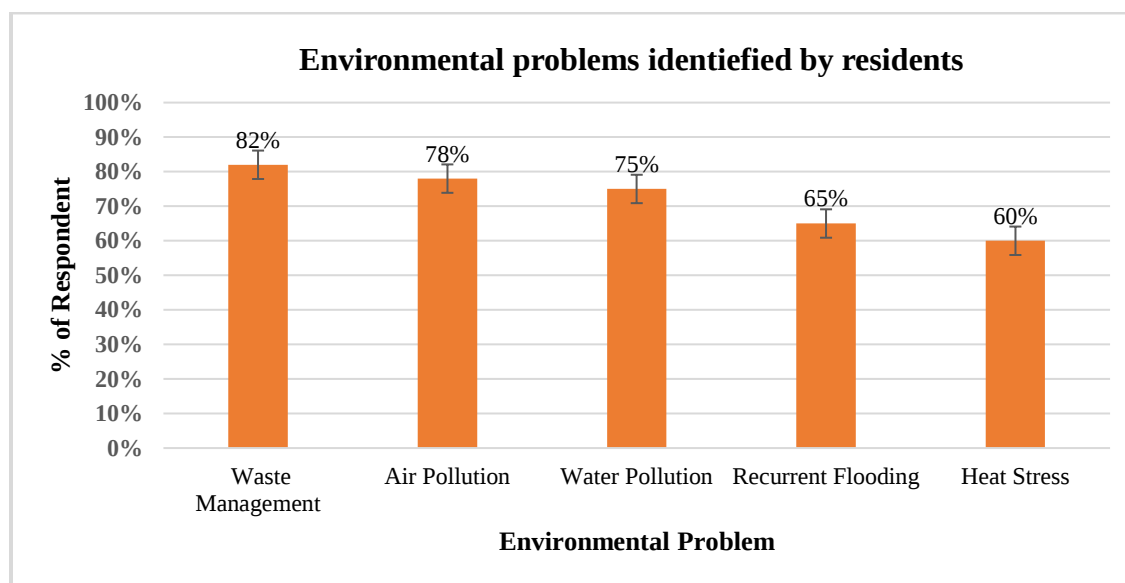
Despite development gains, the study revealed environmental challenges linked to devolution-driven urban expansion. Interviews with residents showed that 82% identified worsening waste management due to governance changes and rapid growth in informal settlements as shown in Figure 3. Similarly, 78% attributed air pollution to unregulated construction and poor environmental

oversight post-devolution. Water pollution was linked by 75% to inadequate sanitation in new urban areas. Flooding was connected to devolution by 65%, while 60% noted heat stress from urban heat islands and broader climate variability beyond

governance factors. These findings show how devolution has amplified environmental vulnerabilities, highlighting the need for integrated spatial planning and sustainable infrastructure.

Figure 3

Environment Problems linked with devolution in Suna- East



Source: Field Data, 2025

These findings align with a 2018 Kenyan study by Wanjohi and Muia on solid waste management under devolution in Kiambu County, which reported worsening waste problems due to rapid urbanization and insufficient infrastructure (Wanjohi & Muia, 2018). A 2022 continental study by Kizza et al. on air pollution trends in African cities, including Nairobi and Kigali, confirmed that rapid urban growth and weak transport infrastructure drive increased pollution (Kizza, Oyoo-Okoth, & Tumwebaze, 2022). Together, these studies validate the local impacts of devolution-driven urban growth on environmental quality and stress the importance of sustainable planning to mitigate these issues.

Stakeholders interviewed suggested integrating sustainable urban planning and green infrastructure approaches, such as urban green belts, permeable surfaces, and protected wetlands, to mitigate these ecological impacts while maintaining development gains. This suggestion is consistent with findings

from Wambua and Ouma (2023) in Nakuru County, where poorly planned urban growth resulted in ecological degradation. Comparable stressors have also been documented in peri-urban Nairobi (Ng'ang'a et al., 2022) and Kisumu (Munga et al., 2023).

Farmland Decline in Suna East Sub County: A Consequence of Devolution

An analysis of land use and land cover changes in Suna East Sub County reveals a significant and accelerating decline in farmland between 2008 and 2018. Agricultural land contracted by 11% (2,417.55 hectares) during the pre-devolution period (2008–2013), but this decline intensified sharply to 36% (7,370.21 hectares) post-devolution (2013–2018). This trend indicates that the shift to decentralized governance has profoundly altered land dynamics, exacerbating farmland loss and raising critical

concerns for local food security and rural livelihoods.

