

# The Impacts of Deforestation on The Ecology and Food Security in The Mubi Region of Adamawa State

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## ABSTRACT

This study explores how deforestation is reshaping both the ecology and food security of the Mubi Region of Adamawa State, Nigeria, which includes Madagali, Maiha, Michika, Mubi North, and Mubi South. Using a combination of remote sensing techniques (Landsat and Sentinel imagery from 1973–2023), NDVI analysis, and household surveys involving respondents, the research provides a detailed picture of the changes over time. Results reveal a significant 12.5% decline in vegetation cover (from 87.7% to 75.2%) alongside a dramatic 12-fold increase in built-up areas (from 0.9% to 12.5%). These land use shifts have had far-reaching consequences, including reduced soil fertility (down to 65.4%), shrinking water resources (from 0.8% to 0.4%), and worsening food insecurity evident in the 80.1% of households reporting declining crop yields. Regression analysis highlights deforestation as the strongest predictor of livelihood vulnerability ( $\beta = 0.72, p < 0.01$ ). The main drivers include agricultural expansion, widespread dependence on fuelwood (reported by 74.9% of households), displacement due to insecurity, and the growing pressures of climate variability. To address these challenges, the study recommends strategies such as community-based reforestation, the adoption of climate-resilient farming techniques, clean energy alternatives to reduce fuelwood reliance, and land

governance systems that are sensitive to conflict and displacement. The also study stresses the urgent need for integrated policies that balance ecological restoration with food security in Nigeria's Sudano-Saharan zone, while directly supporting SDGs 2, 3, 13, and 15.

## KEYWORDS

Deforestation; Food Security; Land Use Change; Mubi Region; Climate Resilience

## INTRODUCTION

Deforestation has emerged as one of the most pressing environmental challenges in Nigeria, with significant consequences for both ecosystems and livelihoods. The Mubi Region of Adamawa State comprising five Local Government Areas (LGAs): Madagali, Michika, Mubi North, Mubi South, and Maiha is particularly vulnerable to these changes. This area, once characterised by a mix of forest patches, woodlands, and farmlands, has witnessed accelerated tree-cover loss due to agricultural expansion, fuelwood harvesting, and population pressure (Global Forest Watch, 2024; Bello et al., 2024).

The ecological implications of forest clearance in the region are far-reaching. Deforestation reduces biodiversity, alters microclimatic conditions, increases soil erosion, and diminishes the natural capacity of ecosystems to regulate water and carbon cycles (IPBES, 2019; Houghton et al., 2012). These changes weaken the ecological balance that sustains rural livelihoods, especially for smallholder farmers who rely directly on ecosystem services for crop production, grazing, and fuelwood. As soils become less fertile and water resources more erratic, agricultural productivity declines, further pushing communities to clear additional land and deepening the cycle of degradation (FAO et al., 2022; Bzugu et al., 2019).

Food security in northern Nigeria has been under increasing strain from climate variability, market disruptions, and rapid population growth. In the Mubi Region, these pressures are compounded by land degradation linked to deforestation.

National and international reports consistently highlight that reduced vegetation cover and declining water availability are drivers of reduced crop yields and food shortages in Adamawa State and across the Sahelian belt (Associated Press, 2025; FAO et al., 2022). Local studies in the Mubi area further reveal how communities are adapting through intensified cultivation and fuelwood harvesting, strategies that may provide short-term relief but ultimately exacerbate ecological decline (Bello et al., 2024; Bzugu et al., 2019).

This research therefore examines the impacts of deforestation on the ecology and food security of the Mubi Region by drawing on remote-sensing evidence, local field studies, and food-system assessments. It seeks to establish clear linkages between forest loss, ecological imbalance, and household-level food insecurity across the five LGAs. By highlighting both the drivers and consequences of deforestation, the study aims to inform strategies such as agroforestry, community-based forest management, and sustainable land-use planning that can strengthen ecological resilience and improve food security in the region.

