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DETECTING VEGETATION LOSS AND ITS ECOLOGICAL IMPACTS USING GEOSPATIAL TECHNIQUES IN POTISKUM LOCAL GOVERNMENT AREA, YOBE STATE, NIGERIA

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ABSTRACT

Ensuring good management and sustainability of natural resources is paramount for future generations to thrive and live in cleaner and safer environment. This research examines the land use/land cover changes over three decades (1990 to 2019) in Potiskum using geospatial techniques. The Land use and land cover changes of the years 2010 and 2019 showed a continuous trend of vegetation being converted to cultivated areas while cultivated areas are converted to built-up areas. The findings show significant changes in vegetation cover across the study area between 1990 and 2019. Specifically, the years 2010 and 2019 witnessed a significant reduction in vegetation cover of 38% compared to 1990 and 2000 which reveals a decrease of 14.5%. From 2000 to 2010, a decrease of 8% in the vegetation cover was found. Cumulatively, the vegetation loss in the study area was found to be 60.5% between 1990 and 2019. This is highly significant and almost irreversible due to the fragile nature of the environment. The several causative factors responsible for the vegetation loss include intensification of agricultural activities, deforestation, rapid urbanization and exponential population growth. These causative factors have led to many ecological impacts such as drought, desert encroachment, sand storm, flooding, rise in temperatures, soil erosion and rainfall variations. The research recommends afforestation and reforestation measures, legislation on sustainable utilization of natural resources, tree planting campaign and subsidies on alternative sources of energy.

Keywords: Vegetation loss, Ecological impacts, Geospatial Techniques

INTRODUCTION

Vegetation cover forms an integral part of man's environment therefore plays a significant role in man-environment relationships. Optimum vegetation cover offers climatic, socio-economic and ecological benefits (Westphal, 2003; Nowak and Dwyer, 2007; Munyati and Mboweni, 2013; Naibbi *e tal.*, 2014). Urban trees cover refers to "the structural layers of leaves, branches, and stems of trees that cover the surface of the earth when observed from above" (Sexton *e tal.*, 2013).

Recent studies have revealed the environmental impacts of land use/land cover change from global to local scales. These range from changes in regional climates, changes in carbon and hydrologic cycles, decline in biodiversity through the loss and fragmentation of habitats, degradation of soil, water and overexploitation of native species (Lambin *e tal*., 2003). In developing countries, studies revealed that tree cover is being lost continuously owing to various anthropogenic activities (Macaulay, 2014).

Globally, the world has lost over178 million ha of forests between 1990 and 2020 which nearly equivalent to the total land area of Libya. Africa had the largest annual rate of net forest loss between 2010–2020, at 3.9 million ha. Moreover, the rate of net forest loss has increased in Africa in each of the three decades since 1990 (FRA 2020).

National Population Commission of Nigeria reported that about 95% of the households in Potiskum and its environs are still dependent on fuelwood for cooking (NPC, 2010). Naibbi and Healy, 2013 asserted that vegetation cover was on decline due to exponential increase in demand of fuelwood between 1990 and 2000.

According to FAO forest assessment report, Nigeria recorded the highest percentage of forest loss among the ten top countries with the largest net loss of forest area since 1990 as a result of high fuelwood demands by working class (FAO, 2010).

In Nigeria, information regarding land cover, especially vegetation cover is seriously lacking and where they do exist, they are not up-to-date (Naibbi *e tal*., 2014). There is dearth of information on vegetation loss and its associated ecological impacts in Yobe State, therefore, there is a dire need to undertake a study to provide up-to-date information on the current condition of vegetation cover using geospatial techniques. Therefore, this study is aimed at detecting vegetation loss and examining its associated ecological impacts in Potiskum Local Government area of Yobe State. Certainly, this information helps decision-makers in taking prompt actions.

MATERIAL AND METHODS

Study Area

Location and Extent of the Study Area

Potiskum lies between latitude 11° 42' 33" N and longitude 11° 04' 10"E with a total land area of 559 km² (NPC, 2006). It is situated in the western part of Yobe State. Potiskum local government is bounded to the North by Nangere local government, to the South by Fika local government area and to the East by Fune local government area (Figure 1).

