EXAMINATIONOF THE RELATIONSHIP BETWEEN VEGETATION COVER INDICES AND LAND DEGRADATION IN THE PERI- URBAN AREA OF KADUNA METROPOLIS, NIGERIA

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ABSTRACT

This study examined the relationship between some vegetation cover indices and land degradation in the peri-urban area of Kaduna metropolis, Nigeria with the aim of reducing, if not stopping, the activities that produce vegetation indices that contribute to land degradation. Methods adopted for data collection are field observation and measurement of variables along twelve transects, using the following indices; size of surface cover, tree crown fullness, area covered by litters, tree density and leaf cover index. The physical measurements were carried out on each transect of 50m by 500m.The data collected was collated and presented in a tabular format which was later subjected to correlation analysis using SPSS software. The results revealed an inverse relationships between the size of land degraded and tree density (-0.521), leaf cover index (-0.387), area covered by litters (-0.332), surface cover index (-0.244) and tree crown fullness (-0.163), but a very strong positive correlation between tree density and leaf cover index (0.886), tree crown fullness (0.718) and area covered by litters (0.557) respectively. From this analysis the major vegetal index contributing to land degradation is the tree density which, when it is improved upon, will lead to the improvement of other indices because of the positive correlation between them and tree density. Therefore it is recommended that agroforestry and land scaping should be embraced in the area with emphasis on short economic trees with moderate crown cover that will allow crops or grasses to grow under it as well as avoid the negative impact of rain water drops from very tall tree that can cause soil erosion.

KEYWORDS: Agroforestry, leaf, land degradation, litters, tree density and vegetation.

INTRODUCTION

Increase in population of any area or settlement has always led to expansion of settlements irrespective of the location around the world. This expansion of settlement also exert enormous pressure on the outskirt of a city; in particular, the peri-urban areas which are transitional zones between rural area and urban centres. One of the natural resources mostly affected is the vegetation (Albaladejo, Martinez-Mena, Roldan and Castillo,1998). Better still, in a much organised country where there is rule of law, there is usually an adherence to standard, planning and environmental laws and regulations. But worst is the situation in most Africa countries and Nigeria in particular where in most cases there are no master plans for most settlements and where they exist, they are usually very hard to implement mostly because of social issues (Adewuyi, 2016).

The importance of vegetation directly and indirectly to the survival of Planet Earth has been emphasised by many studies (Adewuyi & Olofin, 2017), and particular attention and emphasis was also given to it in the 2016 Paris climate landmark arrangement by most nations of the world on issues of climate change in particular and the environment in general (Olofin and Labesa, 2017). Adewuyi (2011), among many studies, analysed land degradation in the peri- urban area of Kaduna Metropolis using fourteen variables. They include; slope, land use for agriculture, farming system, conservation techniques, type of degradation, types of exotic trees, numbers of exotic trees, vegetation index, soil moisture, bulk density, porosity, degree of saturation and soil air content were all correlated against the size of area degraded and Principal Component Analysis (PCA) for grouping into components. The study concluded that the causes and effects of land degradation in the area is mostly from land use for agriculture, types of degradation, soil air content and porosity, while others have a lower degree of contribution.

Adewuyi and Olofin (2012) further examined the sustainability of fuel wood harvest in the area and found out that harvesting of wood at the rate of 91.9 tons per day as at 2013 was not sustainable and a better and more sustainable sources of domestic energy must be adopted as a matter of urgency, which the study predicted would be very difficult to achieve because of the challenges the country is going through in having consistent electricity, petroleum products and cooking gas supply at affordable rate for the generality of the population.

These environmental challenges further prompted Adewuyi and Olofin (2017) to examine the emerging land use pattern for the forest reserved area adjacent to the metropolis and found out that the changes are significant and are mostly from forestry usage to farming, road track, waste dump and waste land and which are responsible for land degradation already in advanced stages in most of the areas experiencing deforestation. Having realised that land degradation is currently on going in the area at a very significant rate, it is pertinent to begin to understand the relationship between land degradation and the distribution of vegetation. However, it is not just trees, but various vegetation cover indices and their contribution to land degradation.

Tackling land degradation is not an easy task particularly in the third world countries with enormous underdevelopment, endemic poverty, unemployment, dwelling resources, corruption and serious social conflicts. As a result of these and other challenges facing the nation, allowing land degradation at the current rate without check mating it is a bomb waiting to exploded coupled with the pressure exerted by the approaching arid Sahara desert. Consequently, understanding the roles of various factors contributing to land degradation is a necessity for the success of the battle against land degradation in the peri-urban area of Kaduna metropolis (Easdale, 2016).

