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Assessment of Changes in Land Cover by Deforestation in Kurmi LGA, Taraba State, Nigeria Using Remote Sensing/Geographic Information System

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Abstract:
This study assessed the land cover changes between 1999 and 2019 in Kurmi LGA of Taraba state, Nigeria using remote sensing and the Geographic Information System. Landsat imageries of Kurmi LGA for 1999, 2009 and 2019 were acquired to investigate the drivers to these changes and their impact on the natural resources in the area. The geospatial approach was complemented by focus-group discussion, key informant interviews, and semi-structured interviews covering 692 households. The GIS-based analysis of remotely sensed data revealed only two categories of land cover changes; the built-up areas and vegetation cover. Built-up area was 3% (13,059 ha) and vegetation cover was 97% (422,241 ha) in 1999, the built-up area rose to 23.93 % and vegetation cover reduced to 76.07 (331,132.71 ha) in 2009, the built-up area further rose to 47.71% (207,681 ha) and vegetation cover reduced to 52.29% (227,618.27 ha) in 2019. While the built-up area grew dramatically, vegetation cover shrank dramatically. The result of the findings indicates that the community is aware of the land use and land cover dynamics and validated the observed changes. Timber and firewood collection, lumbering, logging, charcoal production, population growth, and poverty were identified as the key drivers of observed land cover changes. The changes exposed rural households to extreme events such as climate change, wind storms, soil erosion, food shortage, thereby posing a big threat to the sustainable management of natural resources. The study results are expected to support decision-makers and planners in the design and implementation of holistic guidelines for effective natural resource management. The study recommends massive afforestation programs that go beyond yearly rituals, tree planting in public places, institutions, roadsides and rural afforestation programs should be embarked upon. Government should also lead in the tree planting enlightenment campaign on the need to protect the forest and sustainable management of forest reserves in the area.
Keywords: Landcover change, Deforestation, Kurmi LGA-Taraba, Remote Sensing, GIS

1- Introduction

Most of Sub-Saharan Africa's ecological environment and forest resources, including Nigeria, is depleting due to land cover change as a result of deforestation. Deforestation is a severe issue that continues to put many of the world's delicate ecosystems in jeopardy, despite the fact that its consequences are well-known and have been documented on several occasions.

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Deforestation is a common environmental problem that has a significant impact on the resilience and distribution of forests across geographic borders. It is simply described as the loss of tree cover as a result of forest clearing for other objectives (Gorte & Sheikh, 2010).

According to the newly revealed major findings of the Global Forest Resources Assessment (FAO, 2020), there are 4.06 billion hectares of forest left on the planet. Only about **1.11 billion hectares of this area are primary forests** or native forests that remain largely undisturbed by humans, while the world is still losing its forest resources. Deforestation has resulted in the loss of an estimated **420 million hectares of land** since 1990 (FAO and UNEP. 2020). According to the key findings of the Global Forest Resources Assessment 2020 (FAO, 2020), **the rate of net forest loss has** decreased substantially, from an annual average of 7.8 million hectares between 1990 and 2000 to 4.7 million hectares between 2010 and 2020 (FAO, 2020)

In most developing countries, trees play a vital role in local people's livelihoods. People in the area rely on woods for a variety of things, including firewood, construction materials, medicinal herbs, and food. Furthermore, 350 million people who live near dense woods rely on them for food and income (Langat., et al., 2016). Environmental resources are projected to provide 20-25 per cent of rural people's income in underdeveloped nations and also serve as safety nets during seasonal crises or food shortages.

From 2002 to 2020, Nigeria lost 141kilo hectares of humid primary forest between 2002 and 2020, accounting for 14% of the country's total tree cover loss over the same period. Within this time span, the total area of Nigeria's humid primary forest shrank by 7.4%. In Nigeria from 2001 to 2019, 14% of tree cover loss occurred in areas where the dominant drivers of loss resulted in deforestation. In Nigeria, tree cover loss in Edo is 268 Kha, in Ondo, it is 107 Kha, Cross River is 102 Kha, in Taraba is 91.1 Kha and in Ogun is 82 Kha, the top 4 states were responsible for 54% of all tree cover loss between 2001 and 2020 (Global Forest Watch, 2020). Edo experienced the greatest loss of tree cover, with 268kha compared to an average of 28.2kha (Global Forest Watch, 2020). From 2001 to 2012, Nigeria gained 60.3kha of tree cover, equal to less than 0.1% of the global total. In 2010, Taraba had 1.64 Mha of tree cover, extending over 27% of its land area (Global Forest Watch, 2020). In 2020, Taraba state lost 7.82 Kha of tree cover, equivalent to 2.39 Mt of CO_2 of emissions. In Nigeria, 4.0Mha of land was burnt so far in 2021 (Global Forest Watch, 2021).

Taraba State is one among the eight states in the country, which accounts for 50% of Nigeria's forest cover, with Kurmi being one of the most forested Local Government areas in the state. The rainfall distribution and topography are the major factors influencing the pattern of vegetation in Kurmi LGA. It has much vegetation during the wet season and its foliage wilt during the dry season.

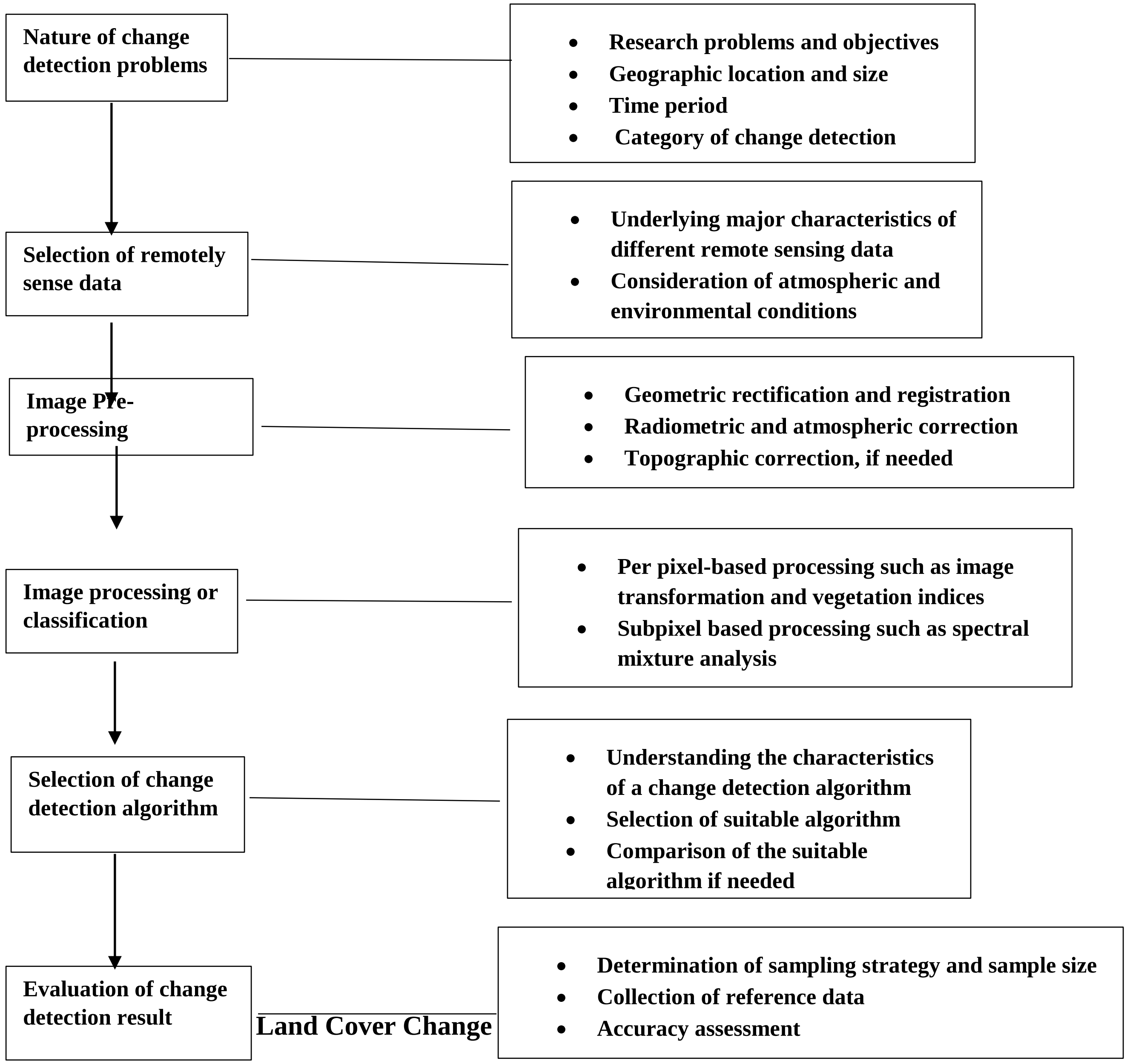
Taraba state lost 15.2 Kha of humid primary forest between 2002 and 2020, accounting for 17% of the overall tree cover reduction in the same period. During this time, the total area of Taraba's humid primary forest shrank by 6.4 per cent. From 2001 to 2020, Taraba state lost 91.1kha of tree cover, equivalent to a 5.9% decrease in tree cover since 2000, and 28.1Mt of CO_2 emissions. In Taraba state, tree cover loss in Kurmi LGA is 36.3 Kha, in Gashaka is 23.2 Kha, in Sardauna is 14.5, in Bali is 8.31 Kha and in Donga is 5.78 Kha (FAO, 2020). The top two local government areas, Kurimi and Gashaka, were responsible for 65% of all tree cover loss between 2001 and 2020. Kurmi LGA had the most tree cover loss at 36.3kha compared to 5.70kha. From 2001 to 2012, Taraba state gained 1.82kha of tree cover region-wide, equal to 3.0% of all tree cover gain in Nigeria (Global Forest Watch, 2015). In Taraba state, 410kha of forest land was burnt so far in 2021. This amount is typical when compared to other years' totals dating back to 2001. The year with the most fires was 2005, with 1.4 million hectares burned (Global Forest Watch, 2015).

