

Perceived impact of land use/land cover change in Kalinga

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ABSTRACT

The study focused on the Assessment of the Impact of Land Use/Land Cover Change in Kalinga. It assessed the extent and impacts of land use/land cover (LULC) change in Kalinga and determine its environmental, social, and economic implications, over a defined period, are the key drivers (e.g., agricultural expansion, urbanization, logging, infrastructure development) contributing to LULC changes in the province. The study utilized the mixed method of quantitative and qualitative designs. The study revealed that Kalinga is undergoing significant land use and land cover (LULC) changes driven by population growth, agricultural expansion, urbanization, infrastructure development, and logging. These changes have major environmental, social, and economic impacts, including soil erosion, increased flood risks, biodiversity loss, and reduced ecosystem services. Socially, communities face greater vulnerability to hazards, while economic challenges arise from declining agricultural lands, despite some opportunities from urban development. Governance and management efforts, exist but are limited by gaps in capacity, participation, and enforcement. Sustainable strategies such as integrated land-use planning, climate-smart agriculture, reforestation, mangrove protection, secure land tenure, and inclusive governance are essential to balance development with environmental protection. Overall, while Kalinga is progressing developmentally, these LULC changes pose significant risks to ecosystems, livelihoods, and community resilience without coordinated management.

Keywords: Impact, land use, land cover, changes, hazards.

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INTRODUCTION

Land use and land cover (LULC) change is one of the most important environmental challenges in the twenty-first century all over the world. Globally, LULC is a key contributor to climate variability, biodiversity and socio-economic development. According to Lambin et al. (2001), in any given land use system changes occur not due to a single factor but rather through an interaction of many aspects including population growth, economic demands, technology innovation and socio-political governance structures. Globally, the alteration of ecological functions through LULC can be seen in the form's massive deforestation, land conversion for agriculture and urbanization stretching across geographical boundaries. Foley

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et al. (2005) observe, the global conversion of land not only contributes to the destruction of biodiversity but to greater climatic volatility. It takes place because of the degradation of vital ecosystems that control hydrology, sequester carbon and offer crucial goods and services to human beings.

Urbanization is one of the leading global trends today, which dramatically alters landscapes and interactions between nature and people. Nuissl and Siedentop (2020) indicate that cities have become powerful agents of change, in which urban sprawls replace fertile lands and vegetative surfaces with impermeable ones. As a consequence, there arise several problems such as the creation of urban heat islands, lack of water infiltration, and vulnerability to flooding (Alp et al., 2020; Nwakaire et al., 2020). The same problem exists in fragile ecosystems like the Himalayan mountains, where geomorphological and climatic constraints worsen the impact of unregulated land expansions (Naikoo et al., 2020).

In South and Central Asia, the impacts of LULC change takes on great importance due to rapid population growth and demands for land resources. Recently, India surpassed China in terms of population numbers becoming the most populous country in the world (UN DESA, 2023). Which in turn, increases the pressure on natural ecosystems and drives deforestation, agricultural expansion and urbanization. Studies based on remote sensing over the Pakistan's Khyber Pakhtunkhwa (KPK) have shown dramatic changes in key ecological parameters like land surface temperature (LST), normalized difference vegetation index (NDVI), and water indices mainly caused by deforestation and land degradation processes (Ramzan et al., 2022). That leads to higher temperatures, reduced biodiversity and water scarcity. In the prediction of KPK will face more ecological disruption by 2100, Scientists used earth observers satellite imagery like as Landsat and statistical models including Random Forest, CA-ANN (Aliyu et al., 2023). Thus, this experience may benefit other mountainous ecosystems such as the Cordillerans.

On the global stage, in countries like the Philippines, there is an issue of land conversion to be tackled because of high population growth rates and increasing economic activity alongside environmental degradation. As a specific example related to Lasco and Pulhin (2006), the researchers identified issues ranging from soil erosion, depletion of watersheds, loss of biodiversity all resulting in deforestation and land degradation throughout the country. It also erodes the resilience of rural sector with livelihoods. The detrimental effects of LULC change are especially apparent in upland regions where forests play a vital role in regulating the water supply for lowland areas and preventing floods and landslides (Cruz et al., 2017). However, although it generates some economic benefits, the rapid development of infrastructure and large-scale agriculture causes degradation of ecosystems. For instance, deforestation and subsequent transformation of the land in monocultures leads to its further exhaustion, thereby harming marginalized farmers.

There are several regulations that aim to control LULCC in the Philippines in order to guarantee land management and conservation. To start with, Republic Act No. 7160 gives authority to local government units to prepare comprehensive land use plans and zoning ordinances for the allocation of lands. The second focus is that of Republic Act No. 6657 (1988) which collective provides the basis for either land distribution and prohibits the further conversion of agricultural lands to any end other than agriculture (Borras, 2007). Third, they need to create Strategic Agriculture and Fisheries Development Zones for the protection of productive lands under Republic Act No. 8435 (1997). Fourth, Presidential Decree No. 705 (1975) it works to. ensure proper forest management and prevent Fifth, we must conserve and protect ecologically sensitive areas as provided for under Republic Act No. 7586 and Republic Act No. 11038 (2018) (La Viña et al., 2022). Sixth, land use for urban planning should be used as per Republic Act No. 7279 (Ballesteros, 2020). Finally, Republic Act No. 9729 brings

climate into areas of land planning to prevent further degradation of the environment (Lasco et al., 2021).