Field surveys, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) consistently identify key drivers of farmland decline, with devolution-related changes leading at 80% (see Table 2). These governance shifts have fragmented land management and fueled speculative land use. Accelerated land subdivision (75%), mainly due to inheritance and urban encroachment, further breaks farms into smaller, less viable plots. Speculative real

estate investment (70%) treats farmland as a short-term financial asset, while inheritance-driven fragmentation (68%) continues to reduce farm sizes. Additionally, 60% of respondents noted youth converting farmland into sale or rental plots, reflecting shifting economic priorities away from farming. As one FGD participant noted, “farms have become plots,” illustrating how land is increasingly commodified rather than used productively, jeopardizing long-term sustainability and food security.

Table 2

Drivers of Farm Decline in Suna East

S/No	Courses of Farm Declines	Frequency (%)
1	Devolution-related changes	80
2	Accelerated land subdivision	75
3	Speculative real estate investment	70
4	Inheritance-driven fragmentation	68
5	Youth converting farmland into sale/rental plots	60

Source: Field Data, 2025

Farmland fragmentation reduces plot sizes, undermining productivity and mechanization potential essential for food production. Smaller parcels limit farmers' ability to adopt modern technologies, and economies of scale become unfeasible. Fragmented holdings also restrict access to credit and inputs, as lenders favor larger farms perceived as more viable. This exacerbates rural poverty by limiting farmers' capacity to intensify production or diversify income sources. With population growth and urban expansion, these trends pose serious risks to food security and rural livelihoods. As farmland is subdivided and converted, communities face increased vulnerability to food shortages and marginalization. These challenges underscore the urgent need for policies that enhance land tenure security, promote sustainable land management, and support smallholder integration.

Paradoxically, farmland loss has occurred alongside increased tree cover, driven by afforestation, agroforestry, and community forestry programs. While vegetation cover has improved, much of this

expansion comprises non-food species such as eucalyptus. This raises questions about whether such gains compensate for farmland loss in terms of livelihoods and ecosystem services. Agroforestry benefits soil conservation and income diversification but does not fully replace lost food production. Economic returns from timber or non-timber products often favor wealthier landowners, with mixed effects on household food security.

The socio-economic impacts of farmland decline are profound. Although land value appreciation benefits some owners, these gains are offset by declining productivity, weak zoning enforcement, and diminished agricultural investment. Converting farmland into speculative assets raises urgent governance concerns about protecting food systems, promoting climate-resilient agriculture, and sustaining rural livelihoods under devolution.

These dynamics align with findings from other Kenyan and international studies. In Vihiga County, Mwendwa, Muglavai, and China (2024) report that smallholder farms under one acre suffer from

inheritance-driven subdivision, limiting productivity, credit access, and mechanization. Kangethe (2024) similarly shows fragmentation accelerates arable land loss without technological gains. Nationally, despite legal restrictions on subdividing land below five acres, enforcement remains weak, contributing to structural governance challenges.

Weak enforcement capacity—due to financial constraints, limited technical expertise, and political interference—was frequently cited in KIIs as a major barrier to effective zoning and land-use regulation. Local authorities face underfunding, insufficient training, and political pressure, undermining oversight. Although some participatory monitoring and awareness campaigns exist, these remain limited and often unsustainable. Strengthening institutional capacity and political commitment is crucial to improving land governance and curbing unregulated conversions.

Quantitative analysis supports these findings. Regression analysis shows a strong, statistically significant relationship between land tenure status, farm size, and household food insecurity ($R^2 = 0.59$, $p < 0.001$), suggesting tenure insecurity and fragmentation account for nearly 60% of food insecurity variation. Smaller, insecure farms limit productivity, credit, and technology adoption, increasing vulnerability. Similar results were found by Leta et al. (2022) in Ethiopia, underscoring the widespread nature of these challenges and the urgent need for context-specific interventions addressing land tenure security and farm consolidation.

FGDs and KIIs suggest several policy implications: strengthened land-use planning and zoning enforcement to protect agricultural zones; revitalized extension services promoting sustainable farming; governance reforms to curb speculative sales and secure tenure, especially for smallholders and marginalized groups. Empowering women and youth through improved access to land, finance, and inclusive decision-making was also emphasized. Community-led initiatives that preserve indigenous knowledge while integrating modern practices are essential for building resilience.

These perspectives highlight the multifaceted nature of farmland decline and its socio-economic consequences, underscoring the need for integrated policies that align land governance, productivity, and social inclusion within devolved systems.

