ANALYSIS OF SPATIO-TEMPORAL TRENDS IN NORMALIZED DIFFERENCE VEGETATION INDEX OF HONG LOCAL GOVERNMENT AREA, ADAMAWA STATE, NIGERIA

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Abstract: Dense vegetation cover is significantly ceding to sparse and bare land surfaces. The study was embarked upon to identify the spatio-temporal trends in vegetation cover indexes and to analyze the causes of changes. The scope is limited to Hong Local Government Area of Adamawa State, Nigeria. The time frame of the study covers from 1976 to 2009 with sample years of 1976, 1987, 1998 and 2009. The study focused on spatio-temporal change detection of bare, dense and sparse vegetation covers. Data on vegetation covers were generated from landsat images of 1976, 1987, 1998 and 2009. Geographic Information System (GIS) and Remote Sensing techniques were adopted to analyze the data. Comparison of vegetation cover situation was adopted to determine the thriving state of vegetation cover from 1976 to 2009. The result indicates that dense vegetation cover decreased by 10.25% while sparse and bare surfaces increased by 8.65% and 1.60% accordingly. These changes were attributed to increase in population from 112,845 in 1976 to 170,452 in 2009 manifested by increase in arable farming, bush burning, vegetal resources harvesting and infrastructural development. The result implies with increase in human activities in the area will result in loss of more vegetation cover. It is recommended that inhabitants should embark on agro-vegetation on tree species that are adapted to the environment and have proved important to populace as sources of fuelwood should be cultivated by farmers on the bare lands.

Keywords: Change detection, foliage greenness, human activities, spatio-temporal, vegetation index

Introduction

Vegetation covers have been affected adversely by human activities from time immemorial (Meichen *et al*., 2017). In Africa human activities such as arable farming, pastoralism, settlement, mining and construction affected the climax vegetation adversely by conversion from dense cover to sparse and bare lands (Mabogunje, 2010). Omisore (2018) reveals that human intervention with the landscape to obtain his basic needs like food and shelter have transformed the vegetation cover on the affected areas into varied land cover such as farmlands and built-up areas. Wikipedia Project (2018) and Pantami *et al.* (2010) observed that human activities such as uncontrolled bush fire and arable farming are the most important causes of greenery foliage cover depletion. This is because of the possibility of wild fire to cover large area and burn susceptible plants while rotational bush fallow and continuous cultivation that have been practiced since the 13th century are the contributing reasons for the depletion in vegetation cover.

Kabthimer (2012) used Normalized Difference Vegetation Index (NDVI) to assess spatio-temporal patterns of vegetation change in Ethiopia using National Oceanic and Atmospheric Administration (NOAA) images. Bolanio (2015) in study on vegetation cover change detection stated that anthropogenic activities such as arable farming and construction have transformed significant parts of the natural landscape into modified surface. Furthermore, Gadiga (2015) in study on monitoring the spatio-temporal dynamics of vegetation cover stated that around the world vegetation cover is undergoing an exhaustive change at various scales due to human activities like arable farming and natural factors such as climate change. The Foliage Network (2018) indicate that degradation of foliage cover index is not solely dependent on biological factors such as disease, old age, plant parasite and diverse human activities, but significantly due to climatic factors such drought. From the literatures, the diverse human activities such infrastructural development, fuelwood harvesting, arable farming, bush burning, and climate change are the major initiative to alteration of vegetation cover index.

Despite studies on effects of human activities on vegetation cover especially those of Omisore (2018), Bolanio (2015), Gadiga (2015), Kabthimer (2012), and Pantami *et al.* (2010) none has focused on greenery foliage situation such as dense, sparse and bare land covers of Hong Local Government Area. It is against this background that the research was carried out to identify the vegetation indexes with a view to determine the magnitude of changes from 1976 to 2009.

