An Analysis of Land use and Land cover Characteristics of Kanke, Pankshin, and Langtang Local Government Areas, Plateau State, Nigeria.

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Abstract

This study assessed landuse and landcover changes and how they affect the agrarian production in Kanke, Pankshin and Langtang North Local Government Areas of plateau state, Nigeria. The study adopted the survey design. The primary data was obtained through field observations, interview of stakeholders, satellite (landsat8 and shuttle radar terrain mission) and questionnaire administration which asked questions on socioeconomic status of respondents, constraints to farmers and the respondents' perception on the existing adaptation strategies in place. ArcGIS10.6version software was employed for the classification of land cover types while supervised classification method was adopted using maximum likelihood algorithm for the classification of feature types. Data generated by Landsat8 and ArcGIS10.6 version software were subjected to Pan-Sharpening processing for clarity of terrain features. The study findings revealed that 66.13% of the earth's surface in the study area is covered by rock outcrops while water body; one of man's most precious resources occupied less than 1% (0.15%). The distribution of farmers based on constraints to farming indicated that poor soils and small farm land sizes constituted the most severe challenges to farming activities in the study area. As an adaptation strategy to inadequate farm lands, terrace farming practice and dry season farming, large scale quarrying activities is recommended to serve as a source of employment and income to authorities and a means of surface leveling to convert the dominant rock outcrops to productive land and prioritizing farming in the limited plains.

Keywords: Agrarian Activities, Land Resources, Landcover, Landuse, Water Resources

Introduction

Land cover dynamic has the global concern of the twenty-first century, with the dramatic implication for human survival. Land cover change is the change in the physical as well as biological characteristics of land which is attributable to management including conversion of grazing and forest land into farming land, pollution and land degradation, removal of vegetation, and conversion to non-agricultural uses (Meshesha, *et. al.,* 2016). Analyzing the trend of land use/land cover change and its cause and consequence on human livelihoods as well as on the environment is a matter of concern for sustainable development and management of natural resource. The increasing change is alarming, and can have a huge implication on local, regional, national and global environment and consequently affect the food availability (Minale, 2013 and Danjuma, *et. al.,* 2014).

Land and water resources degradation are the major problems in most highland areas. Poor land use practices and improper management systems have played a significant role in causing high soil erosion rates, sediment transport and loss of agricultural nutrients. The effect of land cover change has caused the loss of fresh and portable water needs loss in the area alongside occupational dislocation (Andualem, *et. al.,* 2018). According to Pandian *et. al.,* (2014) Land use/ land cover is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to monitor and detect the changes to maintain a sustainable environment.

Land and water resources are two of the most important assets of humans throughout the world especially, for the rural and urban poor whose livelihoods basically rely on agriculture (USAID, 2007). Land is the custodian of all the natural resources like water, mineral resources, plants and animals that man depends on for survival and all his activities, but this valuable property is being degraded due to soil erosion, adverse weather conditions and soil nutrients depletion (Amsalu and Graaff, 2007). Land is an indispensible resource and a prerequisite for both direct and indirect activities of man such as farming, construction, and infrastructure. As one of the most precious resources, it serves as soil and mineral nutrients for crops and plants, as open space and wild places for recreational activities with interminable list of uses as it also supports natural ecosystem, source of water, mineral and energy for agriculture and other human activities.

Agrarian activities are dependent upon having sufficient access to water but water scarcity is already a critical constraint to agriculture in many parts of the world in addition to environmental degradation, declining groundwater, lack of infrastructures and greater health risk. Without access to clean water, nearly every industry would suffer, most notably would be agriculture. As water scarcity grows as a global concern, food security is also brought to consideration (Sheila, 2011 and Vivan, *et. al.,* 2015). Water is one of the most precious resources we have on this earth and it is under increasing stress therefore, all of us have responsibility to provide leadership in preserving it for efficient utilization and for future generation (Silvakumar, 2011).

Just the way humans require water and nutrition for a healthy life storm immune system, plants and animals require the same for healthy growth and good yield. Unfortunately, today, 31 countries accounting for about 8% of the world's population face chronic fresh water shortages (UNEP, 2008). By the year 2025, however, 48 countries are expected to face shortages, affecting more than 2.8 billion people, 35% of the world's projected population (VJEL, 2007). Among countries likely to run short of water in the next few years are Ethiopia, India, Kenya, Nigeria and Peru. Parts of other large countries such as China already face chronic water problems (UNEP, 2008). Intense pressure on agricultural land, forest land and the availability of fuelwood in the sounding area is the result of spatial and demographic changes; it exerts massive pressure on land use, agricultural productivity, water resources and the use of ecosystem in general (Minale and Rao, 2011, Minale and Rao, 2012a).