Tree Cover in Suna East: Restoration Gains Amid Governance Gaps

Tree cover in Suna East Sub County increased significantly between 2008 and 2018, rising from 1,228.57 hectares to 6,007.39 hectares, an overall growth of approximately 23%. The pre-devolution period recorded a rapid increase of 18%, while the post-devolution phase saw a slower growth of 5%. This expansion is largely attributed to community-based agroforestry, afforestation campaigns, and national reforestation programs such as the Greening Kenya Initiative, as reported in Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). Participants observed active involvement by schools, churches, youth groups, and women's associations in tree planting, reflecting a growing grassroots commitment to environmental conservation.

However, despite these vegetation gains, FGD participants across multiple locations reported persistent or worsening environmental conditions, including recurring floods, rising temperatures, and uncomfortable microclimates. This contradiction suggests that restoration efforts may not be well-aligned with ecological priorities. According to KIIs with forestry officers and environmental experts, most planting occurs in easily accessible public spaces rather than ecologically critical zones such as riparian areas, steep slopes, or degraded hills. The widespread use of fast-growing exotic species like eucalyptus—reported in both KIIs and FGDs, raises additional concerns due to their impacts on soil moisture and water availability, undermining ecosystem services.

Supporting this, statistical analysis revealed no significant association between proximity to reforested areas and perceived environmental improvements ($\chi^2 = 1.28$, $p = 0.24$). This finding aligns with observations from KIIs and FGDs, where

participants noted limited positive outcomes for households located far from reforested zones. Similar results were found in a continental study by Tadesse et al. (2021) in Ethiopia, which reported minimal environmental benefits when afforestation programs were not integrated with local livelihoods or land-use practices. These findings highlight the challenges of translating large-scale tree planting into tangible, localized environmental improvements, particularly in ecologically and socially complex contexts.

The case of Suna East reflects a broader regional pattern. A study by Hailemichael, Bekele, and Tamirat (2025) in Ethiopia similarly found that community involvement in reforestation did not always lead to improved environmental conditions, especially when restoration sites were poorly selected or inaccessible. That study emphasized the importance of land tenure security and extension services, also raised in Suna East KIIs, as critical to long-term success. Comparable challenges were documented in Ghana, where FGDs and KIIs reported elite capture and land insecurity as barriers excluding marginalized groups from restoration benefits (Guuroh et al., 2024).

Despite these limitations, FGDs in Suna East identified several socio-economic benefits linked to increased tree cover. These included improved agricultural productivity, enhanced microclimates, and income diversification through the sale of timber, fruits, and non-timber forest products. Nonetheless, both FGDs and KIIs stressed that such benefits were unevenly distributed. Communities with unresolved land tenure issues or limited access to restoration programs remained largely excluded, reinforcing spatial and social inequalities. This is particularly concerning given ongoing population growth and urban expansion, which exacerbate land fragmentation and threaten future food security and sustainable land use.

The study also found that post-devolution governance structures have enhanced community participation in environmental management, with county governments supporting grassroots forestry initiatives. However, KIIs consistently highlighted

weak regulatory enforcement due to financial constraints, limited technical expertise, and political interference. Conflicting land-use interests, such as charcoal production and urban development—remain major barriers to effective forest stewardship. As one elder in a rural FGD remarked, “We plant trees only in schools and churches. The hills are still bare,” illustrating the limited spatial scope of many tree-planting efforts.

These governance and ecological challenges point to several policy-relevant considerations. Participants emphasized targeting ecologically sensitive and degraded areas for tree planting, rather than symbolic or easily accessible sites. There was broad support for prioritizing indigenous species, valued for their roles in hydrology, biodiversity conservation, and ecosystem resilience. KIIs also recommended enhanced inter-agency coordination and stronger county-level enforcement to improve reforestation outcomes.

Furthermore, securing land tenure, particularly for marginalized groups, was identified as essential for sustained community participation. Both KIIs and FGDs underscored the need for inclusive governance, calling for transparent decision-making, participatory planning, and the integration of traditional ecological knowledge into restoration efforts.

These perspectives underscore the complexities of translating increased tree cover into meaningful environmental outcomes. While local actors and devolved governance have driven notable vegetation gains in Suna East, the disconnect between these gains and perceived improvements highlights the need for strategic spatial planning, strengthened institutional capacity, and attention to social equity. Devolution holds promise for transformative environmental governance, but its effectiveness hinges on aligning restoration with ecological, social, and institutional priorities identified by stakeholders.

Shrub Land: Erosion of Pastoral Livelihoods, Ecological and Cultural Integrity

Shrub land cover in Suna East Sub County declined by approximately 7% between 2008 and 2013, followed by an additional 2% loss between 2013 and 2018. While these reductions might seem modest numerically, they signify substantial degradation of critical ecological services, including soil stabilization, carbon sequestration, and habitat connectivity, which underpin both environmental health and pastoral livelihoods.