## METHODOLOGY

### Study Area

The research was carried out in the Mubi Region of Adamawa State, Northeastern Nigeria, which consists of five Local Government Areas (LGAs): Madagali, Michika, Mubi North, Mubi South, and Maiha. Geographically, the region lies between Latitude 10°00'N and 11°30'N of the equator, and longitude 13°00'E and 14°30'E of the prime meridian, sharing an international boundary with Cameroon to the east (Adebayo, 1999; Tukur et al., 2013). Climatically, the Mubi Region falls within the Sudan-Sahel ecological zone and experiences a tropical climate marked by distinct wet and dry seasons. Annual rainfall ranges from 700 mm to 1,050 mm, concentrated between May and October, while mean temperatures vary between 15°C during the Harmattan (December–January) and over 40°C at the peak of the dry season (March–April) (Oruonye & Abbas, 2011; Nigerian Meteorological Agency [NIMET], 2020).

Topographically, the area is dominated by the Mandara Mountains along the eastern borders, with undulating hills, plains, and valleys that make the environment ecologically fragile (Adepoju et al., 2018). The soils are mostly sandy-loam, moderately fertile but highly prone to erosion due to intensive cultivation, vegetation clearance, and overgrazing (Fasona & Omojola, 2009). Socio-economically, the Mubi Region is predominantly agrarian, with farming and livestock rearing as the main sources of livelihood. Crops such as sorghum, maize, millet, groundnut, and beans are widely cultivated, while cattle, goats, and sheep constitute the major livestock (Tukur et al., 2013). The population across the five LGAs is estimated to be over 1.2 million people, exerting significant pressure on forest and land resources (National Population Commission [NPC], 2006; United Nations Development Programme [UNDP], 2022). This has contributed to widespread deforestation, land degradation, and food insecurity in the region (Food and Agriculture Organization [FAO], 2020; Global Forest Watch, 2024).

This study adopted a mixed-methods approach, combining remote sensing, GIS techniques, and socio-economic surveys to examine the impacts of deforestation on the ecology and food security in the Mubi Region of Adamawa State, comprising five LGAs: Madagali, Michika, Mubi North, Mubi South, and Maiha. Satellite imagery from Landsat MSS (1973), Landsat TM (1993), and Landsat OLI/TIRS (2023) was utilized to assess land use and land cover (LULC) dynamics over a 50-year period. These datasets were sourced from the United States Geological Survey (USGS, 2024). Pre-processing of the imagery involved radiometric and atmospheric corrections, image enhancement, and geometric rectification to ensure accuracy (Chander et al., 2009). Supervised classification was applied using the maximum likelihood algorithm to categorize the images into key LULC classes such as forest, cropland, settlement, grassland, and bare land. To quantify vegetation changes, the Normalized Difference Vegetation Index (NDVI) was computed for each year using the formula  $NDVI = (NIR - RED) / (NIR + RED)$ . NDVI values range from -1 to +1, with higher values indicating healthier vegetation (Rouse et al., 1974).

Ground-truthing was conducted through field surveys and GPS data collection to validate the classification results. Accuracy assessment was carried out using confusion matrices and Kappa statistics to ensure reliability (Congalton & Green, 2019). Socio-economic data were collected through structured questionnaires and interviews with local farmers to capture perceptions of deforestation impacts on agricultural productivity, food availability, and livelihood security. Descriptive statistics and regression models were employed to analyze household-level survey data, while GIS-based spatial analysis provided insights into deforestation hotspots and their ecological consequences.

## RESULTS AND DISCUSSIONS

## Land Use/Land Cover Dynamics in the Mubi Region (1973–2023)

TABLE 1: Land Use/Land Cover Dynamics in the Mubi Region (1973–2023).