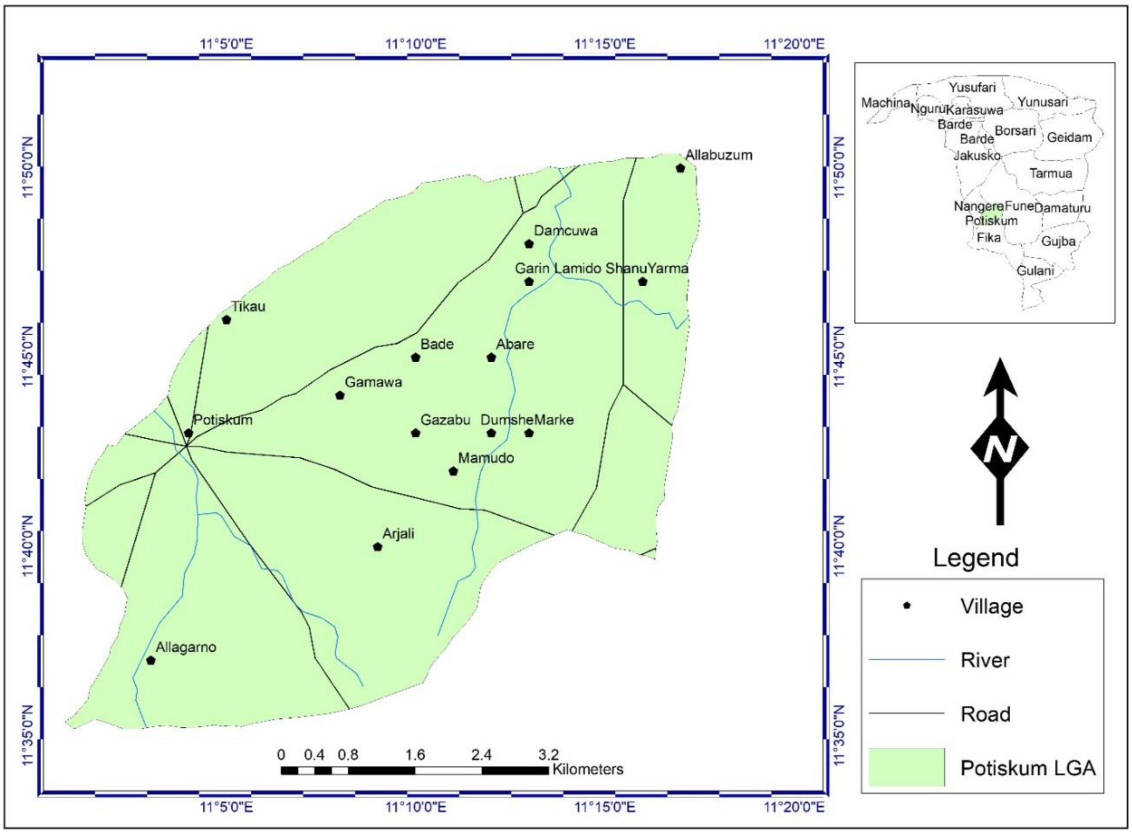


Figure 1: The study area

Sahel and Sudan Savannas covered Yobe State to the North and South respectively. Potiskum being in the southern part of the State falls under Sudan Savanna. The climate is tropical hot and dry with mean annual rainfall of between 500 mm to 1000 mm (Hess *et al.*, 1995).

The soils of the study area comprise of brown and reddish-brown soils. Calcium carbonate concentration may be present at about a meter depth.

Satellite Data Used

Landsat satellite data was used in this study. The imageries were procured from United States Geological Survey (USGS) Glovis archives (www.glovis.usgs.gov/). The detailed characteristics of the scenes is presented in Table 1.