For the past decades, Kurmi LGA has witnessed significant expansion, growth and developmental activities such as housing and road construction, deforestation and many other anthropogenic activities. The rapid and accelerating population and increasing socio-economic necessities in the area have placed pressure on natural resources and the environment in general. This pressure usually results in unplanned and uncontrolled changes. Unsustainable management of natural resources such as agricultural, urban, range and forest areas causes land use and land cover changes, resulting in significant environmental problems such as biodiversity loss, deforestation, and soil degradation.

Furthermore, Kurmi's population growth from 91,282 according to National Population Commission (2006) figures to a projected figure of 138,369 in 2021 and expanding socio-economic activities (lumbering, urbanization, logging, firewood collection etc.) have resulted in increased land consumption and unplanned changes in the status of its land use and land cover over time. Therefore, it is necessary to have insights and information about the kind of land use and land cover changes that has occurred, where and when they occurred, and at what rates they occurred. Documenting the drivers and processes that created these changes in Kurmi LGA is critical at a time like when the area is suffering from excessive heat, high day and night time temperatures, among others. In recent years, the dynamics of land use, land cover change and especially settlement expansion in the area have necessitated the employment of Geographic Information System and remote sensing techniques to give a broad extensive synoptic coverage of huge areas rather than aerial photography. Thus, data on land use and land cover changes are required to detect the rate of land consumption and forecast potential future changes in the study region, providing planners with a basic planning tool.

During the first quarter of 2015, Chinese imports of *Pterocarpus Erinaceus* from West Arica surged by more than 300 times in value, from 21,350 US dollars to 63,943,732 US dollars (Evans, 2012). During the first quarter of 2015, West Africa accounted for roughly 30% of China's total rosewood imports (Irande & Dang, 2019). According to available records, Chinese imports of Rosewood from West Africa are restricted to a single species, *Pterocarpus erinaceous* (Nadro & Modibbo, 2014). Nigeria has been leading in the rosewood trade since 2011 to date (Adam, 2012). Figure 2.1 depicts the summary of the land use and land cover change detection procedure and main contents for each step as described by Lu *et al*. (2004).

Change detection is considered an imperative process in monitoring land use and land cover changes because it provides a quantitative analysis of the spatial distribution of the population of interest, and this makes land use and land cover study a topic of interest in remote sensing (Song et al., 2001; Gallego, 2004). Therefore, Lu *et al*. (2004) suggest that sound change detection research should provide the following indispensable information; area of change and change rate, the spatial distribution of changed types, change trajectories of land-cover types and accuracy assessment of detection results. The major source of data for change detection is geographic and usually in digital forms, such as satellite imagery, analogue format (older aerial photos) and vector format (e.g., feature maps).



The aim of the study is to assess land cover change in Kurmi L.G.A, using a geospatial approach involving remote sensing and Geographic Information System and the objectives are to examine the extent of land cover changes in Kurmi LGA using satellite imageries from 1999 – 2019; ascertain the main drivers of land cover change in the study area; assess the impacts of land cover change dynamics on natural resources and rural livelihood in the Kurmi LGA and examine strategies that are effective for sustainable forest management in Kurmi LGA.

2- Materials and Methods

2.1 Study Area

Kurmi Local Government Area (LGA) is located between latitudes of 5° 31'N and 7° 18'N, and between longitudes of 10°18'E and 11° 37'E. It has a total land area of 4,353 Km^2, with an elevation of 872feet (fig 2, fig 3 and fig 4). The Kurmi LGA has a dry and rainy season as its dominant climatic feature. The rainy season starts from March to early November. The maximum rain occurs in August and September. Late November marks the start of the dry season, which lasts until early March. Average annual rainfall ranges between $1,200mm^3$ to $2,500mm^3$ with a mean annual temperature of $28^{o}C$. The mean wind speed in Kurmi LGA is estimated to be 12km/h.

Kurmi Local Government Area is a Guinea Savannah which is marked by forest and tall grasses. It shares a southern border with the Republic of Cameroon. The area is heavily forested. The climate, soil and hydrology of Kurmi LGA provide a conducive atmosphere for the cultivation of food and cash crops like cocoa, banana, plantain, palm trees, bananas, plantains, rice, groundnuts, oranges, palm trees, cocoyam, and cocoa. Maize, Guinea corn, and sesame are among the others. Kurmi LGA is a high-quality timber producer and the only LGA with the state-owned Baissa Timber Development Corporation, which is now defunct (Lenshie & Yakubu, 2014).