In the Cordillera Administrative Region, which includes the Kalinga Province, LULC changes also occur spatially differently. First, there are several drivers of LULC change that lead to deforestation in upland municipalities. They include roads construction, settlements' development, and shifting cultivation (Alibuyog et al., 2023). Besides, according to the Philippine Statistics Authority (2020), there are certain fluctuations of timberland and land assets between 1999 and 2018. Despite numerous efforts of communities to practice proper community-based forest management, the country experiences constant pressures due to economic expansion. Although Cordillera Administrative Region still has the largest land area under natural forests, fragmentation of these forests was a threat to biodiversity, watershed systems and indigenous cultures relative to lowland provinces.

Land use and land cover changes play a critical role in Kalinga, especially because of its agriculture and forestry-based economy. Based on Global Forest Watch data in 2020, Kalinga has an estimated 206000 hectares of Natural Forest or 71% of its land area (Global Forest Watch, 2020). Recently, there occurred annual deforestation that equals thousands of hectares of carbon emissions. Consequently, it decreases the capacity of watersheds for regulating hydrology, putting the communities of lowlands in danger of flash floods and landslides during typhoons (Cruz et al., 2017). For upland farmers, the expansion of plantations leads to reducing livelihood options, decreasing food security, and promoting soil erosion. In addition, according to Baguilat (2011), the influx of infrastructure and economic activities in ancestral domains poses a threat to indigenous systems and traditions of governing these lands.

The cumulative impacts of these transformations in Kalinga highlight the trade-offs between short-term economic gains and long-term sustainability. While agricultural conversion and infrastructure development may generate immediate income and connectivity, they compromise forest ecosystem services, increase disaster risks, and erode cultural landscapes (Acosta, 2019). Verburg et al. (2011) argue that assessing LULC change is essential for identifying these trade-offs and informing policies that balance economic development with ecological and social well-being. For Kalinga, such assessments are not only an academic exercise but a practical necessity, as they guide land use planning, watershed protection, and the safeguarding of indigenous rights.

In summary, the process of land use and land cover changes in Kalinga represents a global tendency, when human activity dramatically transforms landscapes, leading to various consequences. By situating Kalinga's experience within this continuum from global urbanization to South Asian mountain systems and Philippine upland transformations it becomes clear that proactive monitoring and management are essential. Hence, the study "Assessing the Impact of Land Use/Land Cover Change in Kalinga" aims to shed light on these problems and provide evidence base, offering insights that can help local governments, indigenous communities, and development actors chart a path toward sustainable land governance and resilience.

Statement of the problem

This study focused on Perceived Impact of Land Use/Land Cover Change in Kalinga. Specifically, it sought to answer the following questions to wit:

1. What are the key drivers (e.g., agricultural expansion, urbanization, logging, infrastructure development) contributing to LULC changes in the province.

2. What are the perceived impacts of land use/land cover (LULC) change in Kalinga and determine its environmental, social, and economic implications.
3. What is the proposed sustainable land management strategies and policy interventions that balance development needs with environmental protection?

METHODOLOGY

This study employs a mixed-method research design to investigate the impact of land use and land cover change in Kalinga. By integrating both qualitative and quantitative data, the research seeks to identify the factors driving land use and land cover change in the province, including agricultural activities, urbanization, logging, and infrastructural developments, to examine the impact of such changes, and to recommend strategies for sustainable land management and policy interventions that ensure development and environmental preservation in Kalinga. This methodological approach allows for a more comprehensive understanding of the phenomenon under investigation by capturing both the measurable dimensions of land use change and the contextual, experiential perspectives of the people most directly affected by and involved in the governance of the province.

The participants of the study were drawn from five groups: planning officers from the city and provincial levels, board members, community members, city councilors, and indigenous people. These groups were identified through random sampling to ensure that a broad and representative range of perspectives was included in the dataset. Planning officers from both the city and the province contributed two respondents, board members contributed six, community members contributed twenty, city councilors contributed twelve, and indigenous group members contributed twenty, yielding a total of sixty respondents across all participant categories. This composition was deliberately designed to capture the institutional, legislative, civic, and indigenous dimensions of land use governance and community experience in Kalinga.

The primary data collection instrument was a checklist survey questionnaire developed by the researcher in accordance with the guidelines established under the Local Government Code, or Republic Act No. 7160, the National Integrated Protected Areas System Act and its expanded counterpart for ecological sustainability, Republic Act No. 9729 on climate change, and Republic Act No. 10121 on disaster risk reduction management. The questionnaire was organized into three parts. The first part gathered information pertaining to the background profile of the respondents. The second part sought to obtain information concerning the effects of land use and land cover alterations in Kalinga. The third and final part sought information concerning land management measures. This tripartite structure ensured that the instrument addressed both the descriptive profiling of respondents and the substantive concerns central to the research objectives.

The data gathering procedure was initiated by the researcher through a formal application for authorization submitted to the Office of the Provincial Governor, the City Mayor, and the heads of concerned offices. Following the grant of authorization, the researcher personally distributed the questionnaire to all respondents in order to address any queries or clarifications that arose during the completion of the instrument. One-on-one interviews were subsequently conducted using an interview guide prepared by the researcher, allowing for deeper exploration of individual perspectives. Focus group discussions were also facilitated to verify and triangulate the information gathered through the questionnaire and interviews. All data collected throughout this process were treated with strict confidentiality.

The ethical dimensions of this study were observed throughout all stages of the research process. Permission to conduct the study was formally granted by the Office of the City Mayor. Informed consent was sought from all participants prior to their engagement in any interview

process, and participation was entirely voluntary. Respondents were explicitly informed that no harm would come to them should they choose to withhold their consent or withdraw from the study. Strict confidentiality was maintained in both the collection and analysis of all data, and the anonymity of all respondents who completed the questionnaire was preserved throughout. All external sources consulted in the conduct of this study, including prior research, magazines, websites, and books, have been cited appropriately in accordance with academic conventions.