Table 1: Satellite image data specifications

S/N	Spacecraft/Sensor ID	WRS Row	WRS Path	Cloud Cover %	Spatial Resolution	Date Acquired
1	Landsat 8/OLI TIRS	52	187	7.86	30 x 30m	2019-10-20
2	Landsat 7/ETM+	52	187	1.00	30 x 30m	2010-10-19
3	Landsat 7/ETM+	52	187	0.00	30 x 30m	2000-10-23
4	Landsat 4/TM	52	187	0.00	30 x 30m	1990-11-29

Image Pre-processing

The Landsat bands of the study area were stacked and the quality of the images was enhanced through radiometric correction and pan-sharpening. The area of interest (AOI) was subset. This was carried out using spatial modeler tool in ERDASIMAGINE 15.

Image classification

A supervised classification was performed using maximum likelihood algorithm. This algorithm assumes that the distribution of pixels forming a cluster of training data is Gaussian (normally distributed). Therefore, decision rule can be applied to the unknown measurement vector X for each pixel in the scene as:

decide unknown measurement vector X is in class i if, and only if

$$P_i \geq P_j \quad (1)$$

for all i and j out of 1, 2, ... m possible classes and,

$$P_i = -\frac{1}{2} log_e|V_i| - \left[\frac{1}{2}(X-M)_i{}^T V_i{}^{-1}(X-M_i)\right] \quad (2)$$

where $M\,i$ is the mean measurement vector for class i and Vi is the covariance matrix of class i for bands k through l. Therefore, to assign the measurement vector X of an unknown pixel to a class, the maximum likelihood decision rule computes the value pi for each class. Then it assigns the pixel to the class that has the maximum value (Asmala, 2012; Jensen, 2015).

Derivation of NDVI and Change Detection Analysis

The NDVI images were derived from the division of difference and addition of Near Infrared and Red bands of Landsat images of 1990, 2000, 2010 and 2019). The NDVI was derived using equation 3.

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (3)$$

Whereas NDVI is Normalized Difference Vegetation Index and NIR and RED represent Near Infrared and RED bands respectively.

Change detection technique of image differencing was used to detect the areas of significant vegetation loss and gain in the study area. The classified NDVI images of 1990, 2000, 2010 and 2019 (as before and after images of the study area) were equally subtracted to obtain the results of the image difference.

Sampling technique and sample size

Stratified random sampling technique was used in administering the questionnaires so as to ensure that all parts of the population are represented and to increase efficiency. This involves the classification of Potiskum into five zones- northern, southern, eastern, western and central zones. Each zone was further subdivided in to 2 sub-zones. The total sample size was 100, each sub zone was administered with 10 questionnaires making 20 questionnaires in each zone (Table 2).

Table 2: Sample size and sample locations

Zones/Subzone	Northern	Southern	Eastern	Western	Central
1	Mamudo	Angwan Jaji	Nahuta	Lailai	Tsohuwarkasuwa
2	Damcuwa	Dumbulwa	Badejo	Arkime	Tudunwada
Total	20	20	20	20	20