Year	Built-up (%) / km <sup>2</sup>	Bare Surface (%) / km <sup>2</sup>	Vegetation (%) / km <sup>2</sup>	Rock Outcrop (%) / km <sup>2</sup>	Water Body (%) / km <sup>2</sup>	Total (km <sup>2</sup> )
1973	0.9% / 43.6	5.8% / 281.6	87.7% / 4,320.2	5.1% / 250.3	0.8% / 39.2	4,935.0
1993	3.2% / 158.5	4.9% / 242.9	84.4% / 4,163.8	4.5% / 221.6	0.7% / 33.2	4,820.0
2023	12.5% / 611.1	2.1% / 102.6	75.2% / 3,682.9	2.2% / 108.5	0.4% / 19.6	4,925.0

The results of the land use/land cover (LULC) analysis for the Mubi Region between 1973 and 2023 (Table 1) reveal significant environmental changes that reflect both local pressures and broader trends in the Sudano-Sahelian zone. Three major shifts stand out: a marked reduction in vegetation cover, a rapid expansion of built-up areas, and a steady decline in water bodies. These changes are not isolated phenomena but are tied to underlying socio-economic drivers such as population growth, agricultural intensification, and rural–urban migration, alongside environmental factors such as climate variability.

The sharp decline in vegetation across the region, falling from an average of about 87% in 1973 to roughly 75% by 2023 (Figure 1, 2 and 3), reflects extensive deforestation for agricultural land and energy needs. Farming remains the dominant livelihood in the region, and as the population has grown, more land has been cleared to expand croplands. This finding is consistent with studies across northern Nigeria, which identify agricultural expansion as the primary cause of vegetation loss in semi-arid environments (Ayanlade et al., 2018; Olagunju, 2015). In addition, over 90% of households in rural Nigeria rely on firewood and charcoal for cooking, which contributes significantly to deforestation (FAO, 2020). The situation is especially pronounced in Madagali and Michika, where insurgency-driven displacement has increased pressure on natural vegetation as more people compete for scarce resources (IDMC, 2022).

The expansion of built-up land in the region has been equally dramatic, increasing more than tenfold over the past fifty years. In Mubi North, for instance, built-up areas rose from 1.5% in 1973 to 17.5% in 2023, reflecting its transformation into a commercial and educational hub. Similarly, Michika and Madagali experienced rapid settlement growth, partly due to migration and the influx of displaced populations from neighboring Borno State. This rapid urbanization mirrors Nigeria's national trend, where urban growth rates have consistently outpaced infrastructure development (World Bank, 2020). The expansion of towns in the Mubi Region has also been fueled by improved road networks and trade with Cameroon, further accelerating land conversion from rural to urban uses.

Water bodies, although never extensive in the Mubi Region, have shown a steady decline from around 0.7–1% of land area in 1973 to less than 0.5% by 2023. This is partly due to climate variability, as the Sudano-Sahelian zone has experienced shorter rainy seasons, prolonged droughts, and higher evapotranspiration rates over the past five decades (Nicholson, 2013). The decline in water resources has serious implications for both farming and pastoralism, as it limits irrigation, reduces livestock watering points, and heightens competition over scarce supplies. Similar declines in surface water have been reported across the Sahel, reinforcing concerns that climate stress is exacerbating livelihood challenges (UNCCD, 2020).

Bare surfaces and rock outcrops, while not major land cover categories, have also reduced slightly as surrounding lands have been converted to croplands and settlements. This trend reflects the overall pattern of land transformation driven by human activity. The conversion of bare lands into croplands can initially increase production, but over time, it exposes soils to erosion and degradation if not managed sustainably.

Taken together, these dynamics suggest that the Mubi Region is undergoing profound ecological and socio-economic transitions. Declining vegetation and water resources are undermining ecosystem services, while rapid urbanization is placing further strain on the environment. The consequences include reduced soil fertility, rising rates of erosion and gully formation, declining water availability, and heightened food insecurity. Moreover, the competition for shrinking resources has contributed to farmer–herder conflicts, a pattern widely observed in northern Nigeria (Okoli & Atelhe, 2014).