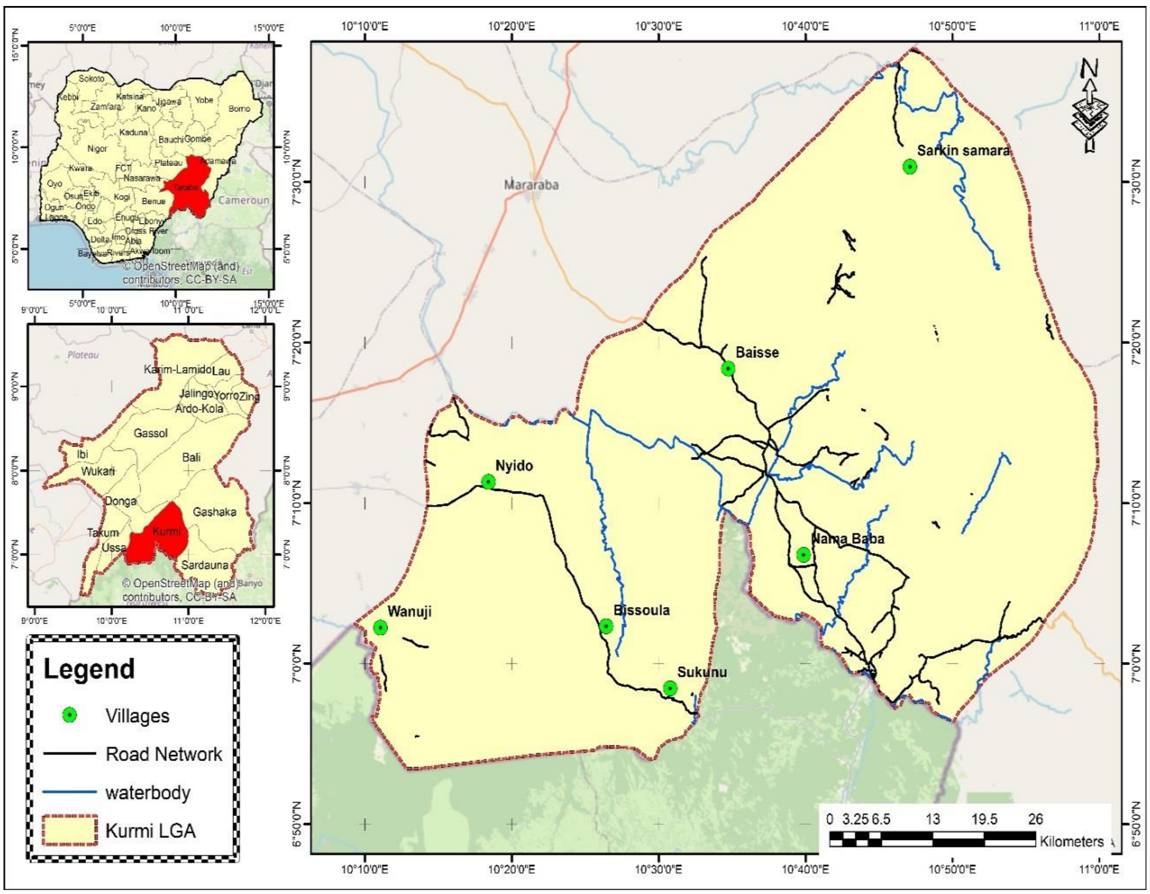


Fig 2: Map of the Kurmi LGA showing the study locations (Nigeria/Taraba State insert)

The Projected population of Kurmi LGA in 2021 is 138,369, based on an annual growth rate of 2.55% per annum from the 2006 population census figure of 91,531 people. There are three major ethnic groups in Kurmi LGA: Ndola, Tigun and Itchen (Lenshie and Yakubu, 2014). As a result of the agrarian nature, the predominant population engages in farming, hunting, cattle rearing and fishing as an occupation and as a means of livelihood. They also engage in the felling of trees for lumbering, fuel woods, and commercial quantity for timber development and export.

Grassland grows the majority of the cash and food crops in the north-western region. Because the majority of the population are farmers, the crops are produced in great quantities for local consumption and the remainder is exported, either to other areas of the country or beyond (Lenshie and Yakubu, 2014).

2.2 Methods

Data collection processes and sources: Data were collected through primary sources (through administration of questionnaires, interviews, field observations and pictures) and secondary sources include remotely sensed data from Landsat imageries, reputable journals, articles, books and the internet). It involves both formal and informal interactions with locals who are knowledgeable about the research study; both quantitative and qualitative data were collected. Three Landsat imageries (path 176, row 38) acquired in 1999 ETM+ (Enhanced Thematic Mapper Plus), 2009 ETM+ and 2019 Landsat 8 were used in the study to obtain land cover and monitor Normalized Difference Vegetation Index (NDVI) over the study area over 20 years (Table 1).

Table1: Characteristics of the Landsat Imageries and the date of acquisition

Imageries for the study	Path/Row	Resolution	Date of Acquisition
Landsat 7 ETM+	**176/38**	**30m**	**22-11-1999**
Landsat ETM+	**176/38**	**30m**	**22-12-2009**
Landsat 8	**176/38**	**30m**	**22-12-2019**

Digital Image Processing: To offer precision to the erratic sensor response over the image and to rectify the geometric distortion owing to the earth's rotation, images were radiometrically and geometrically rectified (ITT, 2009). The study employed the use of knowledge-based supervised classification using ENVI 5 Imagine for production of the land use/ land cover map. Prior to image classification, Normalized Difference Vegetation Index (NDVI) images were generated. A simple classification technique was then applied to the NDVI images of 1999, 2009 and 2019 using ENVI 5 and ArcGIS 10.7.1 software. The ratio between the satellite image's visible (VIS) and near-infrared (NIR) bands are used to create NDVI images. This emphasizes the qualities of plant vigour and density, as well as the various levels of vigour and density. The equation is written mathematically as:

$$NDVI= (NIR-VIS)/ (NIR+VIS)$$

NDVI values are always in between -1 and +1, where higher values represent more vigorous and healthy vegetation. According to Vishwakarma *et al.*, (2021), very low values (0.1 and lower) correspond to barren areas of rock, sand and snow. Moderate values (0.2-0.3) indicate shrub and grassland, while temperate and tropical rainforests are represented by high NDVI values (0.6 to 0.8) (NASA, 2020).

Furthermore, in carrying out the study, 692 copies of questionnaires were administered which represents 0.5 percent of the total projected population as of 2021 in order to assess the land cover change as a result of deforestation and its impacts and the driving forces. A stratified and random sampling technique was used in the administration of questionnaires. The study area was stratified into Northern, Central and Southern zones. Two wards were randomly selected from each of the three zones, given a total of six wards selected out of the ten wards in the study area. The copies of the questionnaires administered in these wards are Baissa (140 questionnaires), Bente (104 questionnaires), Bissaula (106 questionnaires), Guanda (104 questionnaires), Didan (118 questionnaires) and Nyido/Tosso (120 questionnaires).

The data collected were both qualitative and quantitative and includes interview carried out to obtain information on the demographic and socio-economic aspects of the respondents, their opinions on the use of the nearby forests, causes of deforestation in the area, effects of deforestation on the socio-economic development of the people, and roles of various groups and institutions on initiatives or efforts toward controlling deforestation and enhancing sustainable forest management in the study area. Descriptive statistics were used to analyze using simple percentages, maps, tables, bar charts and pie charts.

4. Results and Discussions

4.1:Extent of Land Cover Changes in Kurmi LGA.

The extent of land cover change in Kurmi LGA is presented in figures 5 (a,b & c); two categories of land use and land cover were identified; built-up areas and vegetation cover. The satellite imageries of Kurmi LGA depicting the land cover change in Kurmi from 1999, 2009 to 2019 is shown in Figs 5 (a,b & c).

Figure 5 (a) shows the satellite imagery of Kurmi LGA in 1999, three years after the creation of Kurmi Local Government Area. The figure shows a few patches of built-up areas in the South Western part of the study area and even fewer patches of built-up areas around the North-Eastern part of the study area. This finding revealed that Kurmi LGA was largely forested in 1999.

Figure 5 (b) shows the land cover change in Kurmi LGA in 2009. The figure clearly reveals increased patches of the built-up area around the South Western part of the study area and more dominant built-up areas in the North-Eastern and South-Eastern part of the study area. This shows that there has been a rapid increase in built-up areas in 10 years, while the large forested areas are decreasing rapidly too.

Figure 5 (c) shows the land cover change in Kurmi LGA 2019, which has shown a tremendous increase in built-up areas, almost equally the forested area. The GIS analysis in database query (AREA) was used to acquire the area extent (in hectares) of the resulting land cover type for each study year and for further comparison. In terms of the overall landscape, as well as the type and degree of changes that have taken place, tabulation and area calculations offered a thorough dataset. Table 2 shows the spatial extent of land cover in hectares and in percentages.