The analysis of data employed frequency count and the percentage formula to describe the profile of the respondents. The weighted mean was used to describe the ratings and perceptions of the respondent groups on the variables under investigation. To measure the extent and impacts of land use and land cover change in Kalinga and to determine its environmental, social, and economic implications, a four-point rating scale was applied. Under this scale, a range of 3.25 to 4.00 corresponds to Strongly Agree and is represented by the symbol SA. A range of 2.50 to 3.24 corresponds to Agree, represented by the symbol A. A range of 1.76 to 2.49 corresponds to Neutral, represented by the symbol N. A range of 1.00 to 1.75 corresponds to Disagree, represented by the symbol D. Analysis of variance, or ANOVA, was used to test the hypothesis concerning the responses on the assessment of the impact of land use and land cover change in Kalinga, allowing for the determination of statistically significant differences in perceptions across the respondent groups.

RESULTS AND DISCUSSION

This chapter presents the results and discussion of a study examining the perceived impacts of land use and land cover (LULC) change in Kalinga province, the key drivers contributing to such changes, and the proposed sustainable land management strategies and policy interventions that balance development needs with environmental protection. The study employed a mixed-methods research design combining quantitative survey data and qualitative thematic analysis. A total of 60 respondents participated in the quantitative survey component, drawn through purposive sampling to include planners, city officials, board members, community elders, and farmers who are directly engaged with or affected by land use transitions in the province. Data were collected using a structured questionnaire with Likert-scale items for the quantitative strand, and in-depth interviews were conducted for the qualitative strand. The quantitative data were analyzed using weighted means and descriptive statistics, with interpretive scales applied to categorize mean scores into descriptive equivalents. The qualitative data were subjected to thematic analysis to identify recurring patterns and categories across participant responses. The discussion that follows is grounded in the data gathered from these instruments and interprets the results in direct relation to the objectives of the study.

Profile of respondents

The demographic profile of the respondents reveals a composition that is broadly reflective of community-embedded perspectives on land use. In terms of occupation, community elders comprised the largest group at 35%, followed by farmers at 26%, city officials at 18%, board members at 18%, and planners at 2%. This distribution indicates that the majority of participants possess substantial lived experience within the community and direct engagement with land-based livelihoods and governance. This profile is further reinforced by the length of residence data, which shows that 53% of respondents had lived in

the community for 6 to 10 years, while 32% had resided there for 1 to 5 years, 13% for 11 years and above, and 2% for less than one year. The predominance of long-term residents among the respondents strengthens the credibility of their perceptions regarding observable changes in land use and land cover over time. With respect to land ownership, 65% of respondents reported owning their land, 25% indicated they were leasing, and 10% were renting. The high proportion of land-owning respondents is particularly noteworthy, as it signals a personal and material stake in how lands within the community are managed and utilized, which may correspondingly heighten their sensitivity to and concern about LULC transitions.

Perceived impacts of land use and land cover change: extent of LULC change

The first dimension of the survey assessed respondents' perceptions of the extent of land use and land cover change in Kalinga. The subtotal mean for this section was 2.99, carrying a descriptive equivalent of Agree, which indicates a moderate to strong consensus among respondents that observable LULC changes have occurred across the province. Among the seven indicators assessed, the conversion of agricultural lands into residential or industrial areas obtained the highest mean score of 3.25, interpreted as Strongly Agree, suggesting that this particular transformation is the most pronounced and widely recognized form of land cover change in the area. This finding is consistent with the observation by Seto et al. (2012) that rapid urbanization frequently results in the displacement of productive agricultural land in favor of residential and commercial uses, with downstream consequences for food security, ecosystem stability, and local livelihood systems. The reduction of vegetation and tree cover received a mean of 3.00, equivalent to Agree, reflecting broad recognition of the thinning of green cover as a co-occurring consequence of land conversion. This aligns with the findings of Foley et al. (2005), who established that deforestation and the loss of vegetative areas intensify the adverse effects of climate change and disrupt established local climate patterns. Research by Guiang and Castillo (2022) similarly confirmed through remote sensing and spatial analysis that the expansion of residential and industrial areas is consistently accompanied by a reduction in vegetative cover.

The overall landscape change indicator obtained a mean of 3.03, also equivalent to Agree, while alteration of water bodies such as rivers, creeks, and ponds received a mean of 2.90. The expansion of roads and infrastructure and the decrease of forested areas each registered the lowest mean scores in this section at 2.88, both interpreted as Agree. Although these values represent the lower end of the range within this section, they nonetheless reflect agreement among respondents that infrastructure expansion and forest loss constitute real and observable dimensions of LULC change. Turner et al. (2022) have noted that deforestation typically accompanies increased agricultural and urban development activity, resulting in biodiversity loss, habitat disruption, and altered regional climate patterns. The role of road and infrastructure expansion in accelerating land conversion has also been documented by Seto et al. (2022), who found that improvements in accessibility tend to facilitate further LULC conversions and promote the repurposing of land for housing and industrial use.

Environmental impacts of LULC change

The second dimension of the survey examined the environmental consequences of LULC change as perceived by respondents. The subtotal mean for this section was 3.06, equivalent to Agree, indicating a consistent and reasonably strong recognition of adverse environmental outcomes attributable to land cover transformation. The two highest-rated indicators were frequent flooding, which received a mean of 3.26, and soil erosion and landslides, with a mean of 3.25, both interpreted as Strongly Agree. These scores indicate the

strongest level of consensus across the entire survey, signaling that respondents overwhelmingly associate LULC changes with heightened vulnerability to natural disasters and hydro-geomorphic hazards. This finding is corroborated by Makinano Santillan et al. (2023) and Boongaling, Faustino Eslava, and Lansigan (2018), who demonstrated that land use and land cover changes, particularly the expansion of built-up areas and the clearing of forests, lead to significantly elevated surface runoff, increased flooding frequency, and accelerated soil degradation. Smith et al. (2021) have similarly documented that altered land cover disrupts natural drainage patterns and heightens flood risk, while Jones (2020) confirmed a direct empirical linkage between land use change and higher rates of soil erosion, the consequences of which extend to agricultural productivity and community safety.