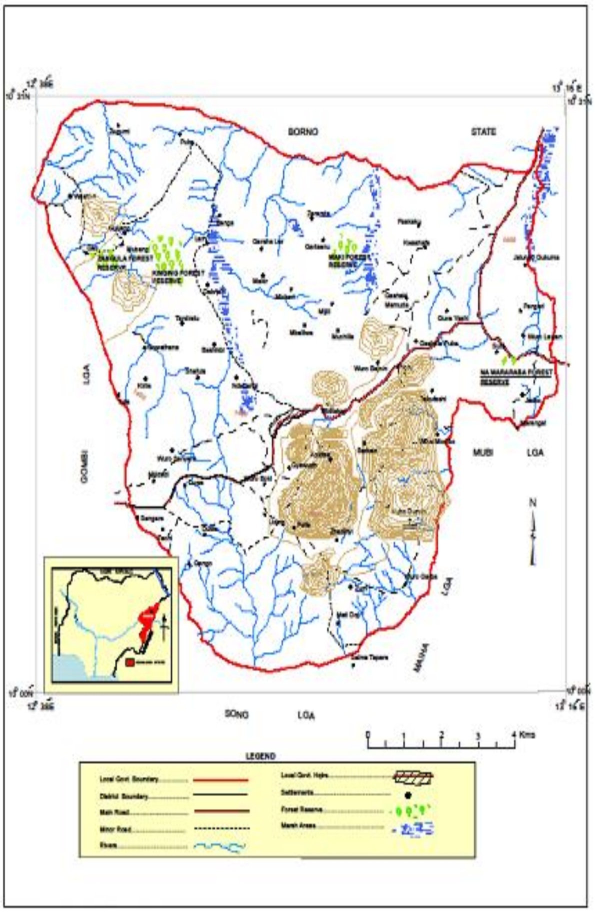
The aim was to establish spatio-temporal trends in NDVI cover such as dense, sparse and bare land. The objectives include: to categorize the vegetation cover into bare, dense and sparse; to find out the landmass of the area; to determine the area covered by dense, sparse and bare land; and to establish the inhabitants opinions on causes of changes in vegetation cover. The scope covers Hong Local Government Area with landmass of 2,486 km^2. The time frame covers 1976 to 2009 with sample years of 1976, 1989, 1998 and 2009. The 11 year interval was adopted to give a 10 year clear period to identify changes that occurred in dense, sparse and bare land over time and space.

Materials and Methods

The study area

Background to the Study Area: Hong Local Government Area lies between latitudes 09^{0}57'N to 10^{0}32'N and between longitudes 12^{0}38'E to 13^{0}16'E. It has an approximate area of 2,486 km^2 as shown on Fig. 1.

The dry season is experienced from the months of November to April while wet season starts in May and end in October. The mean annual rainfall varies between 700 to 1000 mm while the mean daily temperature is between 36^0 to 41^{0}C of the dry season to about 20^0 to 25^{0}C during the wet season (Online Nigeria, 2017). The seasonal rainfall implies that dense canopy is restricted to the rainy season when water and nutrients are absorbed by plants while the dry season encourages bush fires which exhibit sparse foliage cover. The high temperature induce evapotranspiration and soil desiccation with broader disadvantage on plant wilting, withering and finally susceptible species dry up which harmfully affects dense leaf index.



Source: Garkida, Nigeria, Sheet 155
Fig. 1: The study area

The relief and landforms is generally hilly ranging from about 426 to 1158 m above mean sea level while the most important rivers are Fa'a, Bubulum, Dogwaba and Ngilang (Garkida, Nigeria, Sheet 155). The floodplains had dense vegetation cover in 1976, but have significantly reduced in 2009 due to increase in farmlands on crops such as sugar cane and rice. For the reason the population increased from 112,845 in 1976 to 170452 in 2009 (National Population Commission, 2010). The soils are hard, compacted, dry, and of low fertility that hinder the development of luxuriant vegetation cover with the exception on the moist, fertile and deep soils along the floodplains like Fa'a, Dogwaba and Ngilang.

The area lies within the Sudan vegetation zone (Adoti, 2018; Makinwa, 2018). The vegetation is dominated by annual grasses while woody plants are short with height ranging from less than 1 to 15 m; the distribution varies from 1 to 17 stands per 100 m^2 and the girth differs from 0.17 to 3.10 m. Most woody plants shed leaves and remain dormant in the dry season to reduce transpiration and conserve water (Gandapa, 2014). The sparse woody plants are affected unfavorably by fuelwood harvesting, bush burning, arable farming, settlement and road network development.

The population increased from 112,845 in 1976 to 170,452 in 2009 (National Population Commission, 2010). This implies more farmlands, infrastructures and vegetal products are required. Gandapa (2014) stated that about 60% of the populace practice arable farming on crops such as groundnuts, maize and guinea corn on rotational bush fallow, mono cropping, continuous cropping and crop rotation.