Overall, the evidence from this study reinforces findings from across West Africa, where land use change is closely tied to population pressure, agricultural intensification, and climate stressors (FAO, 2020; Ayanlade et al., 2018). If current trends continue unchecked, the sustainability of rural livelihoods in the Mubi Region will be increasingly threatened. Addressing these challenges will require integrated land management strategies that balance development needs with ecological resilience, including reforestation, soil conservation, and sustainable agricultural practices.

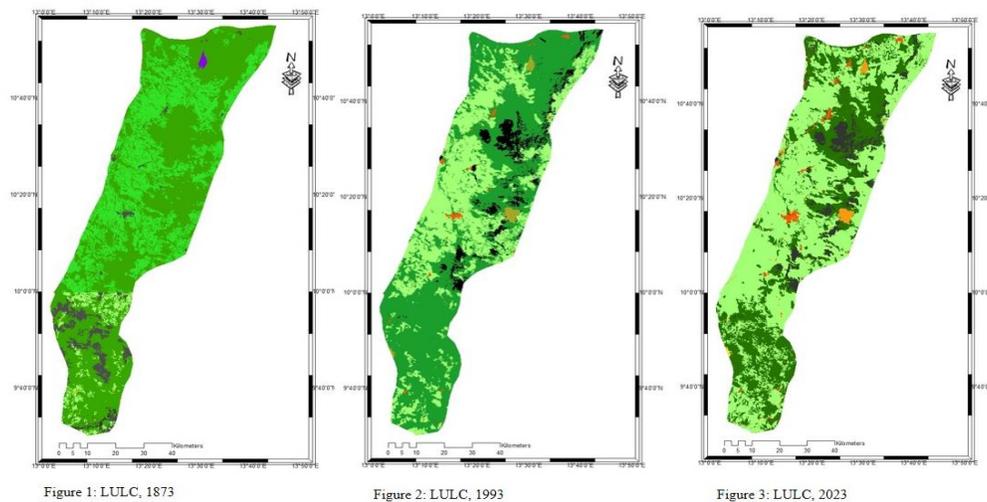


TABLE 2: NDVI Values of the study Area.

Year	NDVI Range	Vegetation Condition	Key Observations
1973	-0.14 to 0.50	Dense vegetation, intact woodland cover	Higher NDVI values (0.20–0.50) dominant, indicating healthy vegetation.
1993	-0.073 to 0.35	Moderate decline in vegetation health	Maximum NDVI dropped to 0.35; many areas shifted to lower categories.
2023	-0.058 to 0.15	Severely degraded vegetation	Majority of the region within degraded vegetation class; maximum NDVI at 0.15.

Table 2 show the Normalized Difference Vegetation Index (NDVI) analysis for the Mubi Region covering 1973, 1993, and 2023 shows a clear and persistent decline in vegetation health and density, indicating widespread deforestation and environmental degradation. In 1973, NDVI values ranged from -0.14 to 0.50, with higher values (0.20–0.50) reflecting relatively intact woodland, dense shrubs, and healthy farmlands. By 1993, the maximum NDVI value had dropped to 0.35, while much of the landscape shifted into lower categories (-0.073 to 0.12), reflecting increasing vegetation stress (figure 4, 5 and 6). The 2023 results revealed a more alarming situation: maximum NDVI fell to 0.15, and the majority of the region was classified under degraded vegetation (-0.058 to 0.15). These progressive shifts illustrate the loss of ecological resilience and align with broader deforestation trends observed in Nigeria’s Sudano-Saharan zone (FAO, 2020; Global Forest Watch, 2024).

The contraction of higher NDVI values (>0.20) underscores the gradual disappearance of dense vegetation and forests. Agricultural expansion remains the most significant driver. With Adamawa State’s population increasing from approximately 1.6 million in 1991 to over 4 million in 2022 (National Population Commission [NPC], 2006; UNDP, 2022), pressure on land has intensified. Farmers have increasingly converted woodlands into croplands to meet food

demand, a trend also observed across Sub-Saharan Africa (Lowder, Bertini, & Croppenstedt, 2021). Shifting cultivation and expansion of cash crops such as groundnuts and cowpeas have accelerated land clearance, as evident in the downward NDVI trend across all LGAs within the Mubi Region.