Table 2: Land Cover Change Distribution 1999, 2009, 2019.

	1999		2009		2019	
Land Cover Type	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)
Built-up area	13059	3.00	104167.29	23.93	207681	47.71
Vegetation cover	422241	97.00	331132.71	76.07	227618.27	52.29
Total	435300	100	435300	100	435300	100

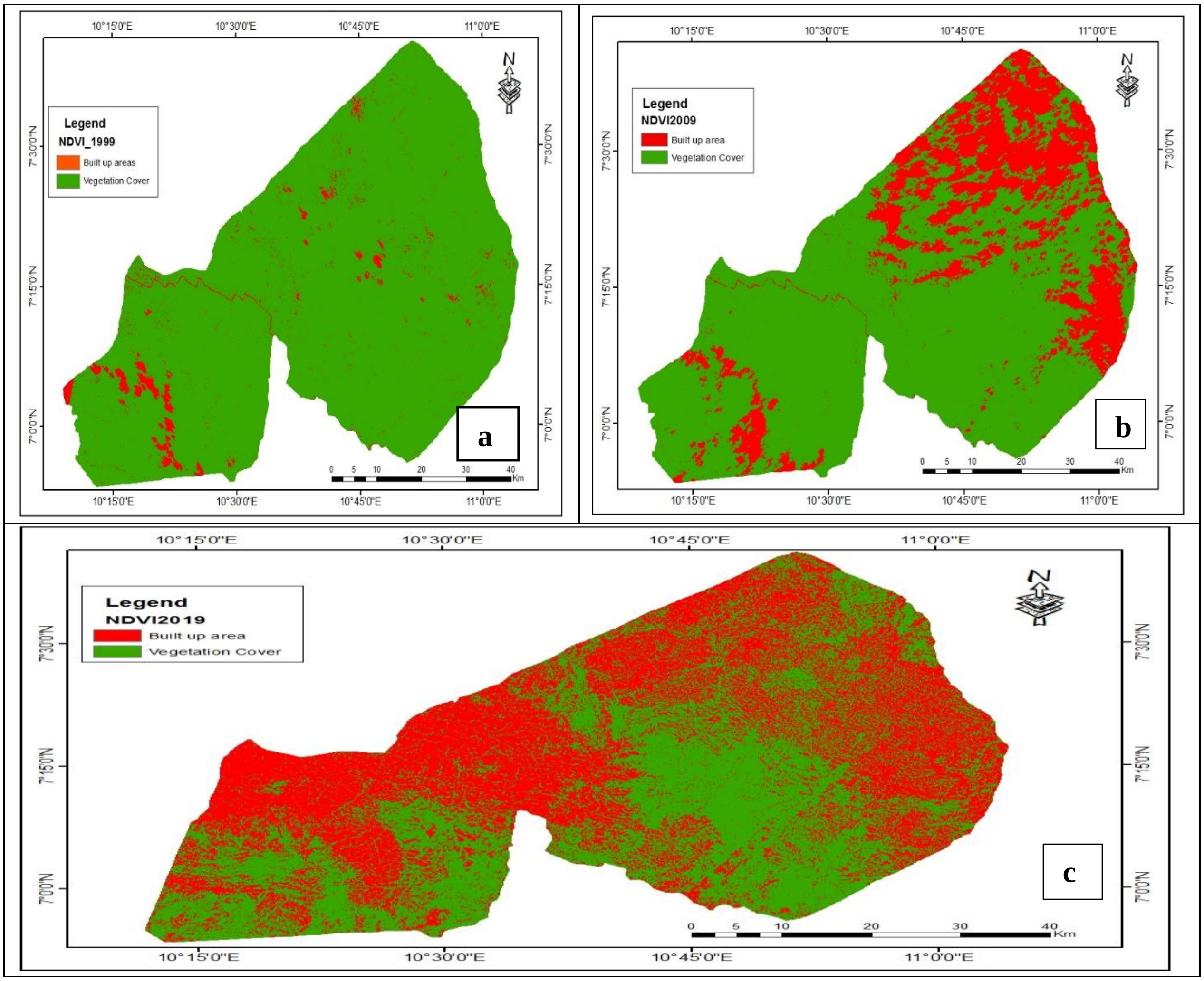


Fig. 5: Land cover changes in Kurmi in (a) (1999), (b) (2009) and (c) (2019)

Table 2 shows that in 1999, the built-up area covered 13,059 hectares which represent 3 per cent of the total land area in Kurmi LGA, while vegetation cover takes up 422,241 hectares which represent 97 per cent of the total area of Kurmi LGA. In 2009, the built-up area took up 104,167.29 hectares which represent 23.93 per cent of the total land area, while vegetation cover drops to 331,132.71 hectares which represent 76.07 per cent of the total area. In 2019, the built-up area took up 207,681 hectares which are 47.71 per cent of the total land area, while vegetation covers further drops to 227,618.27 hectares which is 52.29 per cent of the total land area. This reveals the rapid growth in built-up areas while there is also rapid loss of forested areas or vegetation cover.

Figure 6 shows that built-up areas are taking up more hectares of the total land area as the year progresses, i.e., in 1999 built-up area was 13,059 hectares and increased to 207,681 hectares in 2019. This means that in a span of 20 years, built-up areas gained additional 194,622 hectares.

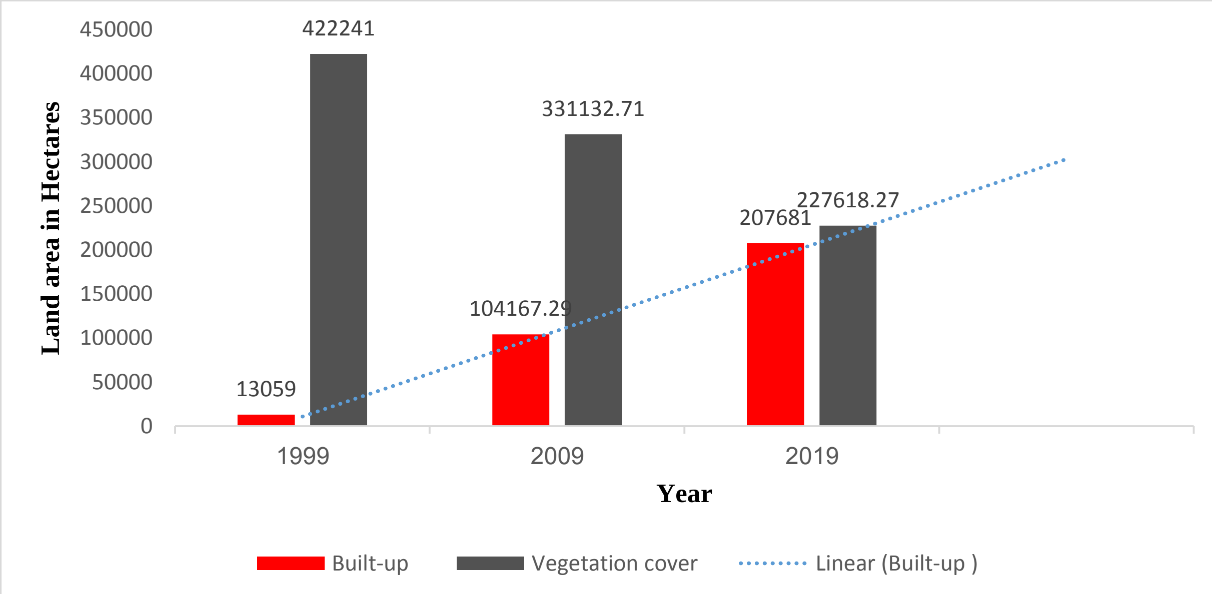


Fig 6: Land Cover Change in Hectares showing the increase in built-up area from 1999 to 2019