The overall worsening of environmental conditions due to land use changes also received a mean of 3.25, equivalent to Strongly Agree, reinforcing the general perception that the cumulative effect of LULC changes on environmental quality has been substantially negative. Open and green spaces were perceived as having decreased, registering a mean of 2.97, while water quality deterioration in nearby rivers and streams received a mean of 2.93, both equivalent to Agree. The loss of wildlife and biodiversity obtained a mean of 2.98, also interpreted as Agree. The indicator with the lowest mean in this section was the increase in air temperature at 2.80, interpreted as Agree. The relatively lower scores for biodiversity loss and temperature increase may reflect the less immediately visible nature of these phenomena compared to flood damage and erosion, rather than any dismissal of their significance. Brown (2022) has noted that increased air temperature resulting from deforestation and urbanization constitutes a measurable form of local climate change, even if its detection requires more sustained observation than the acute impact of flooding.

Social impacts of LULC change

The third dimension of the survey addressed the social consequences of LULC change, producing a subtotal mean of 2.80, equivalent to Agree. The highest-rated social impact was the increased exposure of residents to environmental hazards such as flooding and erosion, which received a mean of 3.12, interpreted as Agree. This finding is consistent with the environmental impact data discussed above and reflects the perception that land conversion has materially elevated the physical risk experienced by community members in their daily lives. Garcia et al. (2023) have reported a similar association, demonstrating that LULC changes typically increase community-level exposure to environmental hazards, particularly in areas undergoing rapid built-up area expansion. The second highest-rated indicator concerned improvement in access to basic services such as water, schools, and health centers, which received a mean of 3.05, also equivalent to Agree. This finding introduces an important nuance to the otherwise predominantly negative assessment of LULC change impacts, suggesting that infrastructural development accompanying land conversion has yielded some degree of service accessibility improvement for residents. However, the variability in infrastructure quality and distribution may limit the extent to which such improvements are experienced uniformly across the community.

The lowest-rated social impacts were the displacement or relocation of families due to land conversion and the destruction or alteration of cultural or ancestral sites, both of which received a mean of 2.67, interpreted as Agree. Conflicts or disputes over land ownership registered a mean of 2.72, and the decline in community unity and cooperation received a mean of 2.73, both also equivalent to Agree. The effects on traditional livelihoods received a mean of 2.65, the lowest score in this section, also interpreted as Agree. The relatively lower salience

assigned to family displacement and heritage site loss does not diminish their significance as documented social consequences of LULC change. Mendoza (2022) has argued that the destruction of cultural or ancestral sites represents a form of heritage loss that is not always immediately perceptible at the community level, particularly when immediate economic gains from land conversion appear to offset such losses in the short term. The broader literature similarly identifies displacement and livelihood disruption as among the most consequential long-term social impacts of land use transitions, even when community members do not immediately foreground them as their primary concerns.

Economic impacts of LULC change

The economic dimension of the survey produced a subtotal mean of 2.64, equivalent to Agree, the lowest of the four impact dimensions assessed. The grand total mean across all sections was 2.84, also interpreted as Agree, reflecting a broadly consistent pattern of moderate agreement regarding the multidimensional impacts of LULC change in Kalinga. The two highest-rated economic indicators, sharing a joint mean of 2.80 and interpreted as Agree, were the decline in farming and agricultural employment opportunities and the creation of new job opportunities through infrastructure and road development. This parallel finding captures a structural economic transition in which traditional agricultural livelihoods are eroding while alternative employment pathways in construction, transportation, and service industries are simultaneously emerging. This dual economic dynamic is consistent with the findings of Bryan et al. (2018) and Sandhi and Sarker (2021), who documented that LULC changes tend to reduce demand for agricultural labor while generating employment in non-farm sectors. Land and property value increases received a mean of 2.78, interpreted as Agree, while the conversion of land decreasing agricultural productivity received a mean of 2.77, also equivalent to Agree. The impact on household income was rated at a mean of 2.55, interpreted as Agree.

The two lowest-rated economic indicators were the increase in the cost of living due to land conversion, with a mean of 2.33, and improvements in tourism and local business investment due to land development, with a mean of 2.47, both of which carry a descriptive equivalent of Neutral. These neutral assessments suggest that respondents do not perceive significant or definitive changes in either cost of living conditions or tourism and business growth as direct outcomes of LULC changes in their area. Muller et al. (2020) and Rasul (2016) have observed that significant cost-of-living effects attributable to LULC change tend to be more pronounced in urban or highly commercialized settings, which may explain the neutral response from residents of a moderately developing rural province. Similarly, the perception that tourism and business investment have not been substantially improved reflects the reality that such outcomes depend not solely on land development but also on deliberate planning, marketing investment, and governance frameworks that may not yet be adequately in place.

Key drivers of LULC change: thematic analysis findings

The thematic analysis of interview data identified three overarching themes that account for the key drivers of LULC change in Kalinga province. These themes are: human-induced environmental pressures; environmental degradation from resource extraction and land clearing activities; and land governance, technological influence, and infrastructure expansion.