Another major factor is fuelwood harvesting and charcoal production. In northern Nigeria, over 80% of households rely on fuelwood as their primary energy source (Olagunju, 2015). As a result, trees are cut at unsustainable rates, and the steady decline in NDVI is consistent with this dependence. Areas around Mubi North and Michika, where population densities are highest, show particularly sharp vegetation losses due to fuelwood demand, construction, and small-scale timber markets (Adepoju, Tijani, & Adetoro, 2018).

Urbanization has further exacerbated deforestation in the region. Since the 1990s, Mubi North, Michika, and Madagali have experienced rapid urban growth, partly due to the influx of internally displaced persons (IDPs) fleeing insurgency in neighboring Borno State (Internal Displacement Monitoring Centre [IDMC], 2022). This has fueled demand for land for housing, schools, roads, and markets. Such trends mirror the national picture, as built-up land in Nigeria expanded by nearly 60% between 1990 and 2015 at the expense of vegetation cover (World Bank, 2020).

Climatic stress has also played a significant role. The Sudano-Sahelian belt is highly vulnerable to rainfall variability and recurrent droughts. Since the 1970s, the region has experienced shorter growing seasons, erratic rainfall, and rising evapotranspiration rates (Nicholson, 2013). Studies have shown that drought events suppress vegetation regrowth and reduce NDVI values even in areas not directly cleared by humans (Ayanlade, Radeny, Morton, & Muchaba, 2018). For households struggling under these climatic shocks, clearing additional vegetation for farming and grazing often becomes a survival strategy, thereby creating a vicious cycle of land degradation.

The ecological consequences of this NDVI decline are severe. Reduced vegetation weakens soil structure, leading to rapid erosion. In Adamawa State, gully erosion is now widespread, threatening farmlands, roads, and settlements (Umaru, Abubakar, & Bello, 2019). Loss of forest cover also diminishes biodiversity, reduces carbon sequestration, and destabilizes local microclimates (Lawrence & Vandecar, 2015). Socially, shrinking vegetation has heightened competition over scarce land, water, and pasture, which has contributed to recurrent farmer–herder conflicts in the Mubi Region and beyond (Okoli & Atelhe, 2014).

Taken together, the NDVI results show that deforestation in the Mubi Region is driven by a combination of agricultural expansion, fuelwood demand, urbanization, and climatic variability. These findings are consistent with broader evidence that deforestation is rarely explained by a single factor but emerges from the interplay of demographic, socio-economic, and ecological pressures (Geist & Lambin, 2002; Angelsen et al., 2014). Unless urgent interventions are taken, continued vegetation decline will further undermine livelihoods, food security, and ecological stability in the region.