The variety of data required include systems of arable farming, vegetal resources, and causes of vegetation cover changes were generated from the field and respondents. Others include landmass; areas covered by dense, sparse and bare lands were generated from topographical map and landsat images while population figure was obtained from National Population Commission. The sets of data were used to determine the magnitude of changes in bare, dense and sparse vegetation covers, and the causes of changes.

In vegetation studies NDVI is a standard that expresses the greenery canopy concentration of vegetation cover (GISGeography, 2018). In an effort to estimate the foliage cover index of the area, NDVI was used to harmonize and quantify the concentration of green leaf indexes (Environmental Research, 2018). The Vegetation Index procedure was designed using ERDAS Imagine to identify, extract and quantify the concentration of vegetation cover (ERDAS Imagine, 1997). From Topographical Sheet Series 37 and 38 on scale 1: 250,000 the study area span across two scenes (p. 185, r. 53; and p.186, r. 53). Scene sub-setting and mosaicking were adapted to produce map of the area from the scenes.

Using ArcGIS (version 9.3) soft wire, the following resolutions were adopted to analyze the imageries: 1976 MSS 50m (resample), 1987 TM 30 m, 1998 TM 30 m and 2009 ETM 15 m. The study adopted landsat images to isolate and generate statistics on dense, sparse and bare land, but not the taking in-field measurements using the active field-portable NDVI sensors (Pietragalla and Vega, 2012). This is because the decadal time frame (1976 to 2009), and large area coverage (2486 km^2) could not favour the use of the active field-portable NDVI sensors.

To identify bare, dense and sparse vegetation covers signature files were developed using green colour bands namely: bright green (depict dense vegetation); dark green (represent sparse cover) while light green (symbolize surfaces such as water bodies, roads, settlement sites and bare rock surfaces that do not have vegetation cover). These colours were run on a supervised classification that generates statistics for the signature files created ERDAS Imagine (1997). The focus is to determine the magnitude of bare, dense and sparse vegetation covers. For the purpose of this study, normalization was adopted to harmonize the different greenery canopy covers of vegetation that was bare, distressed and luxuriant.

Results and Discussions

Dense foliage cover are spotted in the North East, Centre and South central while the bare surfaces corresponds with the granitic rocks in the North West, North East, Centre and South East. The detected trends in vegetation indexes indicate 67.79, 23.46 and 8.75% for sparse, dense and bare surfaces in that order. Dense vegetation decreased by 10.25% while bare and sparse covers increased by 1.60 and 8.65% accordingly. The population increased from 112,845 in 1976 to 170,452 in 2009 while land per capita decreased from 22.22 to 14.49 m^2. Human activities such as arable farming, vegetal resources harvesting, infrastructural development and frequent bush burning are the major causes of changes in vegetation cover indexes.

Detected trends in bare, dense and sparse vegetation covers

Figure 2 shows the images of 1976, 1987, 1998 and 2009 from those statistics on bare, dense and sparse vegetation covers were generated.