The first theme, human-induced environmental pressures, was identified by the majority of respondents as a primary determinant of LULC change in the province. Participants articulated those human activities, including agricultural expansion, urbanization, logging, infrastructure development, and the practice of the *kaingin* or slash-and-burn farming system, collectively transform natural landscapes through deforestation, soil degradation, habitat loss,

and fragmentation. One respondent noted that population growth, agricultural intensification, poverty, and economic development pressures lead to land conversion, while another identified the kaingin system and agricultural expansion as livelihood adaptation practices for survival. Additional accounts pointed to tourism development, aquaculture expansion, and urbanization as drivers of land use transformation, with human-induced demands altering land-use patterns as people manipulate land to meet their social and economic needs. These observations are supported by a body of empirical literature. Studies from the Gambela region of Ethiopia documented that population growth and subsistence farming practices contributed significantly to forest loss and agricultural expansion. Macaspac, Valenzuela, and Ramos (2024) found in Baguio City, Philippines, that population growth and demand for residential and commercial land led to the conversion of vegetated land cover. Canlas and Blanco (2024) identified the kaingin system in Palawan as a direct contributor to deforestation and soil erosion. Research conducted in the upper Kafue River Basin in Zambia and on Phu Quoc Island in Vietnam by Nguyen et al. (2025) similarly demonstrated that agricultural expansion, tourism, and infrastructure development cause vegetation loss and habitat degradation. Urban expansion in Larkana, Pakistan, between 2010 and 2020 was found by Amin et al. (2023) to have reduced green cover and increased land surface temperature, reflecting outcomes consistent with those perceived by respondents in Kalinga.

The second theme, environmental degradation from resource extraction and land clearing activities, was also prominently identified by respondents as a significant driver category. Participants described how practices such as mining, logging, deforestation, and infrastructural development alter natural landscapes, leading to soil erosion, habitat destruction, and biodiversity loss. One respondent specifically noted that mining processes aggravate land degradation, reduce forest area, and affect ecosystems adversely, while another observed that the construction of infrastructure on previously forested or agricultural lands contributes to LULC change and increased rates of soil erosion and reduced vegetation density. These accounts are supported by multiple empirical studies. Peprah (2025) documented that mining activities in Ghana resulted in widespread deforestation and loss of ecosystem services. Research in Singida, Tanzania, showed that mining reduced forest and shrubland cover while increasing barren and built-up areas between 1995 and 2023. John et al. (2023) found that artisanal mining in East Cameroon decreased vegetation density and caused a 14% increase in degraded land between 2018 and 2022. Gold mining in Ghana led to an approximate 36% loss of forest area, negatively affecting biodiversity and carbon stock. In India, coal mining from 1994 to 2022 caused forest loss and soil degradation, while logging and cropland expansion contributed to soil erosion in China's Loess Plateau region. Azinwi Tamfuh et al. (2024) found that mining activity transformed 11.7% of vegetated areas into barren lands between 2019 and 2023.

The third theme, land governance, technological influence, and infrastructure expansion, was highlighted by respondents as an important dimension shaping land-use decision-making. Participants indicated that infrastructure development and urban expansion physically reconfigure landscapes, and that the integration of remote sensing technologies with effective governance structures is essential for ensuring that these changes are managed sustainably, conflicts are minimized, and development priorities are aligned with environmental and socio-economic goals. One participant described the role of infrastructure development, urban expansion, and remote sensing technologies in shaping land-use decisions, while another reflected on the interplay between governance structures, technological tools, and the physical reconfiguration of the landscape. These perspectives are corroborated by Kuyela and Lu (2025), who found in Lusaka that built-up area growth occurred at the expense

of agricultural land, reflecting weaknesses in governance frameworks. Lawal and Gulma (2024) reported a 9.5% increase in built-up areas and a 32.9% decline in vegetation cover in Argungu, Nigeria, between 2013 and 2023 as a result of urban expansion. Osei, Merem, and Twumasi (2006) demonstrated in Lagos that the integration of GIS into land administration and planning processes supports sustainable policy-making and enables more reliable prediction of urban growth trajectories, reinforcing the view expressed by respondents that technological tools, when embedded in sound governance frameworks, are essential for sustainable land-use planning.

Proposed sustainable land management strategies and policy interventions: thematic analysis findings

The thematic analysis also identified three principal themes related to proposed strategies for sustainable land management and policy intervention, which respondents regarded as most relevant to balancing development needs with environmental protection. These themes are: integrated and climate-resilient land-use planning; sustainable land and ecosystem management; and inclusive governance and secure land tenure.

The first theme, integrated and climate-resilient land-use planning, was endorsed by the majority of respondents as a foundational strategy for managing LULC change sustainably. Respondents affirmed that integrated land-use planning protects natural systems, that climate-smart agriculture can conserve ecosystems, and that climate-resilient infrastructure development is vital for environmental protection. Integrated land-use planning, as described by respondents, involves coordinating how land is used across agriculture, infrastructure, water management, and conservation in order to reduce conflicts, protect sensitive areas, and direct development away from high-risk zones. Climate-smart agriculture encompasses practices such as conservation farming, agroforestry, and efficient irrigation aimed at boosting productivity, maintaining soil health, and building adaptive capacity in the face of climate variability. Climate-resilient infrastructure ensures that built structures are designed to withstand extreme weather events, thereby minimizing future damage and safeguarding communities. These perspectives are substantiated by Turner et al. (2019) and the IPCC (2022), whose research demonstrated that coordinated land management reduces environmental degradation, limits land-use conflicts, and directs development away from high-risk areas. FAO (2021) and World Bank (2020) further emphasized that integrated planning strengthens ecosystem protection and supports long-term sustainability. Lipper et al. (2014) and FAO case studies provided evidence that agroforestry, conservation tillage, and efficient irrigation improve soil health and yields while reducing emissions. World Bank (2019) and UNDRR (2020) showed that incorporating climate-risk assessments into infrastructure planning reduces economic losses from extreme weather and improves community protection through approaches such as green infrastructure.