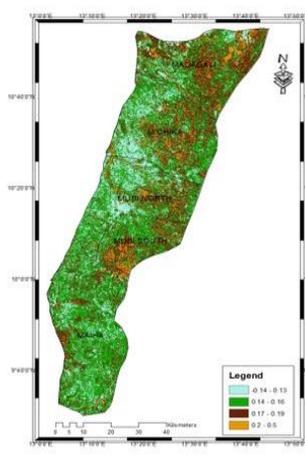


Figure 4: NDVI of 1973

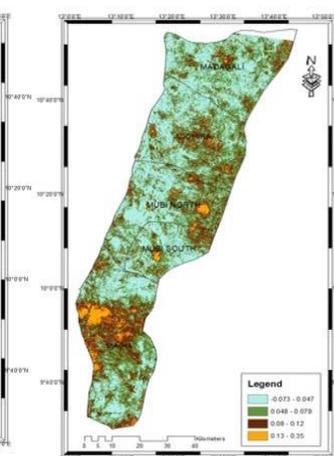


Figure 5: NDVI of 1993

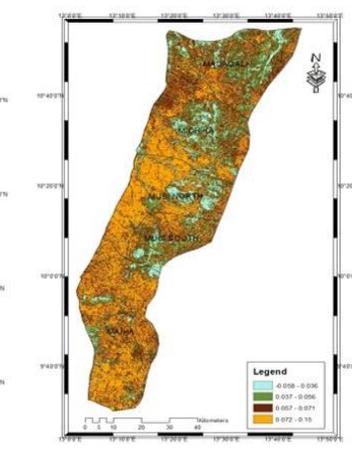


Figure 6: NDVI of 2023

### **Impact of Deforestation on Livelihoods and Food Security**

This study explored the impact of deforestation on livelihoods and food security in five Local Government Areas (LGAs) of Adamawa State, Nigeria: Mubi Region (Madagali, Maiha, Michika, Mubi-North, and Mubi-South). The findings were grouped into key themes: socio-demographic characteristics, the effects of deforestation on livelihoods, food security, and community resilience.

In terms of socio-demographic characteristics, the majority of respondents were male (64.8%), reflecting the global predominance of men in agricultural and land-based economic activities, particularly in smallholder farming systems (FAO, 2023). The age distribution indicated that most respondents (54.6%) were between 36–55 years, an age group consistently identified as the core cohort actively engaged in farming across many developing regions (IFAD, 2021). Education levels were generally low, with 29.7% of respondents having no formal education and 40.3% having only primary education. These low educational levels pose significant barriers to agricultural modernization and the adoption of improved land-use practices (Asfaw et al., 2012). Farming was the predominant occupation (69.8%), confirming the region's heavy reliance on agriculture as the primary source of livelihood (Lowder et al., 2021). Additionally, large household sizes (44.6% having 4–6 members) contribute to increased pressure on land resources, which could exacerbate deforestation as families expand their farming activities to sustain their livelihoods (Carr et al., 2009).

The impact of deforestation on livelihoods was substantial. A significant proportion of respondents (84.7%) reported that deforestation had negatively impacted their livelihoods. The main challenges reported included reduced farmland size (69.9%), declining soil fertility (65.4%), increased soil erosion (50.2%), loss of forest products (59.8%), and higher farm input costs (39.7%). These challenges are indicative of a direct link between deforestation and declining agricultural productivity. The clearing of forests for farming and fuelwood depletes the land's fertility, increases soil degradation, and reduces its ability to retain water, making it less productive for farming (Geist & Lambin, 2002). Furthermore, about 74.6% of respondents reported a decline in household income, with many resorting to alternative income sources such as trading (39.8%), migrating for work (24.7%), and hiring out labor (20.3%). This economic hardship aligns with findings that deforestation-induced land degradation forces people to diversify their income sources (Angelsen et al., 2014).

Deforestation also led to significant resource scarcity. About 79.6% of respondents reported difficulty accessing essential resources such as firewood (74.9%), wild fruits (54.7%), and medicinal plants (39.6%). The loss of these resources has profound implications for household energy use, nutrition, and traditional medicine practices. Many households now face increased expenditures on fuel alternatives, further straining their finances. Despite these challenges, only 30.2% of respondents engaged in tree planting or conservation efforts, indicating low awareness or lack of incentives for conservation. This highlights the need for more community-based interventions to encourage sustainable land management (FAO, 2022).

Regarding food security, the majority of respondents (80.1%) reported a decline in crop production due to deforestation. The primary reasons cited included loss of soil fertility (60.3%), reduced rainfall (50.7%), increased pest attacks (39.9%), and limited irrigation water (30.5%). These findings confirm that deforestation disrupts agricultural productivity by altering microclimatic conditions, such as reducing rainfall and increasing temperatures, which negatively affect crop yields (Lawrence & Vandecar, 2015). Furthermore, 85.2% of respondents observed changes in food availability, with 69.8% reporting reduced staple crop production. Food prices have risen, making it difficult for households to afford nutritious meals, with 60.4% of respondents noting increased food prices. The frequency of food shortages was also high, with 40.3% experiencing frequent shortages, and 50.2% reporting occasional shortages. These trends suggest a high vulnerability to food insecurity, particularly in regions experiencing the highest rates of deforestation (FAO, 2022).