This study aimed at assessing the landcover and landuse characteristics and how they affect agrarian activities in Kanke, Pankshin and Langtang North Local Government Areas while the objectives include determination of the areal coverage of cultivated land, water body, rock outcrops, vegetation cover and built-up area as well as respondents' perception on the existing adaptation strategies in place.

Materials and Methods

This study utilized both primary and secondary data sources. The primary data was obtained through field observations, interview of stakeholders, satellite (landsat8 and shuttle radar terrain mission) and questionnaire administration which asked questions on socioeconomic status of respondents, constraints to farmers and the respondents' perception on the existing adaptation strategies in place. Kanke, Pankshin and Langtang North Local Government Areas were selected for this study due to their similarities in physical settings, contiguity of landmass and peculiarity in land and water resources challenges. The respondents were purposively chosen in order to ensure that only inhabitants that practice farming were selected as study participants. Three hundred questionnaires were strategically administered in the three Local Government Areas that formed the study area. At the end, 294 questionnaire representing 98% were retrieved, analyzed and used for this study.

Satellite data used for the study includes Landsat8 and Shuttle Radar Terrain Mission (SRTM), while ArcGIS 10.6 version GIS software was employed for the classification of land cover types. The data were subjected to Pan-Sharpening processing for clarity of terrain features. Training samples (picture elements in the satellite images) that are representative of terrain features were carefully and systematically identified and selected. Supervised classification method was adopted using maximum likelihood algorithm for the classification of feature types. Statistical computation of each feature class were automatically computed in ArcGIS software and exported to EXCEL for statistical manipulation. Documented sources like satellite images were also explored for data on location, size of landmass, annual rainfall and water resources which were complemented by the researchers' field observation. The data collected were presented, analyzed and summarized using descriptive statistics in the form of mean and percentages. The satellite images of the area were presented in form of tables and maps.

The Study Area

Location, Position and Size

Kanke, Pankshin and Langtang North Local Government Areas have a total projected population of 727,803 based on the 2006 census figure and population growth rate of 3.2% per annum with a total land area of 3,638km^2 located on Latitude 9^0 23′ 35″ N and Longitude 9^0 37′ 58″ E (Kanke); Latitude 9^0 19′ 31″ N and Longitude 9^0 26′ 06″ E (Pankshin); Latitude 9^0 08′N and Longitude 9^0 47′E (Langtang North) Figure 1. These Local Government Areas share boundary with Langtang South to the South, Bauchi State to the East, Shendam, Quaan pan and Mikang to the West and Mangu Local Government Area to the North.

Relief and Drainage

The areas particularly around Kanke and Pankshin have a high relief particularly in the north and this serves as a hydrological centre for many small rivers that drain the place and also confers on the area a cool climate. The landscape of the area rises steeply from 200 metres to an average height of 1,000 metres on the Kanke and Pankshin ranges. Langtang North area has both relief features but with greater expanse of lowland areas with just very few rock outcrops. The areas has radial drainage pattern interspersed area which drains the rain water from high to lowland areas in the three Local Government Areas. Langtang North Local Government Area has relatively flat terrain but with poor soils that is heavily polluted which is not quite fit for agricultural activities while Kanke and Pankshin Local Government Areas have rugged topography apart from quick runoff that occurs immediately after rains resulting in difficulty of

access to ground water and hence, poses serious water scarcity issues as it is very difficult to drill boreholes and wells to access quality water for domestic, industrial and agricultural uses (Wambai, *et. al.,* 2017). The terrain and topography of the area is dominated by hills and valleys with highly limited plains and infertile land which limits agricultural activities in the area (Worldbank, 2019).

Climate

Kanke, Pankshin and Langtang North Local Government Areas has the tropical savannah climate that is marked by rainy and dry seasons with a temperature range of 17^0c to 38^0c and annual rainfall of about 1,500mm (NIMET, 2018). The average annual rainfall is 1324 mm. Average annual humidity rises above 80%. Humidity is highest around July and August at about 85% and then usually drops to about 60% in January. The area has temperate climate on the Jos Plateau and a hot and humid climate on its lower parts. It has two distinct seasons - rainy season (April-October) and much colder during the harmattan period (December - February).