The second theme, sustainable land and ecosystem management, was recognized by respondents as a critical strategy for restoring degraded ecosystems and preventing the further expansion of degraded or barren lands. Participants indicated that practices such as agroforestry, reforestation, mangrove rehabilitation, climate-smart agriculture, and community-based land management help increase vegetative cover, improve soil stability, and maintain key ecosystem services. One respondent observed that community-based management strengthens protection of communal forests, reducing illegal logging and unsustainable extraction. Another noted that promoting practices that restore ecosystems and reduce degradation while encouraging sustainable resource use is fundamental to the strategy. These observations align with the findings of FAO (2021), which demonstrated that agroforestry, reforestation, and climate-smart agriculture effectively reduce land degradation,

improve soil fertility, and maintain critical ecosystem services including water regulation, carbon storage, and biodiversity conservation. IPCC (2022) further affirmed that sustainable land management prevents harmful land-use changes by providing alternatives that reduce pressure on natural resources. World Bank (2020) emphasized that community-based management and secure land tenure strengthen protection of communal forests, reduce illegal logging, and encourage long-term stewardship of ecosystems, while policy incentives support environmentally responsible practices that enhance climate resilience and local livelihoods.

The third theme, inclusive governance and secure land tenure, was strongly emphasized by participants as essential for promoting equity in land management, empowering marginalized communities, and ensuring that LULC transitions are governed sustainably. Respondents articulated that the integration of governance structures, technological tools, and physical landscape management is necessary to ensure that changes are sustainable, conflicts are minimized, and development goals are aligned with socio-economic and environmental priorities. Secure legal land rights were seen as promoting long-term investments in reforestation, soil management, and sustainable agriculture, which in turn enhance productivity and ecosystem resilience. The inclusion of marginalized communities in decision-making was perceived as critical for preventing conflicts and ensuring that land management decisions reflect community needs. These perspectives are supported by Jansen and Kalas (2023), whose analysis of the land governance landscape in the Mekong region demonstrated that recognizing legitimate tenure rights, particularly customary and communal land rights, is essential for achieving sustainable land management transitions. World Bank research in Lao PDR similarly highlighted the necessity of formalizing tenure rights to prevent elite capture and ensure that benefits are equitably distributed. The World Resources Institute (2021) demonstrated that securing land tenure promotes environmental protection, enhances carbon sequestration, and contributes to both biodiversity preservation and social justice. The International Institute for Sustainable Development (2020) further affirmed that the recognition of land tenure rights supports food security, encourages agricultural investment, and ensures environmental sustainability over the long term. The findings from Kuyela and Lu (2025), Lawal and Gulma (2024), and Osei, Merem, and Twumasi (2006) reinforce the view that combining technological tools such as GIS and remote sensing with strong governance structures is indispensable for sustainable infrastructure expansion and responsible land-use planning.

The findings presented and discussed in this chapter collectively demonstrate that LULC change in Kalinga province is a multidimensional phenomenon with significant environmental, social, and economic consequences that are broadly recognized and experienced by community-embedded respondents. The grand total mean of 2.84, equivalent to Agree, across all quantitative impact dimensions reflects a coherent and consistent pattern of community-level acknowledgment that land use and land cover changes have materially altered the province's ecological, social, and economic landscape. The thematic analysis further enriches this quantitative picture by identifying the structural drivers, including human-induced pressures, resource extraction activities, and governance gaps, that underpin these changes, while also surfacing a set of integrated and participatory strategies through which sustainable land management may be pursued. The convergence of quantitative and qualitative findings underscores both the urgency of addressing LULC change in Kalinga and the availability of evidence-informed strategies for doing so. These results directly address the research objectives of this study and make a meaningful contribution to the growing body of knowledge on community-perceived LULC dynamics in indigenous and rural provincial contexts in the Philippines. The conclusions, recommendations, and implications drawn from these findings are presented in the subsequent chapter.

CONCLUSION

This study concludes that land use and land cover changes in the Province of Kalinga are significantly perceived by the respondents and are environmentally, socially, and economically consequential. These changes have been driven by a number of interrelated factors, including increasing population, agricultural activities, urbanization, infrastructural development, and logging, all of which have collectively contributed to deforestation and land degradation, soil erosion, loss of vegetation, and an increase in flood occurrences. From a social perspective, exposure to hazard risks has intensified, while economically, livelihoods and food security are increasingly threatened. Despite these challenges, the respondents demonstrated awareness of the potential offered by geospatial tools, land use zoning, and environmental impact assessment as mechanisms for addressing and managing these changes.

In light of these findings, the study recommends the adoption of sustainable and climate-smart land and ecosystem management approaches to achieve long-term environmental stability in the Province of Kalinga. These approaches include integrated land use management, climate-smart agriculture, reforestation, mangrove rehabilitation and management, and community-based strategies. Central to achieving these goals is the establishment of land tenure security and effective governance characterized by inclusivity and broad stakeholder participation.

Translating these recommendations into concrete action, an integrated approach to land use planning is to be undertaken by provincial and municipal planning offices, the Department of Environment and Natural Resources, local government units, and the National Economic and Development Authority. This integrated framework will ensure proper coordination among the various sectors of agriculture, infrastructure development, conservation, and urbanization, with particular emphasis on minimizing risks such as flooding and erosion in order to preserve the quality of life in high-risk locations.