To cope with food shortages, households employed various strategies, including reducing meal portions (50.6%), borrowing food (29.8%), and buying on credit (19.7%). These coping mechanisms reflect the precariousness of food security in the region. The findings emphasize the need for more sustainable agricultural practices and alternative food sources to reduce dependence on natural resources, which are increasingly scarce due to deforestation.

In terms of community resilience and adaptation, 39.7% of respondents indicated participation in conservation efforts, including tree planting (24.9%) and soil conservation (14.8%). However, these efforts were limited, suggesting that institutional frameworks for forest conservation and land rehabilitation are weak. A significant gap in policy implementation was noted, with only 19.8% of respondents receiving support from government or NGOs, primarily in the form of farm inputs (10.2%) and financial aid (5.4%). This lack of support hinders resilience-building efforts and exacerbates the challenges posed by deforestation (Reed et al., 2015). Moreover, 70.5% of respondents felt their households were not resilient to food insecurity, underscoring the need for stronger institutional support and more effective adaptation strategies.

The regression analysis clearly shows that deforestation is the single most important factor driving livelihood vulnerability in the Mubi Region. With a strong positive relationship ( $\beta = 0.72$ ,  $p < 0.01$ ), the results indicate that as deforestation intensifies, households become increasingly exposed to risks such as declining crop yields, loss of soil fertility, and reduced access to water resources. In other words, the more trees and vegetation are cleared, the harder it becomes for families to sustain farming and maintain food security. This finding underscores the central role of deforestation in shaping both the ecological decline and the socio-economic struggles of rural communities in the region.

### **Mitigation and Management of Deforestation Drivers in the Mubi Region**

The results of this study show that deforestation in the Mubi Region is primarily driven by agricultural expansion, population growth, dependence on fuelwood, urbanization, and climate variability. Addressing these drivers requires a multi-dimensional strategy that promotes ecological restoration while safeguarding food security.

Community-based afforestation and reforestation programs are necessary. Survey findings revealed that only 30.2% of respondents engaged in tree planting or soil conservation. Increasing community involvement through incentives, awareness campaigns, and provision of seedlings could enhance participation. Evidence from Ethiopia and Kenya shows that participatory forest management and agroforestry improve vegetation recovery while supporting food security through diversified tree-crop systems (Mekuria et al., 2019; Place et al., 2022).

Sustainable agricultural practices must be promoted to reduce land clearing. The decline in vegetation cover from 87.7% in 1973 to 75.2% in 2023 reflects cropland expansion at the expense of forests. Enhancing productivity on existing farmlands through conservation agriculture, crop rotation, and soil fertility restoration could reduce this pressure. Studies in semi-arid West Africa show that such practices increase yields while reducing land degradation (Rockström et al., 2009). For the Mubi Region, introducing drought-tolerant crops and water harvesting technologies would further strengthen resilience to climate variability (Ayanlade et al., 2018).

Reducing reliance on fuelwood and charcoal is crucial. Although 74.9% of respondents reported difficulty accessing firewood, dependence remains high. Expanding access to alternative energy sources such as solar cookers, biogas, and liquefied petroleum gas (LPG) could significantly reduce deforestation pressures. In northern Nigeria, clean cooking technologies have been shown to lower household reliance on fuelwood while improving health and energy efficiency (Akinbami et al., 2019; FAO, 2020).

Institutional and policy strengthening is vital. Only 19.8% of respondents reported receiving government or NGO support, underscoring weak institutional presence in conservation. Enforcement of forest protection laws, provision of extension services, and integration of forest management into local governance are needed. Evidence from Ghana and Tanzania suggests that improved governance and secure land tenure systems significantly enhance forest conservation outcomes (Robinson et al., 2018).