Geology and Soils

The geology of the study area is the basement complex of Nigeria which lies entirely within the crystalline basement terrain with no porosity and normally, in fresh non-fractured rocks, which is the case in most parts of the study area, the porosity is often less than 2%, as a result, run off is high, infiltration rate is very low and little or no water bearing (Izam and Izam, 2009). The drainage pattern of the study area is dendritic or tree-like pattern, normally developed on homogeneous rock or beds of equal resistance (Anon, 2011). The area is an erosional relic covering an area of about 7,780 sq.km and is a product of distinct phases of volcanic activities when younger granite rocks extensively intruded into the older basement complex rocks. Each phase of volcanic activities was followed by a long period of weathering and erosion when tin bearing rocks were deposited in the valleys and buried by floods of basalt from subsequent volcanic eruptions. There are also extinct volcanoes and crater lakes on the Jos Plateau (Worldbank, 2019).

The area has a tropical ferruginous soils, which are much thinner on the high plateau but attain greater depths in the southern part of the state. There are also sizeable pockets of loamy soil of volcanic origin in the high Plateau. Soils are generally of poorer quality than those in other parts of the country and dominated by reddish laterite soils that are less fertile than those of the North because they are not subject to as much seasonal drying nor do they receive the greater rainfall that occurs in the southern regions (Bennett, *et. al.,* 1978). Soil erosion and loss of vegetation resulting from over grazing and over cultivation has led to gullying along the numerous cattle paths which criss-cross the surface constituting major environmental issues of the area (Vivan, *et al* 2015 and Worldbank, 2019).

Vegetation

Most vegetation falls largely within the northern guinea savannah zone which consists mainly of short trees, grasses and the Plateau type of mosaic vegetation. There are also fringing woodlands or gallery forests which can be found along some river valleys. Some villages have thick hedges of cacti, which have been planted around household farms or compound lands. The highland areas have montane vegetation especially on mountain tops around the hilly parts of Kanke and Pankshin Local Government Areas (Worldbank, 2019).

Economic Activities

Farming, hunting and petty trading are the major occupations of the inhabitants. The area is endowed with feldspar, quartzite, limestone, granite, marion, muscovite, zircon and pyrite among others making it a potential area for solid mineral mining, precious stones processing and quarrying. Agriculture is also an important activity with major crops like cotton, groundnuts, rice, Irish potatoes, maize and soya bean being produced.

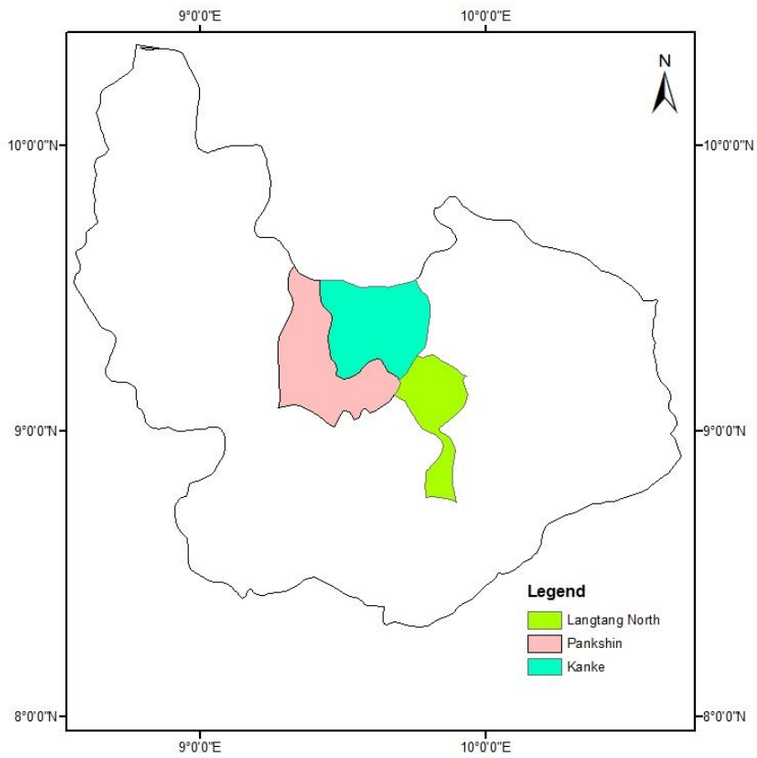

Figure 1: Map of Plateau State showing the study area
Source: *National Centre for Remote Sensing, Jos, 2019*

Results and Discussion

The analysis of the socioeconomic background of the respondents on occupation (Table 1) shows that only 147 out of 294 (50%) of the respondents practice peasant farming against 80 – 90% in most rural communities in Nigeria due largely to inadequate land and water resources as revealed by the statistical feature classes of the three (3) Local Government Areas that formed the study area. Similarly, according to Table 1, fishermen constituted only 2.72% of the respondents which formed the least occupation as a result of limited water bodies in Kanke, Pankshin and Langtang North L.G.As.