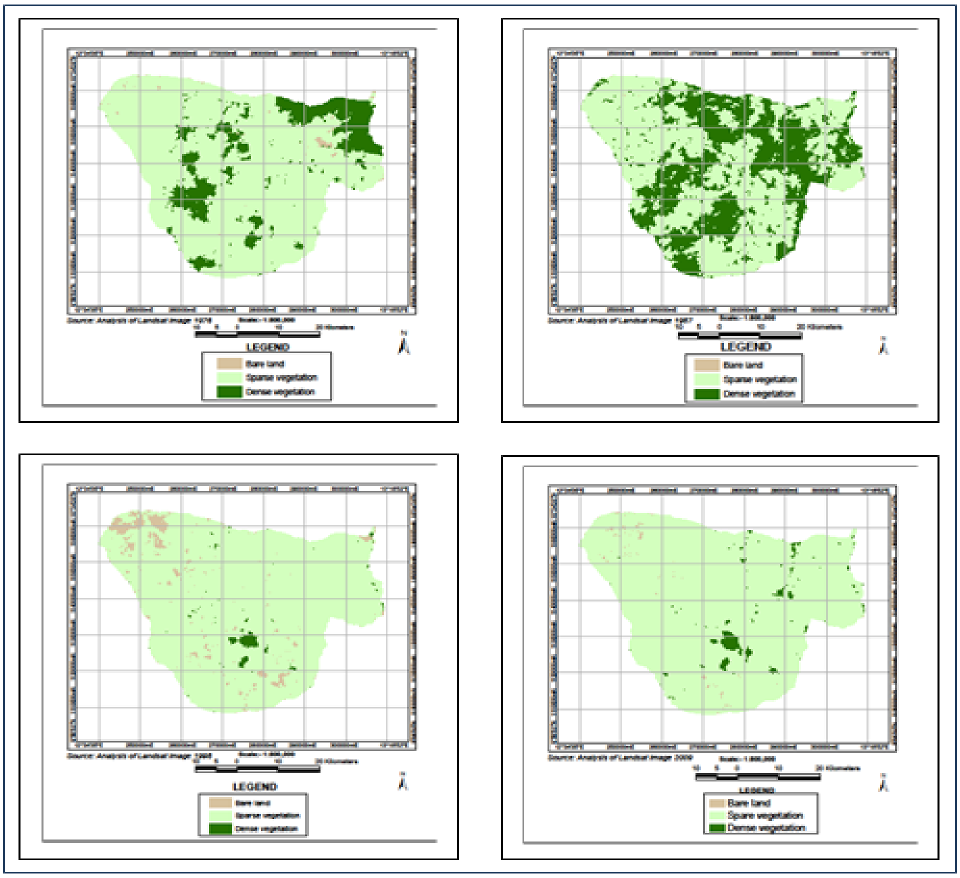


Fig. 2: Vegetation cover distributions of 1976, 1987, 1998 and 2009

Table 1: Detected trends in bare, dense and sparse vegetation cover statistics

Years	1976		1987		1998		2009		Overall %
Parameters	**Area (km^2)**	**%**	**Area (km^2)**	**%**	**Area (km^2)**	**%**	**Area (km^2)**	**%**	
Bare land	155	6.24	98	3.94	422	16.97	195	7.84	8.75
Dense veg.	634	25.50	1105	44.45	215	8.65	379	15.25	23.46
Sparse veg.	1697	68.26	1283	51.61	1849	74.38	1912	76.91	67.79
Total	**2486**	**100.00**	**2486**	**100.00**	**2486**	**100.00**	**2486**	**100.00**	**100.00**

Source: Landsat Images: 1976, 1978, 1998 and 2009

Table 1 presents summary of the detected trends in bare, dense and sparse vegetation cover statistics that were generated from landsat imageries for the period under review.

From Table 1, 67.79% of the area is covered by sparse vegetation followed by dense with 23.46% while the least is bare land with 8.75%. In between 1976 and 1987 dense vegetation increased by 18.95% due to decrease in sparse vegetation and bare land by 16.65 and 2.30%, respectively.

In between 1987 and 1998 bare land and sparse vegetation increased by 13.94 and 22.77% accordingly which is credited to decrease in dense vegetation by 35.80%. More importantly, in between 1998 and 2009 bare land decreased by 9.13% while dense and sparse vegetation covers increased by 6.60 and 2.53%, respectively.

Respondents' views on the causes of changes in vegetation cover indexes

Table 2 presents summary of the respondents' views on the causes of changes in vegetation cover index. For more emphasis the factors are revisited below.

Arable farming

From Table 2, arable farming is the major factor responsible for the alteration of vegetation cover as revealed by 37.40% of the respondents. Established from the respondents, arable farmers clear farmlands by slash-and-burn to cultivate crops on rotational bush fallow, mono cropping, continuous cropping and crop rotation. These systems of crop cultivation affects vegetation cover harmfully because both woodlands and grasses are massively cleared to manage exotic plants such as guinea corn, maize, beans and groundnuts among others.

Table 2: Respondents' View on the Causes of Changes in Vegetation Indexes

Causes of Changes in Veg. Indexes	Respondents	%
Arable farming	187	37.40
Increase in population	101	20.20
Vegetal resources harvesting	96	19.20
Bush burning	61	12.20
Infrastructural development	27	5.40
Poverty	19	3.80
Pastoralism	09	1.80
Total	500	100.00

Furthermore, the forward and backward approaches adopted in rotational bush fallow affect dense vegetation cover adversely. For example, the forward to the reserves such as Dzangula (lat. 10^{0}23'N, long. 12^{0}44'E), Maki (lat. 10^{0}23'N, long. 13^{0}00'E), Mararaba (lat. 10^{0}15'N, long. 13^{0}12'E) and Kinging (lat. 10^{0}23'N, long. 13^{0}48'E) converted significant portions to spare vegetation covers. Besides, the massive clearance of dense woodlands on Dogwaba and Ngilang floodplains for arable farming on crops like rice contributed to the decrease in dense canopy cover from 25.50% in 1976 to 15.25% in 2009 while the backward shift to the fallow lands that have secondary woodlands accelerated increase in sparse vegetation cover from 68.26% to 76.19% as shown on Table 1.