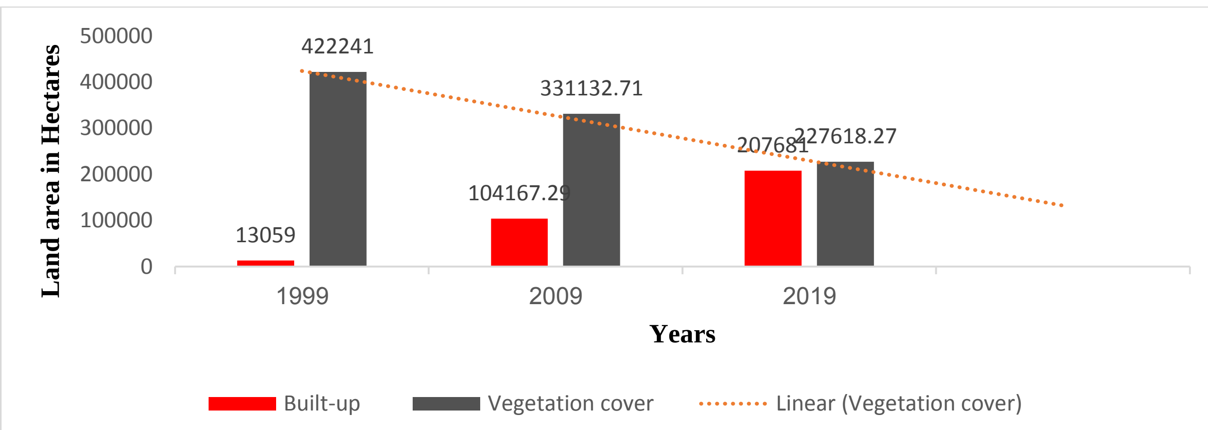


Fig 7: Land Cover Change in Hectares showing the decrease in vegetation cover from 1999 to 2019

Figure 7 shows that vegetation cover decreases as the year progresses, i.e., vegetation cover takes 422,241 hectares of the total land area in 1999 but decreased to 227,618.27 hectares of the total land area in 2019. This means in a period of 20 years, and the Kurmi LGA has lost 194,622.73 hectares of forest land.

Figure 8 shows that in 1999, the built-up area was 3 per cent while vegetation cover was 97 per cent in 2009, built-up area rose to 23.93 per cent while vegetation cover reduced to 76.07 per cent. In 2019, the built-up area further rose to 47.71 per cent of the total land area, while vegetation covers further reduced to 52.29 per cent. This, therefore, means that the forest cover is deforested. This deforestation led to the loss of biodiversity, loss of soil fertility, erosion, susceptibility to wind storms, and increased climatic temperature of Kurmi LGA.

From the results, vegetation cover accounted for 97 per cent of the total land area while built-up area accounted for 3 per cent of the total land area in 1999 (Table 2). Most of the vegetation cover was largely depleted within the 10 years' period between 1999 to 2009, from 97 per cent to

52.29 per cent of the total land area of Kurmi LGA in 2009. Forty-two per cent (42%) of the vegetation cover was additionally converted to the built-up area between 2009 to 2019. This shows the rapid rate of deforestation in Kurmi LGA, which creates imbalances in weather patterns, making the weather drier and hotter, consequently leading to increased drought and desertification, coastal flooding, crop failures, and dislodging major vegetation regimes (Momoh *et al.*,2021).

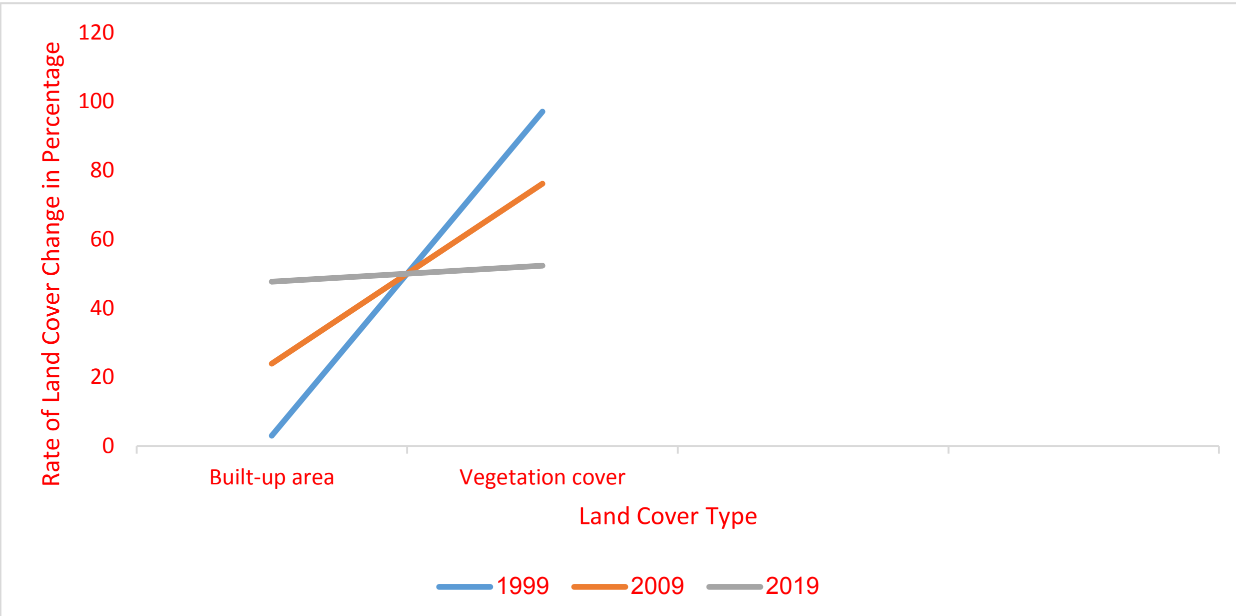


Fig 8: Land Cover Change Distribution Pattern from 1999, 2009 & 2019.

4.2 Main Drivers of Land Cover Change

4.2.1 Occupational activities causing Land Cover Change/Deforestation

The occupational activity of respondents that causes land cover change is deforestation. The majority of the respondents (35%) are engaged in lumbering, 30% are engaged in farming, 25% are engaged in hunting, while the rest 10% are engaged in activities that include gathering food plants in the form of either edible shoot, roots, nuts, fruits, seeds, medicinal herbs and chewing sticks. The findings of the study revealed that over 50% of the activities they people engaged in resulted in deforestation, as shown in Table 3.

Table 3. Occupational Activities of Respondents Causing Land Cover Change/ Deforestation.

Types of Uses	Respondents	Percentage
Hunting	173	25
Farming	208	30
Lumbering	242	35
Others	69	10
Total	692	100

The respondents identified six main activities causing land cover change and deforestation in the study area. Almost all the six factors are a result of man's activities on the environment, which contribute 88% of the activities causing land cover change/deforestation in the study area. Top among the activities is crop cultivation by farmers, which result in encroachment into the forest area. The farming activities can also trigger wildfire when the fire used in burning their cleared fields spread into the nearby forest.

Table 4: Proximate Perceived factors causing land cover change/deforestation in the study area from respondents

Description	Respondents	Percentage
Cultivation	166	24
Fuelwood collection/Charcoal production	138	20
Overgrazing	90	13
Lumbering	104	15
Population growth/Urbanization	35	7
Bush fire	83	12
Agriculture expansion/traditional medicine	76	9
Total	692	100

Table 4 presents the proximate factors causing land cover change/deforestation in Kurmi LGA. Though fuelwood collection contributed 20% to the main causes of land cover changes in the study area, these activities were usually undertaken in the forest areas, which can result in a situation where repeated wood collections are undertaken on the same site beyond what the forest is able to recover from. It is even more alarming to note that 80% of the respondents claimed that fuelwood is the major source of energy as most of them cannot afford other sources of domestic energy, which are more expensive. The heavy dependence on fuelwood indicates that the demand for these resources will be higher in the future, with an increase in population entailing cutting down more trees. Although population increase contributed the least (7%) to the cause of land cover changes in the area, the findings of the study reveal that most of the activities are human-related. Thus, deforestation in Kurmi LGA is totally caused by man. The result of the findings indicated that in the short term, deforestation is a result of population growth and agricultural expansion aggravated over time by excessive wood harvesting for fuel and export.