Table 1: Socioeconomic background of respondents

s/no	Socioeconomic Characteristics	Description	No of Respondent %	Percentage No%
1	Occupation	Farming	147	50.00
		Artisan	43	14.63
		C/Servants	11	3.74
		Trading	36	12.25
		Fishing	8	2.72
		Others	31	10.54
		All of the above	18	6.12
2	Age	≤ 20	13	4.42
		21-30	31	10.54
		31-40	61	20.75
		41-50	137	46.60
		Above 50	52	17.69
3	Farm size(Ha)	1-5	145	49.32
		6-10	83	28.23
		11-20	41	13.95
		Above20	17	5.78
		Landless	8	2.72
4	Household size	1-5	35	11.91
		6-10	162	55.10
		11-15	97	32.99

Source: Field survey 2019

The data on age distribution of the respondents showed that people between the ages of 41 – 50 years constituted the majority, probably, because heads of households are normally persons that must have attained adulthood. The information on farm sizes of the respondents (Table 1) revealed that 145 out of 294 (49.3%) have farm sizes in hectares between 1 – 5 which strongly agreed with the opinion of virtually all the stakeholders interviewed that there is serious land scarcity which is responsible for small farmlands and land fragmentations in the study area. The average household size in the study area is between 6 – 10 persons which constituted 55.10% of the respondents (Table 1). The dominance of 6 – 10 persons in a household in the study area could be due to culture and religious influence. Being a Christian dominated Local Government Areas, men are only allowed to marry one wife and family planning techniques have wider acceptance compared to Muslims dominated areas.

Land use and Land cover Distribution of Kanke LGA

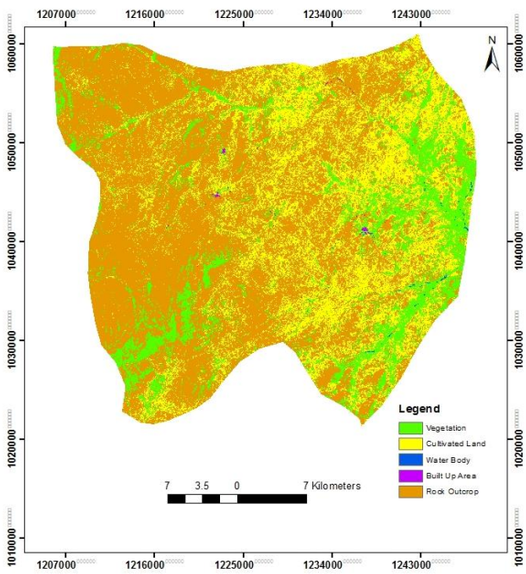

Figure 2: Land cover map of Kanke L.G.A.
Source: *National Centre for Remote Sensing, Jos, 2019*

Table 2: Land Use, Land Cover Distribution for Kanke L.G.A

S/N	Landuse/Land Cover Categories	Area (Ha)	Percentage
1	Cultivated Area	17768.82	15.48
2	Vegetation	29779.89	25.94
3	Built-Up Area	118.3203	0.06
4	Water Body	68.8842	0.10
5	Rock Outcrop	67058.24	58.42
	Total	114,794.1545	100

Source: Field Survey, 2019

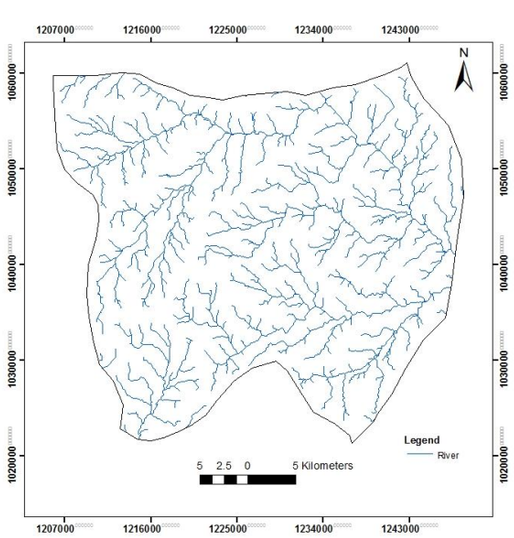

Figure 3: Drainages for Kanke L.G.A.
Source: *National Centre for Remote Sensing, Jos, 2019*