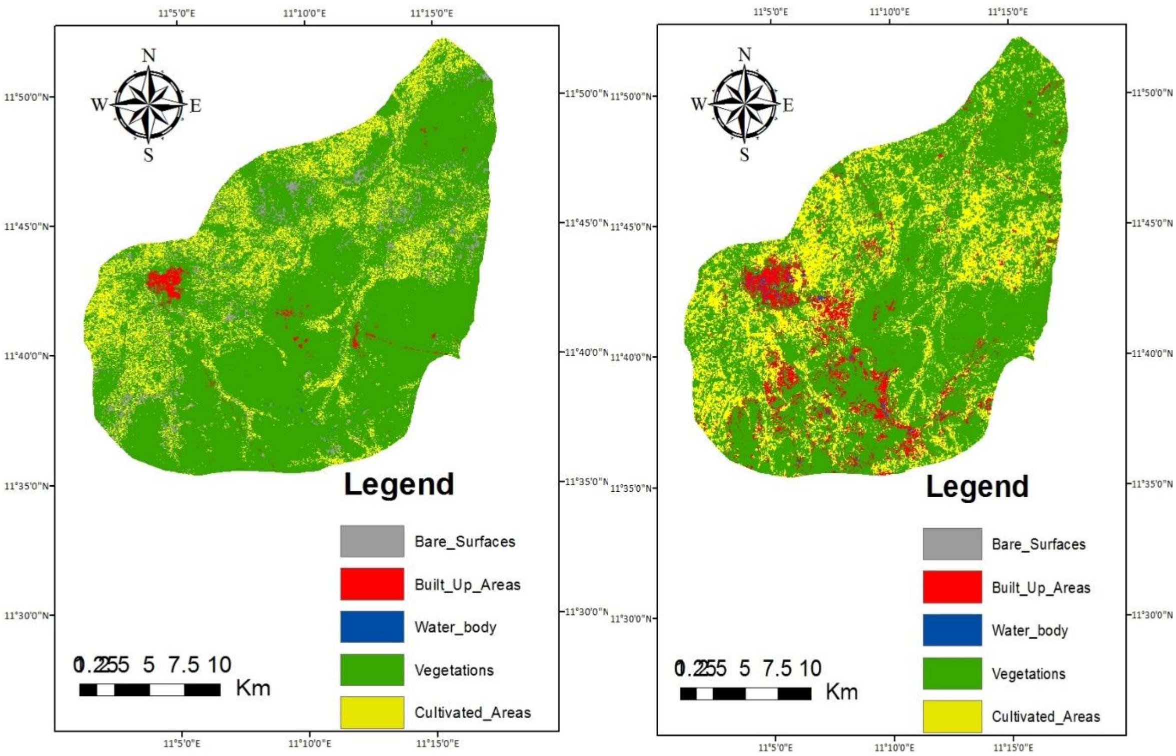
RESULTS AND DISCUSSION

Vegetation Distribution

The vegetation distribution pattern and changes for each year under study is shown in Table 3**.** The vegetation cover of the area witnessed some considerable fluctuations. The results revealed that 75% of the area under study was covered with vegetation in 1990. This percentage drastically reduced to about 60% in 2000. Between 2000 to 2010, a decrease of about 8% was observed. By comparing the differences between first 10 years (1990-2000) and last 10 years (2010-2019), the years of 2010 and 2019 in particular witnessed a significant reduction in the vegetation cover of 38% compared to the years 1990 and 2000 which reveals a decrease of about 14.5%. So, the last 10 years showed a huge difference in comparison to the first 10 years which is very alarming. Generally, the results clearly showed a decline in total vegetation cover over of the study period.

Land use/Land cover change

The land use/land cover classification revealed that there was dense vegetation cover with few cultivated lands and built-up areas in 1990. In the year 2000, vegetated areas were converted to cultivated lands and similarly, cultivated lands were converted to built-up areas. The Land use and land cover changes of the year 2010 and 2019 indicated a continuous trend of vegetation change, that is to say vegetation areas being converted to cultivated areas and cultivated areas being converted to built-up areas. The findings clearly showed significant changes in vegetation cover across the study area from 1990 to 2019 (Figure 2).