From the respondents, the reason for increase in dense vegetation cover by 18.95% between 1976 and 1987 is attributed to significant adoption of agro-vegetation. Species such as *Mangifera indica* and *Azadirachta indica* are planted on the bare lands especially around settlements such as Hong, Pella, Bangshika and Uding that decreased bare land by 2.30% and sparse cover by 16.65%. More importantly, the reason for increase in bare land by 13.03% between 1987 and 1998 was due to increase in pits, gullies, road surfaces and settlement sites at the loss of dense and sparse vegetation covers by 35.80 and 22.77% accordingly. Similarly, between 1998 and 2009 bare land decreased by 9.13% while dense and sparse vegetation increased by 6.60 and 2.53%, respectively. The reason is attributed to the reclamation of some bare surfaces to farmlands on crops such as soya beans and woodlands on *Phoenix sylvestris*, *Azadirachta indica* and *Mangifera indica* for diverse socio-economic purposes such as land grabbing.

Increase in population

Results on Table 2 show that 20.20% of the respondents are of the opinion that increases in population is the cause of changes in vegetation cover indexes. With increase in population density from 45 to 69 persons per km^2 and decrease in land per capita from 22.22 to 14.49m^2 (as shown on Table 3) put forth additional pressure on the available land resources such as soil fertility which affects vegetation cover unfavorably.

Table 3 presents population density and land per capita of Hong Local Government Area

Year	Population	Density(km^2)	Land per capita (m^2)
1976	112,845	45	22.22
1987	116,068	47	21.28
1998	132,555	53	18.87
2009	170,452	69	14.49

Source: NPC Hong

As a result of reduction in land per capita, there is decrease in dense vegetation cover by 10.25% while sparse and bare lands increased by 8.65 and 2.51% accordingly as shown on Table 1. This is accepted by increase in activities of the populace such as arable farming, infrastructural development, fuelwood harvesting that have been carried onto the reserve lands associated with dense vegetation covers at Dzangula, Maki, Mararaba and Kinging. From the respondents, unemployment is a contributing reason for the detected drifts in vegetation cover. The youths who are the most valuable human resources are mostly unemployed in the white-collar jobs. Encountering this problem, they took to peasant agriculture mostly on rotational bush fallow and continuous cropping that convert dense vegetation into sparse and bare surface.

Vegetal resources harvesting

From the respondents, 19.20% opined that vegetal resources harvesting is the major cause of changes in vegetation index (Table 2). The predominant vegetal resources harvested are fuelwood, charcoal, edible native fruits and vegetable, poles and hafts. The adopted clear-cut, lopping and coppicing of woodlands for different purposes inevitably degrade vegetation cover. For example, area covered by dense vegetation decreased by 255 km^2 from 1976 to 2009 (Table 1). Also, the feeder roads that carry traffic from reserves to a municipal that are initiated by the fuelwood vendors increased bare land and sparse vegetation covers by 40 and 215 km^2 for the period under review (Table 1). It is observed that commercial fuelwood collection to feed urban centres is responsible for significant woody plants removal from the community reserve at Bubulum capable of changing the dense vegetation to sparse and even bare covers.

Bush burning

According to 12.20% of the respondents (Table 2), bush burning by different sets of people for dissimilar reasons is the major cause of changes in vegetation indexes. For example, the nomads indiscriminately set fire to the withered and dry grasses in the month of November and December to ensure early sprout of palatable grasses for livestock feed while hunters occasionally set bush on fire during the dry season (January to April) to hunt wildlife such as rat, mice and rabbit. Besides, the shifting cultivators resort to bush burning as a device for easy clearance of farmlands. For those reasons, vegetal covers that are prone to frequent burning have changed from dense to sparse cover. Consequently, bare land and sparse vegetation covers increased by 40 and 215 km^2, respectively at the loss of dense vegetation by 255 km^2 from 1976 to 2009 (Table 1). This is because susceptible species like *Annona squamosa* which has smooth bark is eliminated due to consumption of stems and leaves by fire while the resistant species like *Anogeissus leiocarpus* that have hard and dry bark survive.