Based on the land cover map of Kanke L.G.A (Figure 2 and Table 2), the statistical feature classes' type revealed that rock outcrops constituted 67058.24 (Hectares) out of 114,794.1545 (Hectares) representing 58.42%, This implies that most parts of the land in Kanke L.G.A. cannot be used for crop production as a result of dominance of the surface land by rock outcrops, hence, there is serious scarcity of productive land as evident by the small farm sizes of the respondents. While about 71% of the earth's surface is covered by water, analysis of the statistical feature classes' type for Kanke L.G.A (Table 2) indicated that water body constituted the least with 68.8842 hectares out of 114,794.1545 hectares, representing 0.06%. This suggest glaringly that there is water resources scarcity in Kanke L.G.A. which in turn impact the agricultural sector negatively, thereby, depriving potential farmers practicing it as shown by the occupation distribution of the respondents which agrees with Linping, *et. al.*, (2018).

The land use and land cover distribution for Kanke L.G.A. indicates that vegetation cover formed the second largest in hectares after rock outcrops. According to the analysis, vegetation cover constituted 25.94% of the total land area which could be link to the dominance of poor soils in the study area as revealed by the related literatures reviewed. Similarly, cultivated land area constitute only 15.48% in Kanke L.G.A. due to unfavourable factors like rock outcrops, poor soils and unreliable water supply for farming activities. Analysis of the land cover map of Kanke L.G.A. also showed that built-up area formed the second least after water body with 0.10%. Thus, the rate of urbanization is not as rapid as in most Local Government Areas of Plateau State.

Landcover and Landuse Characteristics of Pankshin LGA

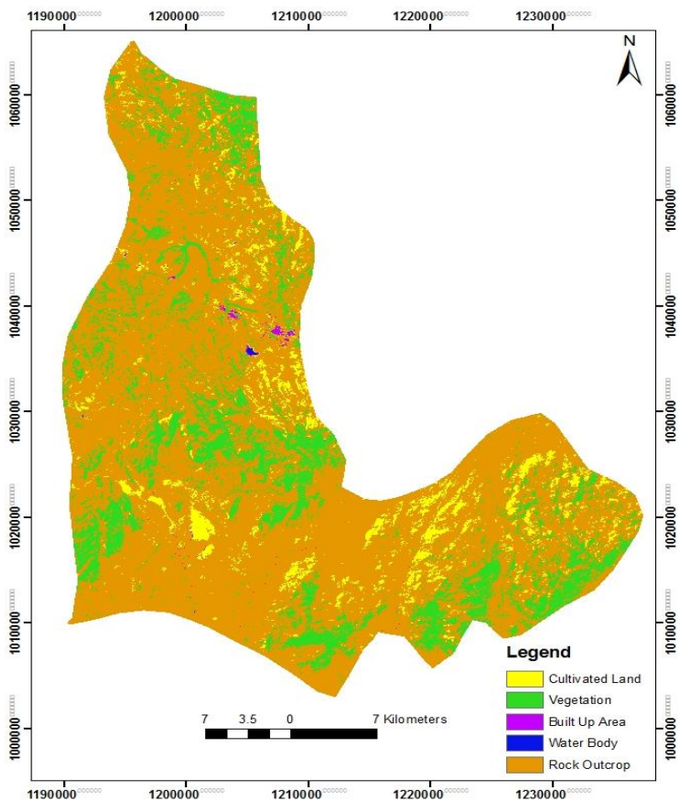

Figure 4: Land cover map for Pankshin L.G.A.
Source: *National Centre for Remote Sensing, Jos, 2019*

Table 3: Land Use, Land Cover Distribution for Pankshin L.G.A.