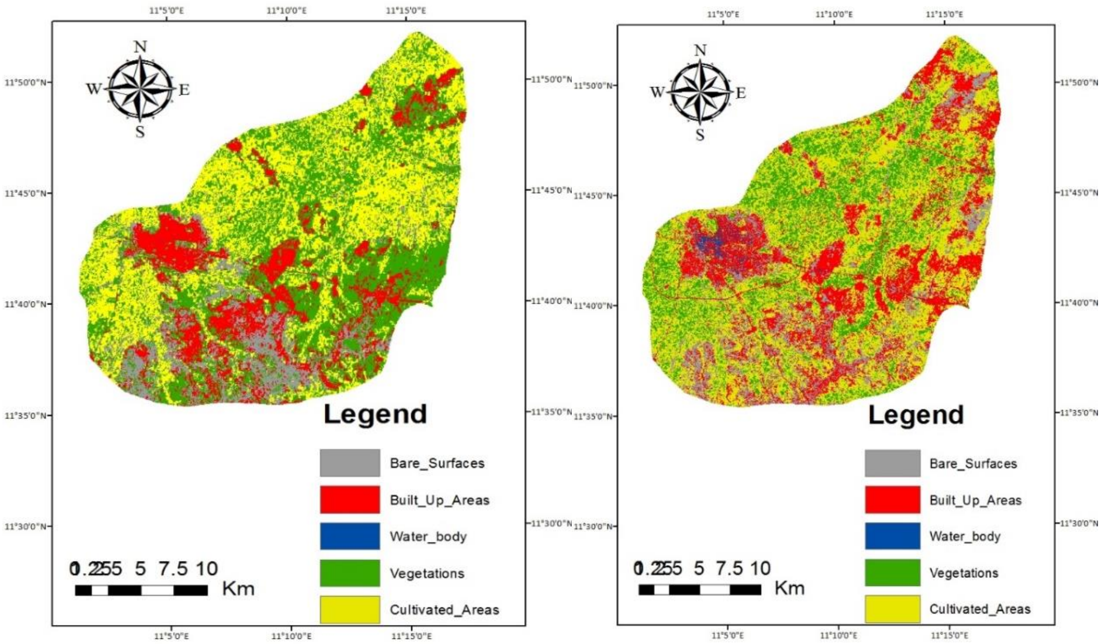


Figure 2: Land use/land cover changes of Potiskum between 1990 and 2019

It is evident that bare surface was 17.08% in the year 2010. This indicated the increased demand of land for cultivation and development of infrastructure in the area. Similarly, built-up areas showed significant increase with 10.86% and 29.13% in the years 2000 and 2019 respectively (Table 3). This can be attributed to exponential population growth. The water body remained fairly stable over the study periods. However, vegetation showed a continuous decline from 1990 to 2019. The cumulative vegetation loss between 1990 and 2019 was found to be approximately 60.5% (Table 3). These findings agreed with the findings of Macaulay, 2014 who revealed that vegetation density in the area was reducing due natural and anthropogenic factors.

Table 3: Land use/land cover changes in percentages of Potiskum from 1990 to 2019

LULC \YEARS	1990 (%)	2000 (%)	2010 (%)	2019 (%)	Difference (1990-2019)
Bare Surface	5.92	2.36	17.08	11.82	5.9
Built-up Area	1.31	10.86	5.82	29.13	27.82
Water Body	0.86	1.62	0.21	1.7	0.84
Vegetations	75.46	60.96	52.95	14.98	-60.48
Cultivated land	16.42	24.18	23.92	42.34	25.92
Total	**100**	**100**	**100**	**100**	

Figure 3 shows the trend of land use/land cover changes over the period under study. Cultivated lands depicts a stable increase between 1990 and 2019. On the other hand, vegetal cover decreases progressively. This was due to increased demand for fuel wood and food to cater the needs of ever-growing population. This provides corroboration for the findings of PRB, 2009.

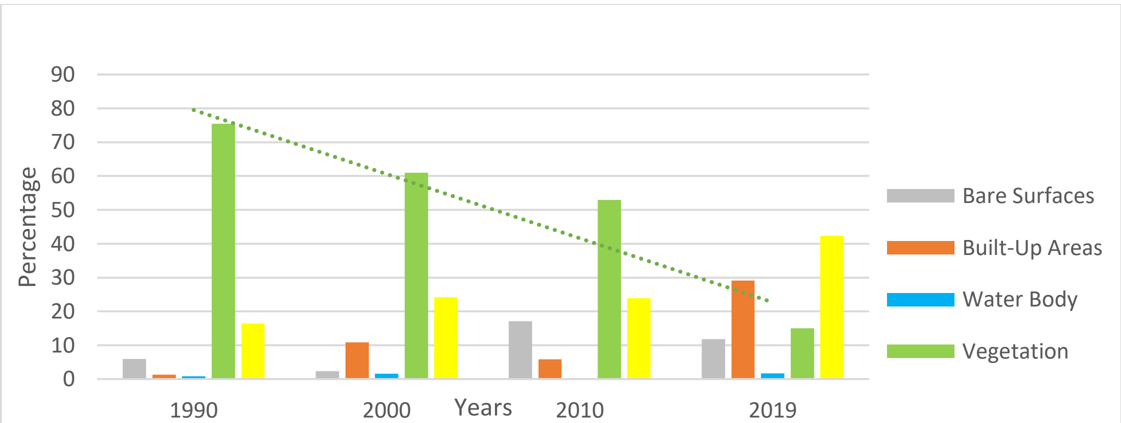


Figure 3: Trend of Land use/land cover changes in Potiskum LGA between 1990 and 2019.