Findings from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) identified overgrazing, firewood harvesting, and conversion of shrubland to agriculture and settlements as the primary drivers of this decline. These factors are consistent with broader regional trends documented in East Africa (Wario et al., 2022), illustrating a pervasive challenge to shrubland ecosystems.

Socially, the study revealed that 64% of respondents reported worsening conflicts over pastureland between pastoralists and farmers. One pastoralist captured this tension vividly: “We fight over land with farmers now.” Key informants confirmed that pastoralists are compelled to travel longer distances to access grazing, occasionally encroaching on cropland, which exacerbates conflicts and reduces livestock productivity.

Supporting evidence from Kenya’s Chyulu Hills reinforces these findings. Donatti et al. (2025) found that grassland restoration efforts led to reduced social conflicts and lowered perceptions of insecurity among local households. Though their study focused on grasslands rather than shrublands, it underscores the potential for targeted restoration and land management interventions to mediate both ecological degradation and social tensions when supported by strong institutional frameworks.

These dynamics reveal an inherent tension between infrastructure and settlement expansion on one side, and pastoral resilience and land stewardship on the other. Shrubland loss threatens pastoral livelihoods not only by shrinking grazing areas but also by eroding cultural practices, such as traditional

itinerant grazing routes, shared knowledge of medicinal shrubs, and seasonal mobility patterns deeply embedded in pastoral identities. Without explicit land-use planning that recognizes pastoral land rights, conserves pasturelands, and promotes sustainable grazing regimes, continued shrubland degradation risks undermining both ecological integrity and socio-cultural resilience in Suna East Sub County.

Bare Land: Environmental Hazard, Economic Marginalization, and Heat Island Effect

Bare land in Suna East Sub County showed a slight 1% decline during the pre-devolution period (2008–2013), but this trend reversed with a 2% increase in the post-devolution period (2013–2018). While these percentage changes may appear modest, their environmental and socio-economic impacts are considerable. Even small increases in bare land can accelerate soil degradation, reduce agricultural productivity, and increase dust emissions, negatively affecting local livelihoods and public health (Lal, 2015). This shift underscores the urgent need for effective land management policies and community-driven interventions to prevent further degradation and protect the region’s environment and well-being.

Focus Group Discussions (FGDs) attributed the post-devolution increase to land abandonment, speculative clearing for development, and degradation from unmanaged land use. Key Informant Interviews (KIIs) reinforced this perspective, highlighting over-cultivation and shortened fallow periods as key drivers of soil fertility loss and widespread land degradation. These issues mirror patterns observed in Western Kenya’s grasslands, such as Kuresoi and Nyando, where degraded sites exhibit lower soil organic carbon, nitrogen, and phosphorus levels, along with reduced water infiltration rates (Sibulu, Quinton, Leitner, & Rufino, 2025). This comparison highlights the broader regional scale and severity of degradation challenges affecting Suna East.

The ecological consequences of expanding bare land are extensive. Exposed soils increase erosion and

siltation of aquatic ecosystems, undermining water quality and biodiversity. FGDs linked this degradation to more frequent dust storms and rising respiratory health problems, particularly among vulnerable populations such as children and the elderly. One survey respondent remarked on the elevated heat and dust levels during dry seasons, which intensify discomfort and health risks.

The chi-square test in this study revealed a significant association between proximity to bare land and respiratory ailments ($\chi^2 = 9.72$, $p < 0.01$), suggesting increased risks of symptoms such as coughing, wheezing, and asthma. Dust and particulate matter from exposed soils exacerbate these conditions, especially among vulnerable groups. This association aligns with Zhao et al. (2020), who emphasize the importance of limiting bare land expansion to safeguard public health.

From a socio-economic perspective, soil degradation has reduced agricultural productivity, compelling many households to seek off-farm employment or migrate in search of better opportunities. Vulnerable groups, particularly those with insecure land tenure or limited capital, are disproportionately affected by land abandonment and degradation, which exacerbates inequality and livelihood insecurity. Although devolution has enabled some restoration efforts, such as tree planting, it has not reversed the trend of bare land expansion, revealing a gap between policy aspirations and ecological outcomes.

These findings underscore key policy imperatives: restoring vegetation through sustainable land management, enforcing land use regulations, securing land tenure rights, and building local capacity for land rehabilitation. Without addressing these systemic challenges, the transformative potential of devolved governance to promote environmental resilience and social equity in Suna East will remain unrealized.