S/N	Landuse/Land Cover Categories	Area (Ha)	Percentage
1	Cultivated Area	7262.432	5.96
2	Vegetation	20159.48	16.55
3	Built-up Area	240.2127	0.20
4	Water Body	32.4576	0.03
5	Rock outcrop	94100.67	77.26
	Total	121,975.2523	100

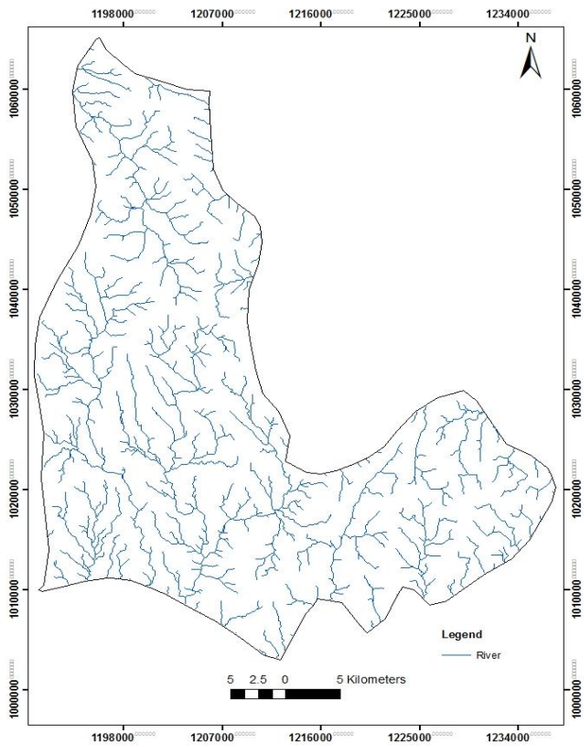

Figure 5: Drainages for Pankshin L.G.A.
Source: *National Centre for Remote Sensing, Jos, 2019*

The land cover map of Pankshin L.G.A. and the statistical feature classes' type of the L.G.A. (Figure 4 and table 3) indicated that rock outcrops occupied 77.26% of the total land area. This result justified the rationale behind the serious land resources scarcity in Pankshin L.G.A. This is further reflected in the cultivated area of 7262.432 hectares out of 121,795.2523 hectares, representing 5.96% which is grossly inadequate to support 80 – 90% of the potential population that are expected to be peasant farmers being the practice in most rural communities in Nigeria.

Water is one of the most precious resources humans have on this earth and plants and animals require it for healthy growth and good yield. Unfortunately, the analysis of the land cover map of Pankshin L.G.A. shows that water body constituted the least with only 0.03% far less than 1% of the total land area in the entire L.G.A. Due to poor soils and unreliable water supply in Pankshin L.G.A, vegetation cover formed 20159.48 hectares out of 121,795.2523 hectares, accounting for 16.55% of the total land area in the L.G.A. but remain untapped because of the above mentioned challenges. According to table 3, built-up areas in Pankshin L.G.A. formed 0.20% which is more than that of Kanke L.G.A.This could be because Kanke was created out of Pankshin L.G.A. which was formerly the headquarters of the two Local

Government Areas and as well the only major town within Kanke and Pankshin Local Government Areas till date.

Similarly, like in Kanke and Pankshin Local Government Areas, the land use and land cover distribution for Langtang North L.G.A. (Table 4) shows that rock outcrops occupied the largest portion of the land surface, contributing 40,561.68 out of 68,442.4907, representing 59.26%. The implication is that there is obviously, less land for agricultural activities. This supports the opinion of most of the stakeholders interviewed that because of inadequate land and the cost of hiring a land for farming, most people ordinarily prefer to be engaged in other sectors than agriculture which is certainly the reason why the largest employer of labour in Nigeria (Farming), accounted for only 50% of the respondents against the over 80% in most rural communities as explained by Ali, *et. al.*, (2014).