Ecological Impact of Vegetation Loss

The findings revealed that 81.9% of the respondents noticed a change in the vegetation density, while 18.1% did not. 44.6% of the respondents noticed an increase while 55.4% noticed a decrease in the vegetation density. On the other hand, 84.3% of the respondents did feel the impacts of vegetation loss while 15.7% did not. The vast majority of the interviewees (90.4%) observed the impacts of vegetation loss on the environment in the study area (Table 4).

Table 4: Ecological impacts of vegetation loss in the study area

	No. of respondents	Percentage
Change in vegetation density		
Yes	68	81.92
No	15	18.07
Change Notice (increase/decrease)		
Increase in vegetation density	37	44.57
Decrease in vegetation density	46	55.42
Feeling of the impacts of vegetation loss		
Yes	70	84.33
No	13	15.66
Notice of any impact of vegetation loss on the environment		
Yes	75	90.36
No	8	9.63

The findings revealed that environmental problems occurred as a result of vegetation loss at different frequencies. The most noticeable environmental problem was significant rise in temperature as observed by 22.34% of the respondents. This is obvious due to greenhouse effect and consequent global warming. Drought, desert encroachment/sandstorm and flood were found to be at 16.66%, 17.04, and 12.87% respectively. Soil erosion and rainfall variability stood at 15.53% each (Figure 4).

The least observed environmental problem was flood. This could be attributed to the change in rainfall pattern as reported by Oguntunde *e tal*., 2011.

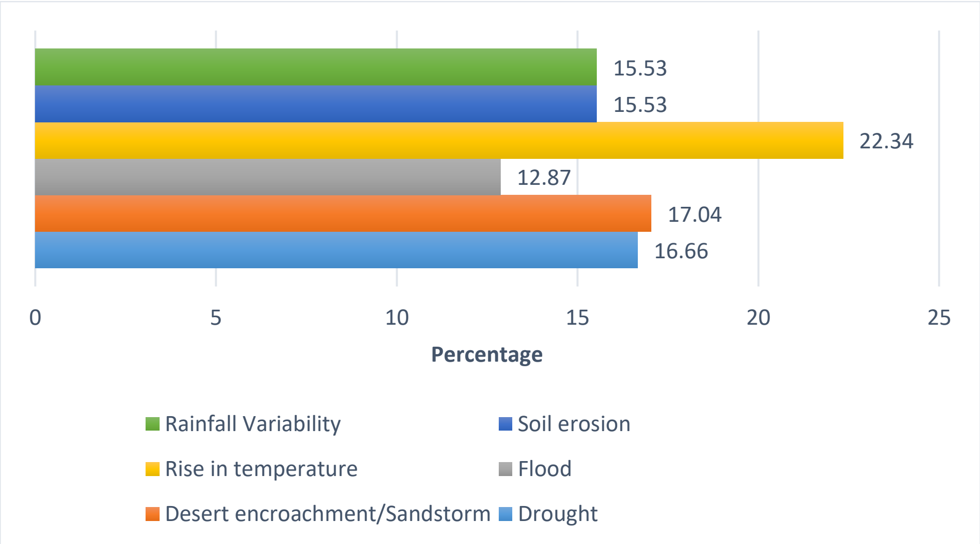


Figure 4: Occurrence of environmental problems

Table 5 shows the severity level of the ecological impacts observed by the respondents. Drought, flood, soil erosion and rainfall variability fall on the moderate scale while, desert encroachment, sandstorm and rise in temperatures are on the high scale.