The adoption of climate-smart agriculture and agroforestry practices is a further recommendation, to be spearheaded by the Department of Agriculture, the Department of Environment and Natural Resources, local agricultural extension agencies, farmer cooperatives, and community organizations. These practices are intended to protect soil fertility and sustain livelihoods while limiting pressure on natural forests. Complementing this, a reforestation and ecosystem restoration program directed by the Department of Environment and Natural Resources, local government units, environmental non-governmental organizations, and community forest organizations must involve the planting of trees, mangrove rehabilitation, and the restoration of degraded lands in order to improve vegetation coverage across the province.

Infrastructure development in the province must likewise become climate-resilient, with the Department of Public Works and Highways, local government units, and the Climate Change Commission involved in assessing climate risks associated with new projects, thereby avoiding damages caused by extreme weather events. Alongside this, the strengthening of community engagement and governance in land use will require the collaborative participation of local government units, barangay councils, the Department of Environment and Natural Resources, and civil society organizations, ensuring that communities actively participate in land use planning and monitoring, as well as in the enforcement of zoning regulations and environmental impact assessments.

The securement of land tenure and indigenous peoples' rights is identified as a critical responsibility to be fulfilled by the National Commission on Indigenous Peoples, the Department of Agrarian Reform, and local government units, taking into account communal and customary ownership claims and creating incentives for sustainable land use practices. Finally, public awareness and capacity building must be carried out by the Department of

Environment and Natural Resources, the Department of Agriculture, local government units, schools, non-governmental organizations, and community organizations in order to promote sustainable land management and build community resilience. Collectively, these recommendations form a comprehensive and coordinated response to the land use and land cover challenges documented in the Province of Kalinga, and their implementation is essential to ensuring the environmental, social, and economic well-being of its communities.

REFERENCES

- Agdas, M. G., & Yenen, Z. (2023). Determining land use/land cover (LULC) changes using remote sensing method in Lüleburgaz and LULC change's impacts on SDGs. *European Journal of Sustainable Development*, 12(1), 1. <https://doi.org/10.14207/ejsd.2023.v12n1p1>
- Akaolisa, C. C., Agbasi, O. E., Etuk, S. E., Adewumi, R., & Okoli, E. A. (2023). Evaluating the effects of real estate development in Owerri, Imo State, Nigeria: Emphasizing changes in land use/land cover (LULC). *Journal of Landscape Ecology*, 16(2), 98–113. <https://doi.org/10.2478/jlecol-2023-0012>
- Alam, H. (2021, June 10). Liveability index: Dhaka fourth least livable city in world. *The Daily Star*. <https://www.thedailystar.net/backpage/news/liveability-index-dhaka-fourth-least-livable-city-world-2107997>
- Aliyu, A., Isma'il, M., Zubairu, S. M., Gwio-kura, I. Y., Abdullahi, A., Abubakar, B. A., & Mansur, M. (2023). Analysis of land use and land cover change using machine learning algorithm in Yola North Local Government Area of Adamawa State, Nigeria. *Environmental Monitoring and Assessment*, 195(12). <https://doi.org/10.1007/s10661-023-12112-w>
- Alp, G., Ozdemir, Y., & Ozdemir, S. (2020). Effects of urban transformation on transportation infrastructure: Goztepe transformation area example. *Asian Journal of Interdisciplinary Research*, 206–218. <https://doi.org/10.34256/ajir20116>
- Aniekwe, S., & Igu, N. I. (2019). A geographical analysis of urban sprawl in Abuja, Nigeria. *Journal of Geographical Research*, 2(1), 12–18. <https://doi.org/10.30564/jgr.v2i1.344>
- Asenso, B. B., Jia, L., Menenti, M., Zhou, J., & Zeng, Y. (2020). Mapping land use land cover transitions at different spatiotemporal scales in West Africa. *Sustainability*, 12(20), 8565. <https://doi.org/10.3390/su12208565>
- Bharatkar, P. S., & Patel, R. (2013). Approach to accuracy assessment for RS image classification techniques. *International Journal of Science and Engineering Research*, 4, 79–86.
- Bernard, S. H., & Bilal, H. (2023). An analysis of the dynamics of land surface temperature on land use/land cover in Kano Metropolis, Kano State, Nigeria. *Science World Journal*, 18(2), 240–253. <https://doi.org/10.4314/swj.v18i2.11>
- Bianchini, L., Marucci, A., Sateriano, A., Di Stefano, V., Alemanno, R., & Colantoni, A. (2021). Urbanization and long-term forest dynamics in a metropolitan region of Southern Europe (1936–2018). *Sustainability*, 13(21), 12164. <https://doi.org/10.3390/su132112164>