Landcover and Landuse Characteristics of Langtang North LGA

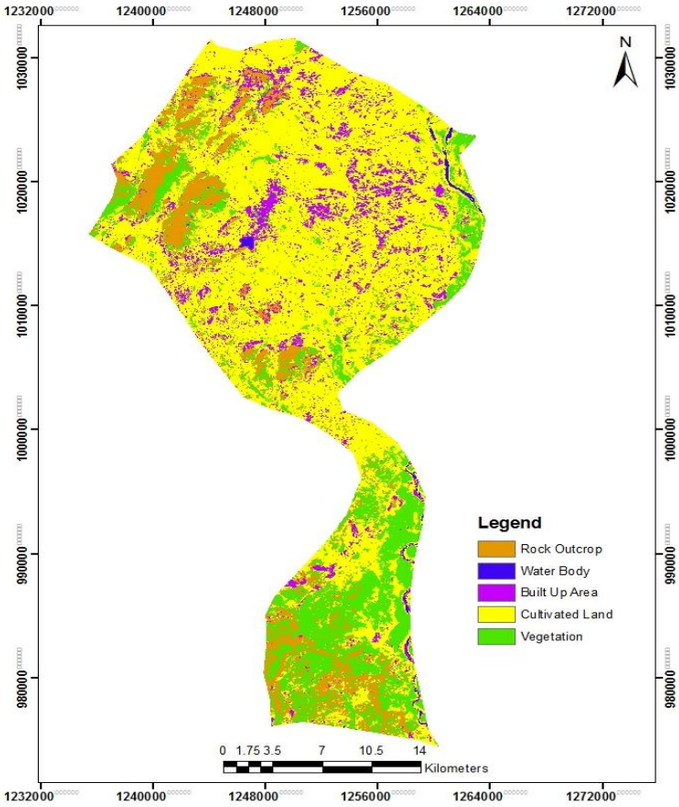

Figure 6: Landcover map for Langtang North L.G.A.
Source: *National Centre for Remote Sensing, Jos, 2019*

Table 4: Land Use, Land Cover Distribution for Langtang North L.G.A.

S/N	Landuse/Land Cover Categories	Area (Ha)	Percentage
1	Cultivated Area	13161.95	19.23
2	Vegetation	6276.224	9.17
3	Built-up Area	8095.261	11.83
4	Water Body	347.3757	0.51
5	Rock Outcrop	40561.68	59.26
	Total	68,442.4907	100

Source: Field Survey, 2019

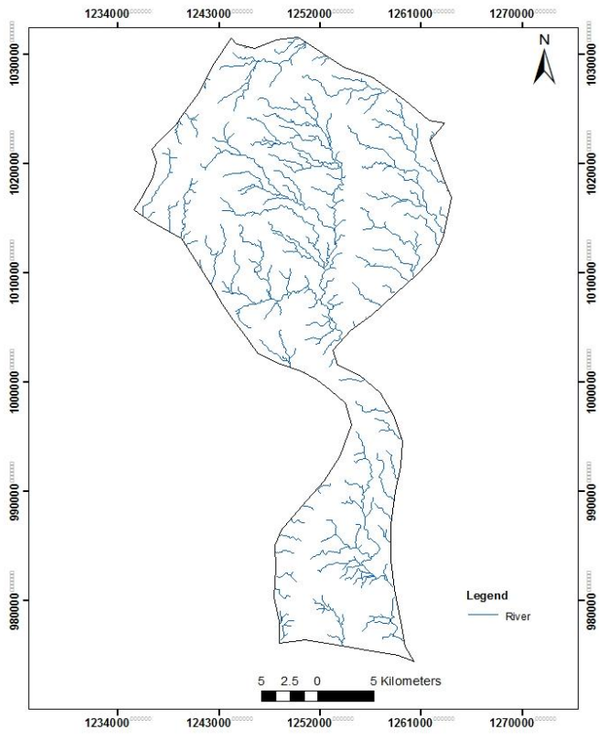

Figure 7: Drainages for Langtang North LGA
Source: *National Centre for Remote Sensing, Jos, 2019*

The analysis of the land cover map of Langtang North L.G.A. (Figure 6 and Table 4) also indicated that water body constituted the least, contributing only 347.3757 hectares out of 68,442.4907 hectares (0.5%). This is in line with the findings of the related literatures reviewed that unreliable water supply is the second most severe problem facing farmers after poor soils in the study area. Unlike Kanke and Pankshin Local Governments Areas, Langtang North L.G.A. has a built up area surface cover of up to 11.83%, indicating evidence of possible rapid urbanization in the near future. Similarly, Langtang North L.G.A. cultivated area is more than that of Kanke and Pankshin, because there is more rock outcrops in Kanke and Pankshin (Tables 2 and 3).

The vegetation cover of Langtang North L.G.A. constituted only 6276.224 hectares out of 68,442.4907 hectares (9.17%). This implies that there is more untapped land in Kanke and Pankshin with vegetation surface cover of 25.94% and 16.55% respectively.

The drainages of Kanke, Pankshin and Langtang North Local Government Areas (Figures 3, 5 and 7) show dendritic or tree-like drainage pattern, normally developed on homogeneous rocks or beds of equal resistance. Also of interest is the fact that flash flooding is common in the study area which contaminates existing water sources making water resources problem more pronounced. As evident from the drainage systems of the three (3) Local Government Areas, rivers are shallow with more run off than percolation due to deep well drained sandy soil and in areas where the soil is porous, rain water infiltrates into the soil rapidly without having been used beneficially and resulting in little or no surface storage for agricultural production as a result, evidence of physical water scarcity is a common phenomenon in the study area (Wambai, 2017).