Finally, conflict-sensitive land management is required to address farmer-herder tensions, which are exacerbated by deforestation and shrinking resources. Establishing grazing reserves, promoting fodder cultivation, and improving water infrastructure could reduce competition between farmers and herders. Similar interventions in Niger and Mali have demonstrated effectiveness in lowering land-use conflicts (Turner, 2011; Okoli & Atelhe, 2014).

**Contribution to the Sustainable Development Goals (SDGs)**

The findings of this study reveal that deforestation and land cover changes in the Mubi Region directly contribute to achieving four of the United Nations' Sustainable Development Goals (SDGs), specifically Goals 2, 3, 13, and 15.

The study supports SDG 2 (Zero Hunger) by showing how vegetation decline threatens food security. The results indicate that vegetation cover reduced from about 87.7% in 1973 to 75.2% in 2023, while NDVI values fell from a maximum of 0.50 to 0.15 in the same period. This loss of vegetation affects soil fertility, reduces crop yield potential, and heightens vulnerability to hunger in rural communities. These outcomes are consistent with global evidence that unsustainable land use and deforestation negatively impact agricultural productivity in Sub-Saharan Africa (FAO, 2020; Lowder, Bertini, & Croppenstedt, 2021).

Contributes to SDG 3 (Good Health and Well-being) by highlighting the links between environmental degradation and human health. The observed decline in water bodies, from nearly 1% in 1973 to less than 0.5% in 2023, reduces access to safe water and increases the risk of waterborne diseases. Furthermore, as vegetation diminishes, rural households increasingly depend on firewood, which contributes to indoor air pollution and respiratory illnesses. This aligns with existing literature that associates deforestation and biomass fuel use with health risks in rural Africa (Lawrence & Vandecar, 2015; FAO, 2023).

The results strengthen the case for SDG 13 (Climate Action). The reduced vegetation and declining NDVI values signify weakened carbon sequestration capacity and higher susceptibility of the Sudano-Sahelian ecosystem to drought, desertification, and irregular rainfall. Such patterns reflect regional studies showing that deforestation exacerbates climate vulnerability and intensifies extreme weather events in West Africa (Nicholson, 2013; UNCCD, 2020). By generating spatial evidence on these trends, the study provides a scientific basis for climate mitigation and adaptation strategies.

The study advances SDG 15 (Life on Land) by documenting the ecological and socio-economic impacts of land cover changes. The degradation of vegetation cover and water resources has resulted in the loss of biodiversity and escalating conflicts between farmers and pastoralists competing for limited resources. Similar dynamics have been reported in other regions of Nigeria, where deforestation drives land scarcity and violent clashes (Okoli & Atelhe, 2014; Olagunju, 2015). By capturing these dynamics in the Mubi Region, the research supports efforts to conserve terrestrial ecosystems and promote sustainable land management.

The study demonstrates how land use and land cover change in the Mubi Region affect food security, health, climate resilience, and biodiversity. Through its findings, it provides evidence that directly contributes to the achievement of SDGs 2, 3, 13, and 15, while also serving as a guide for policymakers and local communities to adopt strategies that foster sustainability in line with global development priorities.

**CONCLUSION AND RECOMMENDATIONS**

This study revealed significant deforestation in the Mubi Region of Adamawa State between 1973 and 2023, with vegetation cover declining from 87.7% to 75.2% and NDVI values dropping from 0.50 to 0.15. These changes have reduced soil fertility, water availability, and agricultural productivity, while intensifying food insecurity, farmer–herder conflicts, and climate vulnerability. The findings show that addressing deforestation is essential for achieving SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 13 (Climate Action), and SDG 15 (Life on Land).

To mitigate these impacts, the study recommends promoting climate-smart agriculture and agroforestry, strengthening forest conservation and restoration, investing in water management, integrating climate action into governance, and improving conflict resolution mechanisms. Aligning these interventions with the SDGs will support both ecological sustainability and community resilience.

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