The major perceived underlying causes of land cover change/deforestation in the study area is poverty and demand for timber which accounts for 71%, while population growth and urbanization account for the least (5%) (Table 5).

Table 5: Perceived underlying causes of land cover change/deforestation in the Kurmi LGA

Description	Respondent	Percentage
Poverty	277	40
Population growth/Urbanization	35	5
Poor access to alternative energy supply	48	7
Demand for timber		
Weak government policies	215	31
Lack of law enforcement	69	10
	48	7
Total	692	100

4.2.2 The Rate of Deforestation in the Kurmi LGA

Respondents expressed their opinion on the rate of deforestation in the study area. 68% of the respondents claimed that there is a high rate of deforestation, 23% of respondents believed that it was moderate, while 9% of the respondents were of the opinion that the deforestation rate was low (Fig. 9). It can be inferred that 91% of the respondents are aware of the moderate and high rate of deforestation in the study area and are also concerned about it. It is important to note that: High rates mean 300 trees or more are being cut annually, moderate; less than 300 but more than 200 trees are being cut annually, and low means 200 or fewer trees being cut down annually (Fig 9)

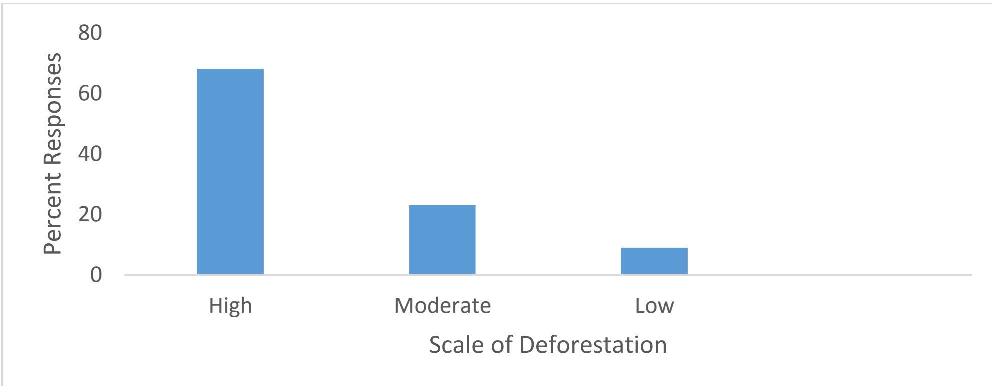


Fig 9: Opinions of respondents on the rate of deforestation

Fig. 9 represents the opinions of the respondents on the rate of deforestation in the study area. 91% of the respondents perceived the rate of deforestation to be moderate and high, leading to increased land surface temperature (LST) of the Kurmi LGA, which causes warming and heat island effects in Baissa, the local government headquarters. This has further made the Kurmi LGA susceptible to the extreme events of windstorms and erosion, which reduces the soil fertility in the study area.

The respondents in the Kurmi LGA correctly perceived that the built-up areas had increased over the past years with a correspondent decrease in vegetation cover. Also, as observed during field visits, demand for vegetation cover is to be converted to built-up areas. The older respondents (above 20 years) gave an accurate historical narrative of the land cover changes in the study area, which corroborated the results of the findings from the analysis of the land-use changes from remote sensing data of the period 1999 - 2019. Similar findings by other researchers show that land cover change occurs in a similar setting. For example, woodlands declined by 88.5 per cent as urban areas increased by 143 per cent between 1984 and 2013 in the Linkangala river catchment in Malawi (Pullanikkatil *et al.,* 2016). A recent study revealed that built-up areas increased by about tenfold at the expense of grasslands, shrub-bushland, and woodlands in the Central Rift Valley of Ethiopia between 1973 and 2014 (Abera *et al.,* 2018). Similar observations of the expansion in built-up areas, accompanied by a decline in forest land and agricultural land, were also reported by other studies (Kindu *et al.,* 2013; Solomon *et al.,* 2017; Meneses *et al.,* 2017).

Firewood collection and charcoal production are the second top-two important proximate drivers of land cover changes in Kurmi LGA between 1999 and 2019. More firewood will be used by households, worsening deforestation and forest degradation in the study area. The Kurmi

LGA's usage of charcoal and fuelwood for energy is prompted by high poverty levels and a lack of access to electricity and alternate energy sources. Poverty is one of the major factors thought to be influencing land cover changes in Kurmi LGA. Due to high poverty levels, high agricultural input costs, and a lack of financial resources, local communities are unable to purchase agricultural inputs. The rural population in local villages in Kurmi LGA are characterized by high levels of poverty as well as a scarcity of alternative sources of revenue. According to group conversations with respondents, in the event of land degradation, decline or failure of agricultural production, and/or soil infertility, rural populations in Kurmi LGA rely on the sale of forest food as a common survival strategy. Overdependence on natural resources and unsustainable extraction without alternative economic strategies, such as forests, land, and water, results in soil erosion, biodiversity loss, natural resource depletion, water and air pollution, deforestation, and forest degradation. This study's findings are in line with those of previous similar research in Africa, where high poverty levels have been recognized as contributory causes to changes in land cover (Kindu *et al.,* 2015; Mdemu *et al.,* 2012; Ariti *et al*., 2015).

4.3 Impacts of Land Cover Change Dynamics on Natural Resources and Rural Livelihood in the Kurmi LGA.

Kurmi LGA has experienced tremendous land cover changes over the years. Population increase, poverty, firewood gathering, and charcoal manufacture, according to recent research, are driving these changes (Munthali *et al.,* 2019). The findings of Munthali *et al*. (2019) study clearly show that rural people in Dedza District rely heavily on natural resources for their livelihoods. However, as these rural residents' reliance on natural resources has grown, enormous changes in the landscape have occurred, with serious environmental repercussions, as evidenced by the loss of forest cover, wetlands, water bodies, and agricultural land (Munthali *et al.,* 2019).

Due to rural residents' reliance on natural resources and the fact that land cover change is affecting the natural resource base's ability to meet the needs of local residents, it is critical to understand the nature of the impacts of land cover changes on rural livelihoods in Kurmi LGA, as well as how rural residents cope or adapt to changes in land cover in their communities. For sustainable land use, land management, planning, and decision-making, a thorough understanding of the nature of land cover changes occurring in the study area and their impacts on rural livelihoods, as well as the coping strategies deployed in response to these changes, is seen as a critical requirement.

4.3.1 Impacts of Land Cover Changes on Agricultural Land

In the study, the household members interviewed held the perception that the size of agricultural land and crop production between 1999 and 2015 has drastically declined (Fig 10). Approximately 68% and 84% of the respondents claimed that agricultural land and crop production had declined, respectively.

With respect to the contributing factors leading to decline in crop production, the respondents were asked to rank the major five (5) causes of decline in crop production. The results revealed that soil infertility, soil erosion and waterlogging, high cost of agricultural inputs, lack of money for inputs and lack of agricultural inputs were the five (5) major causes of low crop production in the Kurmi LGA (Table 6).