Conclusion

This study undertook a spatial-temporal analysis of land use and land cover (LU/LC) dynamics in Suna East Sub-County over a ten-year period (2008–2018), with a particular focus on transitions linked

to the implementation of devolved governance. Utilizing remote sensing and GIS methodologies, the research revealed a marked intensification in land transitions following the onset of devolution. Built-up areas expanded rapidly at the expense of agricultural land and shrubland, while marginal gains in tree cover, largely attributable to community-led afforestation initiatives, remain ecologically tenuous amid continuing land conversion pressures.

While devolution has catalyzed infrastructure development, improved service delivery, and stimulated localized economic activity, these advancements have occurred alongside deepening socio-environmental vulnerabilities. The loss of productive farmland poses a significant threat to local food security and the livelihoods of smallholder farmers, particularly women and youth who face structural barriers to land access and agricultural resources. Concurrently, pastoralist communities have experienced growing marginalization due to the encroachment on communal grazing areas and the escalation of land-use conflicts. These outcomes are compounded by institutional deficits in spatial planning, environmental governance, and participatory decision-making at the county level.

The empirical findings underscore that the benefits of devolution are not only unevenly distributed but are also frequently contested, particularly where developmental imperatives intersect with ecological sustainability and social equity. The study illustrates that devolved authority, while potentially more responsive to local needs, requires robust institutional frameworks, regulatory coherence, and inclusive governance to manage complex land transitions effectively. The comparative approach between pre- and post-devolution periods provides a critical lens through which the spatial consequences of governance reform can be understood and evaluated.

More broadly, this research contributes to the growing body of literature on sub-national governance and land transformation in developing contexts. It affirms that the success of devolution in promoting sustainable and inclusive development is

contingent upon the capacity of local governments to balance competing land-use demands, mitigate environmental degradation, and ensure equitable access to land-based resources. Ultimately, while devolution in Suna East Sub-County has opened new avenues for localized development, it has also intensified land pressures and exposed structural vulnerabilities in land governance. Addressing these challenges requires integrated, evidence-based, and community-anchored policy responses capable of managing the trade-offs inherent in rapid landscape change.

Recommendations

In light of the observed LU/LC dynamics and the multi-dimensional impacts of devolution on land systems, a set of interlinked policy and institutional reforms is recommended to guide sustainable land governance in Suna East Sub-County and comparable jurisdictions. First, there is an urgent need to develop and operationalize integrated spatial planning instruments that align infrastructure expansion with the protection of agricultural, pastoral, and ecological zones. These plans must be underpinned by high-resolution geospatial data and reflect both historical and projected land use trajectories.

Second, the enhancement of institutional and technical capacity at the county level is essential. Investments in GIS infrastructure, remote sensing tools, and continuous land monitoring systems are critical for enabling timely, evidence-driven decision-making. Strengthening regulatory enforcement will also be crucial to curbing speculative land conversion, informal settlement growth, and ecological degradation.

Third, safeguarding agricultural land should be prioritized through the enactment of zoning regulations that prevent indiscriminate conversion, coupled with the revitalization of agricultural extension services. Promoting climate-resilient agricultural practices, particularly those accessible to women and youth, can enhance productivity while mitigating environmental risk. Similarly, rangeland governance must be restructured to recognize

communal grazing rights, incorporate pastoralist voices into planning processes, and promote sustainable land-use practices such as rotational grazing and shrubland restoration.

Fourth, forest restoration efforts must be both ecologically appropriate and socially inclusive. Emphasis should be placed on native species reforestation, community-based forest governance, and equitable benefit sharing, particularly for historically marginalized groups. Parallel efforts to combat land degradation through agroforestry, cover cropping, terracing, and localized incentive schemes can help restore soil health and ecological function.

Fifth, the adoption and scaling of digital land governance tools, such as the Land Management Information System (LMIS)—should be accelerated to improve land administration transparency, monitor land-use change, and support policy compliance. These tools provide a foundation for integrated, data-driven governance and are essential for enhancing institutional accountability.

Finally, the study underscores the importance of fostering comparative and inferential research across counties and governance periods. The use of robust statistical methods to evaluate LU/LC trends can validate observed relationships and inform adaptive policy frameworks grounded in empirical evidence. Such research is critical for understanding the broader impacts of decentralization on land systems and for designing governance models that are both responsive and resilient.

Declaration on the Use of Generative AI and AI-Assisted Technologies

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CRedit Author Contribution Statement

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Conflict of Interest Statement

The authors declare no competing financial interests or personal relationships that could have influenced this work.

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