Table 5: Severity level of ecological impacts

Environmental Problems	**Severity Level**		
	Low	**Moderate**	**High**
Drought	7	30	24
Desert encroachment/Sandstorm	7	24	34
Flood	14	22	13
Rise in temperature	4	9	46
Soil erosion	19	27	14
Rainfall variability	10	32	18

Causes of Vegetation Loss

The underlying causes of vegetation loss were identified by the respondents as urbanization accounting for 13.3%, agricultural activities 18.0%, population growth 30.1% and deforestation 38.6% (Figure 5). Earlier studies on vegetation in northern Nigeria notably Cline-Cole *et al.*, 1990 and Odihi, 2003 identified the absolute reliance on, and demand for fuelwood as the key factor causing deforestation in the northern arid zones of Nigeria.

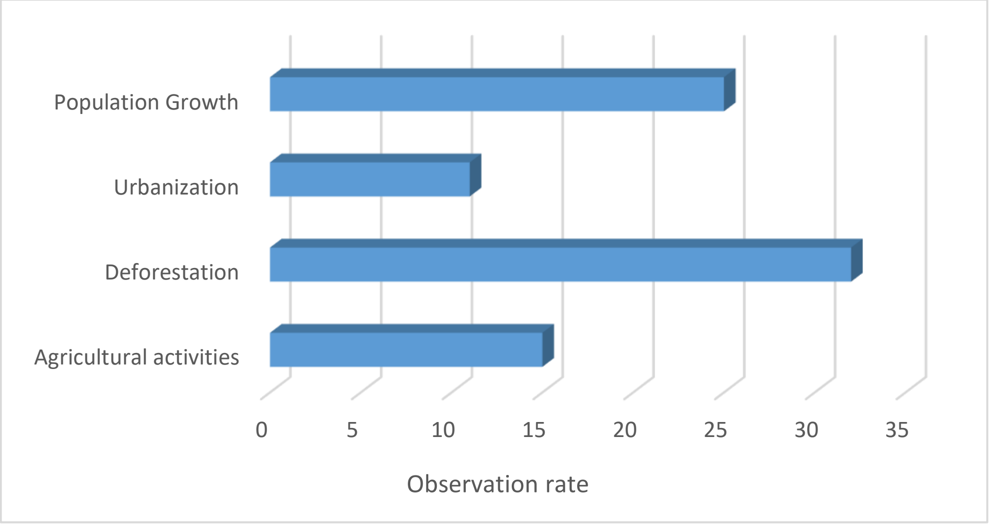


Figure 5: Factors responsible for vegetation loss in Potiskum

The major factor contributing to population change in the area is migration from surrounding local governments of Fika,Nangere, Gadaka and environs in Yobe State, and surrounding districts in Bauchi and Jigawa States (MLGN, 1976).

Table 6: Effect of vegetation loss on immediate communities

Effects of Vegetation Loss	Observed Rate	Percentage Observed
Severely	22	26.50
Highly	33	39.75
Moderately	28	33.73
Total	**83**	**100**

As asserted by 26.5% of the respondents, vegetation loss has been exerting severe effects on the communities either directly or indirectly. 39.8% were highly affected and 33.7% were moderately affected by the ecological impacts of vegetation loss in the study area (Table 6)**.**

CONCLUSIONS

Vegetation loss poses a real threat to the long-term sustainability of environmental resources due to its scale and the preponderance of the factors causing it. The findings of this research showed significant changes in vegetation cover in Potiskum between 1990 and 2019. Specifically, the years 2010 and 2019 witnessed a significant reduction in vegetation cover. The cumulative reduction in vegetation cover was 60.5% between 1990 and 2019. The progressive vegetation loss was attributed to the rapid urbanization, exponential population growth, deforestation and intensification of agricultural activities. The vast majority of the interviewees observed the impacts of vegetation loss on the environment. Therefore, firm and urgent action is needed. The study suggests some ways of mitigating the causes of vegetation loss which include: planting of trees and cover crops, construction of dams for irrigation, conservation of natural habitats, sensitization/public enlightenment, legislation to prohibit indiscriminate felling of trees, provision of alternative source of fuelwood and avoiding bush burning.

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