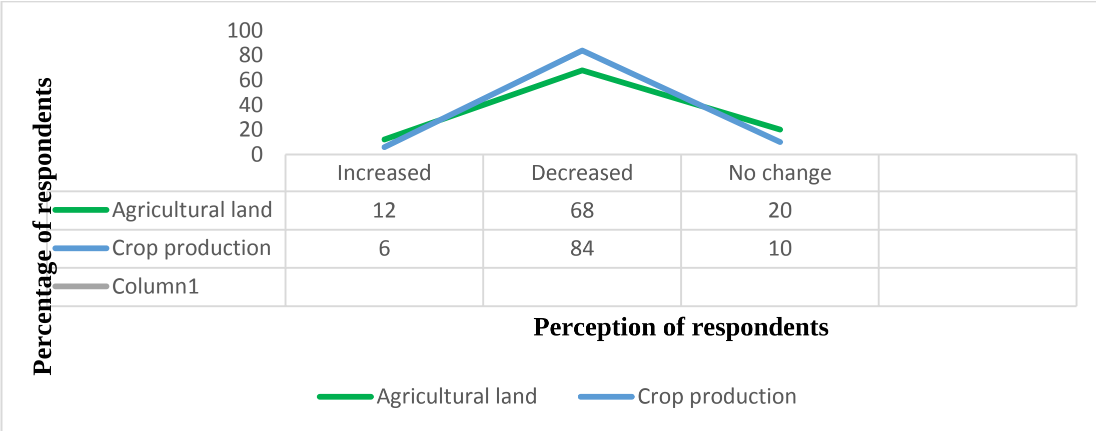


Fig. 10: Perception of respondents on the loss of agricultural land and crop production Source: Field Survey, (2020).

Table 6: Perception on the Causes of decline in Crop Production

Causes of decline in crop production	**Perception Ranking**
Soil infertility	1
Soil erosion and waterlogging	2
High cost of agricultural inputs	3
Lack of money for inputs	4
Lack of agricultural inputs	5
Pest and diseases	6
Poor access to subsidy programmes	7
Limited or inadequate land	8
Low marketing prices	9
Inadequate labour	10

4.3.2 Impacts of Land Cover Change Dynamics on Forest Resources

The result of the study on Fig. 11 revealed that forest cover of the study area has declined, which resulted in increased distances that had to be covered for the collection of forest produce and products. Almost 82 per cent, 12.5 per cent, and 5.5 per cent of the respondents claimed that forest cover had declined, increased and remained unchanged respectively during the study period under study. On the other hand, 61 per cent, 28.6 per cent and 10.4 per cent of these respondents claimed that distance to the collection of forest produce and products have substantially increased, decreased and remained unchanged, respectively. It is clear from Table 7 that the decrease in forest cover as a result of deforestation and forest degradation has impacted the local communities in different ways. The households identified lack of firewood as the most important impact of increased deforestation and forest degradation in the study area, followed by loss of soil fertility, floods and droughts, lack of wood for construction and finally, depletion of water resources.

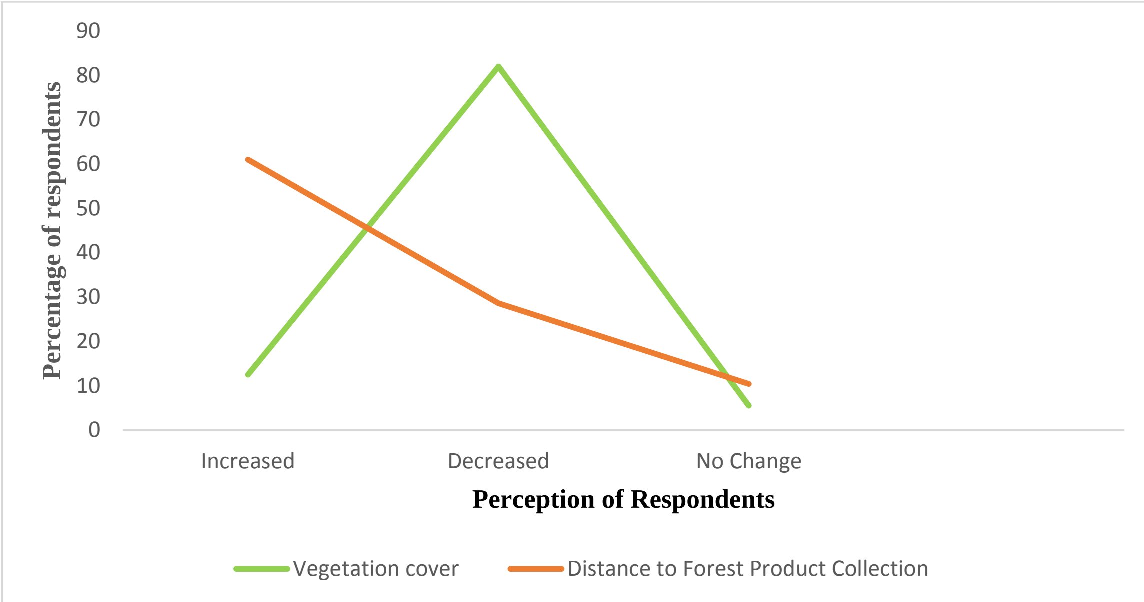


Fig 11: Perception on vegetation cover and distance to forest product collection

The distance from nearby forest has increased tremendously; only 10% of respondents live within 0.5 km to a nearby forest, 14% live within 1 km distance from a nearby forest, while 76% of the respondents live beyond 1 km from a nearby forest. This implies that activities of man have reduced the forest cover and increased the distance to the nearby forest.

Table 7: Distance of Respondents' home to the nearby forest

Distance (Km)	Respondents	Percentage
Beyond 1	526	76
Within 1	97	14
Within 0.5	69	10
Total	692	100

Source: Authors Analysis (2021).

4.3.3 Impacts of Land Cover Changes on Natural Resources and Livelihoods

The results clearly indicated that land cover modifications in Kurmi LGA between 1999 and 2019 have resulted in decreased agriculture, forest resources and depletion of water resources. The decrease in agricultural land has resulted in a reduction of crop production in the study area. These results are similar to other findings from which rural communities perceived that land use and land cover changes resulted in decreased agricultural land, forest resources, depletion of water resources and wetlands (Gessesse & Bewket, 2014; Kirma *et al.*, 2016; Benti *et al.*, 2017; Karki *et al.*, 2018).

The decline in forest cover or increased deforestation and forest degradation reported in this study has consequently resulted in a shortage of firewood and wood for construction, persistent floods and droughts, depletion of water resources and loss of soil fertility in the study area. In Kurmi LGA, forest cover loss and increased deforestation and forest degradation are highly linked to population growth and poverty (Munthali *et al.*, 2019). These results clearly show that rural communities from Kurmi LGA depend majorly on forest resources for their daily energy needs and construction. Consequently, these two factors exert pressure on the forest resource base leading to increased demand for fuelwood and wood for construction. The results are in line with the findings of Wangchuk *et al.*, (2014) who reported that a decrease in forest produce and products such as feed, fuelwood, timber, and litter enhanced their vulnerability in the Himalayas, where livelihood options are primarily limited to agriculture and livestock.

4.4 Effective Strategies for Sustainable Forest Management in Kurmi LGA

Sustainable forest management is a "dynamic and changing concept aimed at preserving and improving the economic, social, and environmental qualities of all types of forests for the benefit of current and future generations." (FAO, 2020). When forests and trees are managed sustainably, they benefit people and the environment by boosting livelihoods, providing clean air and water, protecting biodiversity, and adapting to climate change. Sustainable forest management entails maximizing the benefits of forests, such as timber and contributions to food security, to satisfy society's requirements while conserving and maintaining forest ecosystems for the benefit of present and future generations. Despite significant progress toward Sustainable Forest Management on a worldwide basis, implementation varies greatly, especially in the tropics, where the capacity to utilize or enforce Sustainable Forest Management policies, laws, and regulations is unequal. In addition, other land uses, such as agriculture, are frequently more financially appealing in the near term than forest management, prompting deforestation and land-use changes.