Vegetation on the surface of the earth plays significant roles in the stabilization of many systems (Muñoz-Rojas, Jordán, Zavala, De la Rosa, Abd-Elmabod& Anaya-Romero, 2015;Prosdocimi, Jordán ,Tarolli, Keesstra, Novara &Cerdà, 2016). Its roles in the water cycle, climatic pattern, energy cycle, soil nutrient distribution, biodiversity and ecosystem is great (Bruijnzeel, 2004; Liu, Yao, Huang, Wu & Liu 2014). Therefore, the quantification and analysis of various vegetation indices is a prerequisite in many studies and in this in particular. Though the earth is a complex environment with several interactions between the atmosphere, land and water bodies, in-depth analysis and understanding of various sub units of our environment is required to build a total concept and understanding, so as to know how to manage the environment better (Okin, 2002).

Consequently, the research problem of this study is to establish the relationship that exist between various vegetation indices and land degradation in the study area with the sole aim of using the findings to reduce, if not stop the hazard of land degradation on the environment and the people who either leave or work on the land. Therefore, the objectives are to identify the vegetation indices required for the area, collect data on them and use SPSS to analyse and establish their relationship.

The vegetation cover indices adopted for this study are size of Surface Cover Index (SCI), Tree Crown Fullness (TCF), Area Covered by Litter (ACL), Tree Density (TD) and Leaf Cover Index (LCI) which has been proven by many studies to be very important in the study of the relationship between land degradation and vegetation (Adewuyi, 2011). The role of each of these variables will be examined to see their contribution individually as well as collectively.

MATERIALS AND METHOD

Study Area

The study area is the entire peri-urban area of Kaduna metropolis. It lies within a 500m corridor from the outskirt of the city. As a result the study area circled the city and forms an irregular shape. The area falls within latitudes 10^o 12' 00'' – 10^o 50' 00''N and longitudes 7^o 15' 00'' – 7^o 33' 00''E with the elevation ranging from 600m to 650m above the mean sea level (see figure 1). The approximate size of the study area is 30,000m^2 (30km^2) about 10 per cent of the total area of the metropolis. It falls within two local government areas, namely; Igabi and Chikum.

The area is predominantly used for agriculture. Most part of the area is now covered by cultural vegetation from the original guinea savannah. The area is drained by river Kaduna and its tributaries. The trees are generally moderate in size, ranging from 5m to 15m in height and 15cm to 100cm in trunk diameter. The crops grown are mainly tubers (yams and potatoes), cereal (maize, guinea corn and millet) and vegetables (spinach, tomatoes, cabbage, and onions e.t.c), while, cattle graze the vegetation of the area from time to time.Other physical details of the area can be consulted in Adewuyi (2017).

MATERIALS

The materials utilized were basically physical measurements which are obtained through field measurement. A digital camera was also used in the documentation of some of the interesting features observed during field assessment and measuring tapes were used for geometrical measurements and GPS for taking co-ordinates. The other materials is SPSS software for statistical analysis.