Infrastructural development

From the respondents, 5.40% (Table 2) indicate that the development of public services and facilities such as road networks, parastatals and houses embarked upon by government and individual cause changes in vegetation indexes. With increase in population from 112,845 in 1976 to 170,452 in 2009 (Table 3) have accelerated increase in settlement sizes and road networks. Therefore, bare and sparse land covers increased by 1.60% and 8.93% while dense vegetation decreased by 10.25% as shown on Table 1. For the reason that vegetation is massively removed on the sites to embark on infrastructural development such as road and settlement constructions that convert dense or sparse vegetation cover into bare lands. For example, result of field study indicates pits at Tasha Tiding covering 8,961 m^2, Motuku-Uding occupy 212,50 0m^2, Kala'a subjecting 6,537 m^2 and Tsakuwa-Uding wraps 8,040 m^2 among others which were either dense or sparse vegetation cover have been converted into bare land.

Poverty

From 3.80% of the respondents (Table 2), activities of the rural poor are the major causes of change in vegetation indexes. Poverty is a condition in which there is inadequate necessary means to live within a minimum standard. The linkage between poverty and vegetation cover change manifest through the mode of socio-economic activities in which the plant is massively or selectively removed. The poor clears the vegetation massively to manage economic and food crops; adopt rotational bush fallow in search of fertile soil; harvests vegetal products such as poles, native fruits, vegetables and herbs; fuelwood to generate domestic energy; and occasionally burn bush to hunt wildlife such as grasshopper, rat and mice. These socio-economic activities cause significant change in vegetation indexes. For example, dense vegetation decreased by 255km^2 while sparse vegetation and bare land increased by 215km^2 and 40km^2 from 1976 to 2009 (Table 1).

Pastoralism

From the result on Table 2, 1.80% of the respondents are of the opinion that the activities of both herders and herds are responsible for changes in vegetation cover indexes. For example, cattle trample the undergrowth plants like *Cynodon plactostachyusa* and browse the palatable species like

Pennisetum pedicellatum to near bare surfaces. The herdsmen lope branches of tree species such as *Khaya grandifoliola* and *Acacia albida* to feed their cattle on palatable leaves in the months of February to May (known as '*cheedu*' in Fulfuldi language) when pasture are scarce; and the pastoralists' inclination to new pasture land affects vegetation density and species diversity harmfully. This could be the reasons for the increase in sparse vegetation cover by 7.93%. For example, places such as Kurshu and Mbalagi that are far away from settlements that are managed as reserves by the indigenes are affected unfavorably by herds due to frequent trampling that massively remove the undergrowth vegetation. Also there is massive removal of grasses and shrubs on the kraals because of accumulation of dungs. This could be a factor for the increase in bare land by 1.60% from 1976 to 2009 (Table 1).

To this end, result of the study is in line with those of The Foliage Network (2018), Bolanio (2015) and Kabthimer (2012). There are significant changes in vegetation cover indexes due to arable farming and constructions. Human intervention with the environment is the major causes of changes in vegetation covers. The detected trends indicate dense vegetation cover decreased while bare and sparse cover concealment increased.

Conclusion

Based on the findings of this study, there is a significant variation in bare, dense and sparse vegetation covers. Dense vegetation decreased by 10.25% while sparse and bare land increased by 8.65 and 1.65% accordingly. The changes are due to diverse economic activities of the increasing populations. The major socio-economic activities that convert dense vegetation to sparse and bare land surface are arable farming, bush burning and infrastructural development. The result implies with increase in human population manifested by diverse socio-economic activities lead to changes in vegetation cover.

Recommendations

From the result of this study, the following recommendations are highlighted for sustainable development of vegetation cover:

Alternative sources of domestic energy like kerosene and gas should be made available and affordable to the populace to reduce the existing pressure on woodlands by both the rural and urban households. More importantly, tree species such as *Mangifera indica*, *Azadirachta indica*, *Eucalyptus camaldulensis*, and *Anogeissus leiolarpus* that are adapted to the environment, fast growing and have proved important to the community as sources of fuelwood and income generation should be cultivated by farmers for end-use.

Conflict of Interest

Authors declare that there are no conflicts of interest.

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