4.4.1 Sustainable Forest Management for Economic Development

Harvesting non-wood forest products (NWFPs) and selling forest ecosystem services are two alternative ways to supplement your income. Inadequate market opportunities for a wide range of forest products and services beyond well-known commercial timber species, insufficient capacity to implement Sustainable Forest Management, and a lack of forest-based investments all contribute to forests' high opportunity cost when compared to other land uses. Nonetheless, several payments for environmental services (PES) plans are emerging and have been explored and implemented successfully in some areas.

Future demand for industrial Rosewood and forest-based biofuels are important investments that might help reduce greenhouse gas emissions by serving as a viable substitute for fossil fuels. If implemented in accordance with Sustainable Forest Management principles, such investments in plant and other forests, as well as downstream processing, would result in multiple economic benefits, including increased income and employment, improved livelihoods, strengthened safety nets, and greater environmental conservation. Forest owners and managers have different temporal horizons, which influences how they use forest areas for growing trees or other uses. Forest management should have a higher net present value than other potential land uses if the land is to stay forest. Forestry has a longer time horizon than other land uses, which makes decision-making more difficult, especially when considering the dangers associated with the longer timeframe (e.g., uncertainties over future tenure, regulations and markets, natural disasters, pests and disease)

In addition to the formal economy, the incorporation of the informal sector into sustainable forest management techniques is critical. Small-scale forest users that operate outside of the regulatory system play a significant role in developing countries by creating jobs in the small-scale harvesting and processing of non-wood and wood products, as well as ecotourism and environmental services. In a number of emerging countries, increased commerce in forest products has aided economic growth and poverty elimination. However, in some cases of forest product trading, monopsonies (where a single buyer controls a significant portion of the market) and exploitive market chains have resulted in greater marginalization of disadvantaged people in some countries. To ensure that commerce is based on legal and sustainable forest use, fair working conditions, and equitable distribution of rights, responsibilities, and benefits, strong safeguards must be put in place. In order to enable sustainable and fair production and commerce, good governance is required.

4.4.2 Sustainable Forest Management for Social Development

Forests and trees provide a wide range of products and services, but their substantial benefits to rural livelihoods and food security necessitate a people-centred approach to forestry. More than a billion people rely on forests for food, medicine, and fuel. Wood is used for cooking by nearly a third of the world's population of about 2.4 billion people. In many rural regions, the harvesting, processing, and sale of forest items, as well as environmental services, provide substantial employment and income. Other land uses, such as agriculture, can supplement the revenue and livelihood support offered by forests. As appropriate, adequate provisions for occupational safety and health, as well as respect for labour rights, should be made in the implementation of Sustainable Forest Management, as defined by national legislation and international agreements, as well as forest certification requirements and other voluntary social responsibility codes, where appropriate.

Participation, justice, access and usage rights, worker safety, gender equity, and conflict management in communities affected by forest activities are all part of the social pillar of Sustainable Forest Management. Several elements must be addressed in order to implement Sustainable Forest Management. Those who are directly involved in or affected by a forest's management should be allowed to participate in the development and implementation of Sustainable Forest Management goals. Decisions on forest use and conservation made without consultation with stakeholders lack credibility, are likely to be contested, and may result in conflict.

Recognizing local people as major forest stakeholders and encouraging their participation in decision-making and long-term forest management positively impacts livelihoods, rural development, and forest conservation. Fairness is an important aspect of Sustainable Forest Management, particularly when it comes to the distribution of benefits and expenses associated with forest use in rural areas. Sustainable Forest Management should minimize inequalities, encourage the growth of locally owned and operated businesses, and enhance working conditions. Specific measures, such as investments in housing, education, medical services, and other social infrastructure and the equitable allocation of rights to resources and resource use, may be required to achieve an equitable distribution of benefits.

Social indicators must be monitored, and any negative impacts – such as disagreements over benefit and cost allocation – must be addressed, for example, by supporting social learning, fostering cooperation and trust among stakeholders, and developing a shared vision for Sustainable Forest Management's contribution to socio-economic development. Community forestry has high expectations from policymakers, who want it to meet and integrate other objectives such as climate change mitigation and adaptation, forest law enforcement, forest and landscape restoration, and so on. Community forestry is a significant forest management tool that has the ability to improve local livelihoods while also contributing to Sustainable Forest Management.

4.4.3 Social Inclusion in Sustainable Forest Management

Indigenous peoples, estimated to number around 370 million worldwide, have customary rights that are frequently ignored by statutory laws. Indigenous populations, settlers, the state, agro-industrial, wood, and mining enterprises, and developers of infrastructure and metropolitan regions all have overlapping claims to forests. Many countries lack effective means for enacting tenure reform, resolving conflicts, and assuring indigenous and other local peoples' proper participation in forest management. However, experience demonstrates that Sustainable Forest Management can be conducted efficiently and contribute to indigenous peoples' well-being when it: uses indigenous knowledge appropriately; is participatory and inclusive in decision-making and dispute resolution; facilitates access to financing and markets; improves capacities; and upholds the right to free, prior, and informed consent and other human rights principles. Many approaches to sustainable forest management rely substantially on indigenous peoples' traditional knowledge and experience.

CONCLUSION/RECOMMENDATIONS

This study has assessed land cover change in Kurmi L.G.A, using a geospatial approach involving remote sensing and Geographic Information System. The findings of the study reveal that natural and anthropogenic forces both contributed to land cover change in the study area. The findings of the study show that in 1999, the built-up area covered 13,059 hectares which represent 3 per cent of the total land area in Kurmi LGA, while vegetation covers 422,241 hectares which represent 97 per cent of the total area of Kurmi LGA. In 2009, the built-up area took up 104,167.29 hectares which represent 23.93 per cent of the total land area, while vegetation cover drops to 331,132.71 hectares which represent 76.07 per cent of the total area. In 2019, the built-up area took up 207,681 hectares which are 47.71 per cent of the total land area, while vegetation covers further drops to 227,618.27 hectares which is 52.29 per cent of the total land area. This reveals the rapid growth in built-up areas and rapid loss of forested areas or vegetation cover. The main drivers of land cover change are fuelwood exploitation, bush burning, crop cultivation, overgrazing, population increase and lumbering. The study findings reveal that the people are aware of the great change in land cover in the area and are concerned about its adverse impacts but lack the wherewithal to control it.

Based on the findings of the study, the following recommendations are made;

i. Massive afforestation programmes that go beyond yearly rituals, tree planting in public places, institutions, roadsides and rural afforestation programmes should be embarked upon. Government should also lead in the tree planting enlightenment campaign on the need to protect the forest and sustainable management of forest reserves in the area.
ii. Environmental education about the devastating effects of deforestation on people and society at large should be provided to the general population through posters, cartoons, theatre, focus group discussions, and documentaries. Climate change education should also be organized by the government, non-governmental groups, and concerned citizens to educate people on the need to accept alternative sources of energy such as fuel-efficient stoves.
iii. The government should put more effort into poverty-eradication programs and the

creation of more employment opportunity for educated teenagers through skills acquisition programmes which is directed at rural women and uneducated youths in order to curtail the rate of deforestation. Criminal loggers, as well as corrupt government personnel in charge of forestry laws and regulations, should be punished.

iv. States and Local Governments authorities should fund research on alternative sources of energy such as solar energy and other energy conversion systems. Sustainable use of forest resources to avoid excessive lumbering, excessive firewood collection, bush burning etc., should be encouraged.

v. Government should provide the forestry department patrol team with the needed support such as finances, vehicles and equipment. Communities should be engaged in the management of the forest. They should also be involved in the sharing of the forest benefits.

vi. Saw millers should register their wood processing plants with the Department of forestry and should be given a permit or license, and this should be renewed yearly with the Chief conservator or Director of forestry before they can be engaged in sawmilling. Transporters of logs should also register their timber lorries with the forestry department. The possession of permits and licenses are therefore advocated.

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