Summarily, the land cover maps of Kanke, Pankshin and Langtang North Local Government Areas, revealed that 66.13% of the earth's surface in the study area is covered by rock outcrops, leaving only 33.87% for agriculture, built-up, water body and vegetation cover which suggests tense competition for access and ownership of land resources. Similarly, water body, the second most precious resource after air according to

some literatures reviewed occupied less than 1% (0.15%) of the total earth's surface in the study area. Coupled with significant reduction in the amount and intensity of rainfall as one moves from south to the North and inability to make beneficial uses with rainwater, it is clear that water resources is a major constraint to agricultural production in the study area. According to the statistical feature classes of the three (3) Local Government Areas, vegetation cover constituted 18.43% while cultivated area and built-up area contributed 12.52% and 2.77% respectively.

Table 5: Distribution of farmers based on constraints to farming

Constraints	Frequency	Percentage
Small farm size	57	19.39
Water shortage	40	13.61
High cost of land	12	4.08
Rocky terrain	49	16.66
Poor soils	57	19.39
Long distance to farms	51	17.35
All of the above	28	9.52
Total	294	100

Source: Field survey, 2019

The distribution of farmers based on constraints to farming (Table 5), revealed that poor soils and small farm land sizes constituted the most severe constraints with 19.39% each followed by long distances to farms 17.35%, rocky terrain 16.66%, water shortage 13.61%, and high cost of land 4.08% respectively. An assessment of the respondents' perception on problems of land and water resources availability for farming (table 6),m respondents maintains that poor soils is the most fundamental problem accounting for 20.75%, followed by rocky terrain 19.73%, dominance of high lands 18.37% and water shortage 16.67% in that order. An investigation into the inhabitants' coping strategies (Table 7), shows that mixed farming, wild fruit harvesting, irrigation, trading, mining and quarrying are the popular existing adaptation strategies in place and this is in tandem with studies by Wambai, *et. al.,* (2018).

Table 6: Problems of land and water resources availability for farming

S/no	**Parameter**	**No of respondents**	**percentage**
1	Water shortage	49	16.67
2	Dominance of high lands	54	18.37
3	Poor soils	61	20.75
4	Rocky terrain	58	19.73
5	All of the above	72	24.48
	Total	294	100

Source: Field survey, 2019

Table 7: Inhabitants' coping strategies

S/No	**Coping strategies for farmers**	**Freq**	**yes**	**Freq**	**No %**	**Decision**
1.	Mixed cropping/ mixed farming	188	94	12	6	Agree
2.	Wild fruit harvesting	130	65	70	35	Agree
3.	Trading	150	75	50	25	Agree
4.	Migration to neighboring LGAs	50	25	150	75	Disagree
5.	Solid mineral mining	175	87.5	25	12.5	Agree
6.	Quarrying	195	97.5	05	2.5	Agree
7.	Sand mining	184	92	16	8	Agree
8.	Dry season irrigation	190	95	10	5	Agree

Source: Field survey, 2019

Conclusion

The analysis of the land use and land cover distribution for the study area revealed that rock outcrops constituted 66.13%, followed by vegetation cover 18.43%, cultivated area 12.52%, built up area 2.77% and water body 0.15% respectively. The large area coverage of rock outcrops of 66.13% in the study area is a clear indication that there is inadequate land for farming and probably tense competition for access and ownership of land among the inhabitants.

The distribution of farmers based on constraints to farming shows that poor soils and small farm sizes constituted the most severe constraints to farming with 19.39% each. An investigation of the inhabitants' coping strategies showed that mixed faring, quarrying, irrigation and petty trading are the popular existing adaptation strategies in place.

To ensure efficient and sustainable utilization of land resources in the study area, large scale quarrying activities as a solution is recommended to serve as a source of employment, income to government and local authorities as well as a means of surface leveling to convert the dominant rock outcrops to suitable sites for buildings and prioritizing farming in the limited plain. According to the findings of this study, water resources do not constitute a significant challenge despite occupying only 0.15% (the least) of the earth's surface in the study area and this could pose serious water shortage mostly in dry periods. However, efficient use of water resources in the study area could be a solution to most of the pressing problems facing farmers in the three Local Government Areas.

Recommendations

Due to the abundance of rock outcrops in the study area which renders 66.13% of the earth's surface almost useless, large scale quarrying activities is recommended to serve as a source of employment, income to government and a means of surface leveling to convert the space occupied by rock outcrops to productive land and prioritizing farming in the limited plains.

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