- Chen, J., Theller, L., Gitau, M. W., Engel, B. A., & Harbor, J. M. (2017). Urbanization impacts on surface runoff of the contiguous United States. *Journal of Environmental Management*, 187, 470–481.
- Chou, J., Dong, W., Wang, S., & Fu, Y. (2015). Quantitative analysis of agricultural land use change in China. *Physics and Chemistry of the Earth, Parts A/B/C*, 87–88, 3–9. <https://doi.org/10.1016/j.pce.2015.08.011>
- Congalton, R. (2004). Putting the map back in map accuracy assessment. *Remote Sensing and GIS Accuracy Assessment*, 1–11.
- Cordillera Regional Development Council. (2024). Regional physical framework plan 2024–2054.
- Derdouri, A., Wang, R., Murayama, Y., & Osaragi, T. (2021). Understanding the links between LULC changes and SUHI in cities: Insights from two-decadal studies (2001–2020). *Remote Sensing*, 13(18), 3654. <https://doi.org/10.3390/rs13183654>
- Dewan, A., & Corner, R. (2014). Dhaka megacity. <https://doi.org/10.1007/978-94-007-6735-5>
- Du, Y., Bagan, H., & Takeuchi, W. (2019). Land-use/land-cover change and drivers of land degradation in the Horqin Sandy Land, China. *IGARSS 2019–2019 IEEE International Geoscience and Remote Sensing Symposium*. <https://doi.org/10.1109/igarss.2019.8899221>
- Enoguanbhor, E., Gollnow, F., Nielsen, J., Lakes, T., & Walker, B. B. (2019). Land cover change in the Abuja city-region, Nigeria: Integrating GIS and remotely sensed data to support land use planning. *Sustainability*, 11(5), 1313. <https://doi.org/10.3390/su11051313>
- ESRI. (n.d.). How maximum likelihood classification works. ArcMap documentation. Retrieved July 20, 2022, from <https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/how-maximum-likelihood-classification-works.htm>
- Fletcher, T. D., Andrieu, H., & Hamel, P. (2013). Understanding, management and modelling of urban hydrology and its consequences for receiving waters: A state of the art. *Advances in Water Resources*, 51, 261–279.
- Foody, G. M. (2020). Explaining the unsuitability of the kappa coefficient in the assessment and comparison of the accuracy of thematic maps obtained by image classification. *Remote Sensing of Environment*, 239, 111630.
- Griffith, J. A., Martinko, E. A., Whistler, J. K., & Price, K. P. (2002). Interrelationships among landscapes, NDVI, and stream water quality in the U.S. Central Plains. *Ecological Applications*, 12(6), 1702–1718. [https://doi.org/10.1890/1051-0761\(2002\)012\[1702:IALNAS\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2002)012[1702:IALNAS]2.0.CO;2)
- Hadiuzzaman, M., Basar Baki, A., & Mostafa Khan, S. (2006). Pollution status and trends in water quality of the Shitalakhya and Balu rivers. *Journal of NOAMI*, 23, 1–22.
- Hough, M. (2004). Cities and natural process: A basis for sustainability.

- Khan, M. S., Ullah, S., Sun, T., Rehman, A. U. R., & Chen, L. (2020). Land-use/land-cover changes and its contribution to urban heat island: A case study of Islamabad, Pakistan. *Sustainability*, 12, 3861.
- Krause, C. W., Lockhard, B., Newcomb, T. J., Kibler, D., Lohani, V., & Orth, D. J. (2004). Predicting influences of urban development on thermal habitat in a warm water stream. *Journal of the American Water Resources Association*, 40, 1645–1658. <http://dx.doi.org/10.1111/j.1752-1688.2004.tb01612.x>
- Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources*, 28, 205–241.
- Ma, X., Xu, J. C., Luo, Y., Prasad Aggarwal, S., & Jiatong, L. (2009). Response of hydrological processes to land-cover and climate changes in Kejie Watershed, Southwest China. *Hydrological Processes*, 23, 1179–1191. <http://dx.doi.org/10.1002/hyp.7233>
- Nelson, E. J., & Booth, D. B. (2002). Sediment sources in an urbanizing, mixed land-use watershed. *Journal of Hydrology*, 264, 51–68. [http://dx.doi.org/10.1016/S0022-1694\(02\)00059-8](http://dx.doi.org/10.1016/S0022-1694(02)00059-8)
- Nogueira, M., Albergel, C., Boussetta, S., Johannsen, F., Trigo, I. F., Ermida, S. L., Martins, J. P. A., & Dutra, E. (2020). Role of vegetation in representing land surface temperature in the CHTESSEL (CY45R1) and SURFEX-ISBA (v8.1) land surface models: A case study over Iberia. *Geoscientific Model Development*, 13, 3975–3993.
- Omran, E.-S. E. (2012). Detection of land-use and surface temperature change at different resolutions. *Journal of Geographic Information System*, 4, 189–203.
- Pettorelli, N., Vik, J. O., Mysterud, A., Gaillard, J.-M., Tucker, C. J., & Stenseth, N. C. (2005). Using the satellite-derived NDVI to assess ecological responses to environmental change. *Trends in Ecology and Evolution*, 20, 503–510.
- Schoonover, J. E., Lockaby, B. G., & Pan, S. (2005). Changes in chemical and physical properties of stream water across an urban-rural gradient in western Georgia. *Urban Ecosystems*, 8, 107–124. <http://dx.doi.org/10.1007/s11252-005-1422-5>
- Shuster, W. D., Bonta, J., Thurston, H., Warnemuende, E., & Smith, D. R. (2005). Impacts of impervious surface on watershed hydrology: A review. *Urban Water Journal*, 2, 263–275.
- Sobrino, J. A., & Raissouni, N. (2000). Toward remote sensing methods for land cover dynamic monitoring: Application to Morocco. *International Journal of Remote Sensing*, 21, 353–366.
- Somayajula, V. K. A., Ghai, D., Kumar, S., Tripathi, S. L., Verma, C., Safirescu, C. O., & Mihaltan, T. C. (2022). Classification and validation temperature of multitemporal images. *Sustainability*, 14, 5677.

Tennessee Valley Authority, Madison County Natural Resources Conservation Service, & Madison County Watershed Advisory Committee. (2008). Flint River watershed management plan (Revised May 2008).

Walsh, C., Fletcher, T. D., & Ladson, A. R. (2005). Stream restoration in urban catchments through redesigning storm-water systems: Looking to the catchment to save the stream. *Journal of the North American Benthological Society*, 24, 690–705. <http://dx.doi.org/10.1899/04-020.1>

Wang, F., Qin, Z., Song, C., Tu, L., Karnieli, A., & Zhao, S. (2015). An improved mono-window algorithm for land surface temperature retrieval from Landsat 8 thermal infrared sensor data. *Remote Sensing*, 7, 4268–4289.