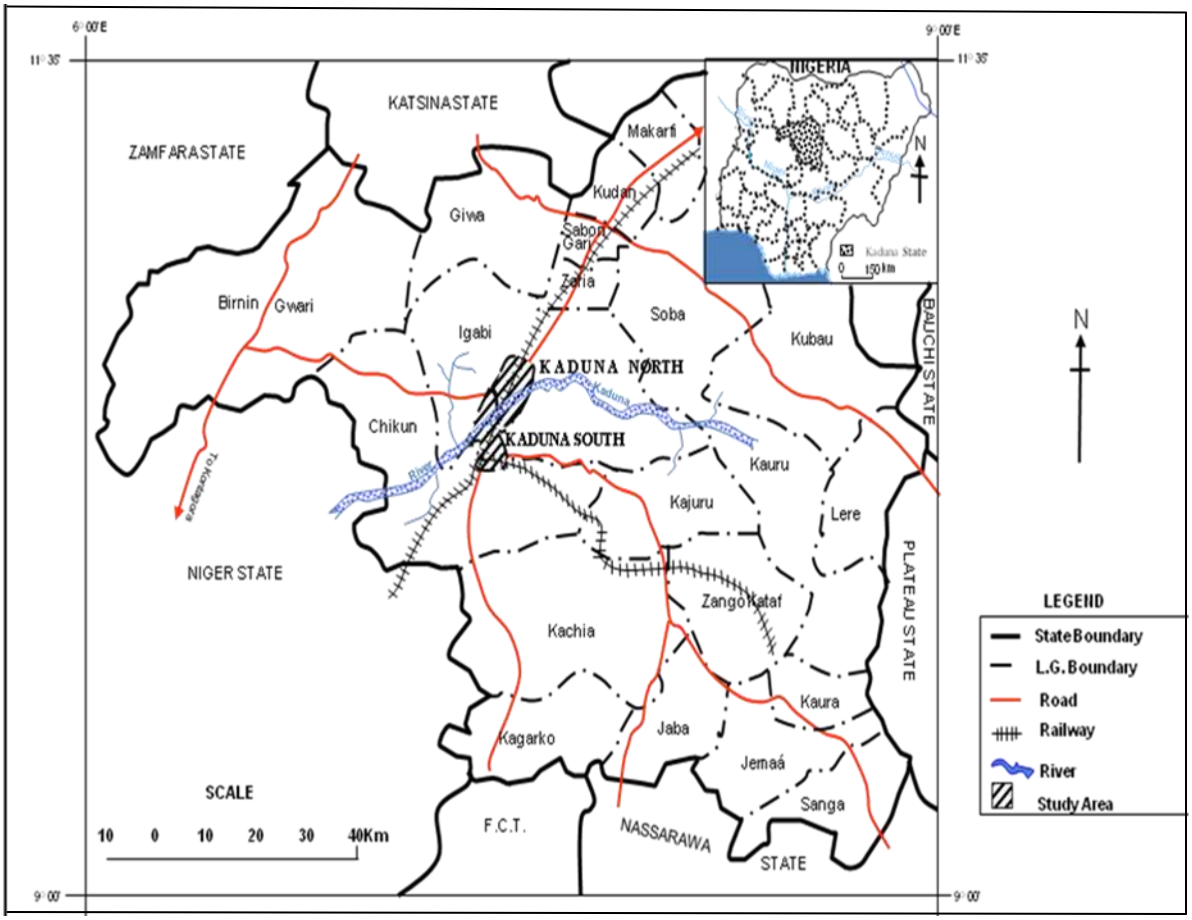

Figure 1: Kaduna Metropolis in Kaduna State
Source: KASUPDA, Kaduna (2005).

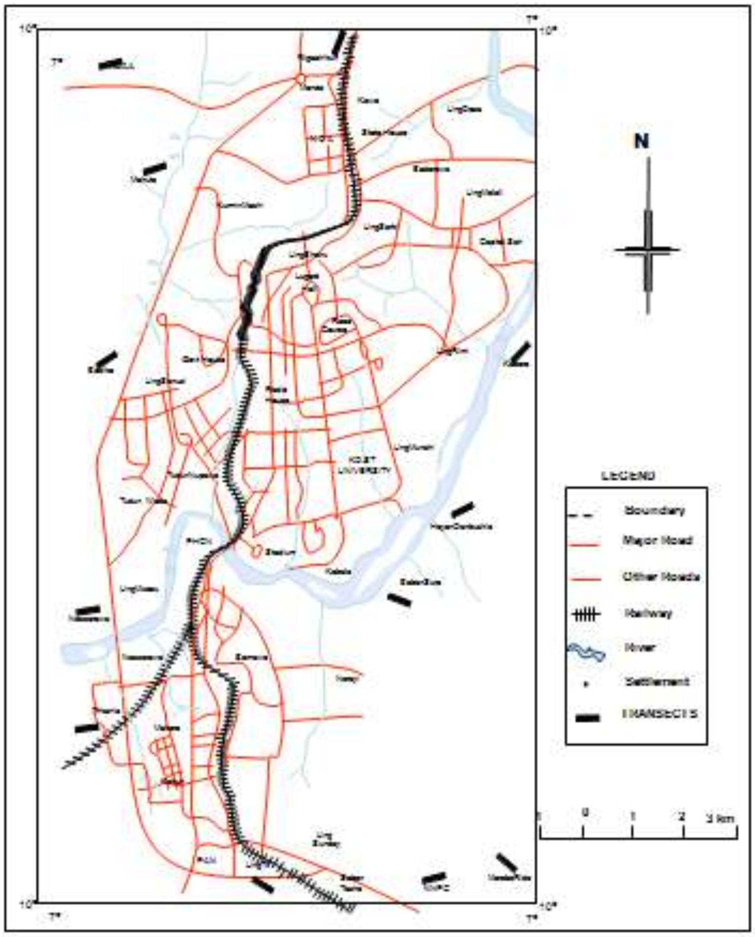

Figure 2**:** Location of Transects

Experimental Design
The methods adopted for the study were the same as the one used by Adewuyi (2011) for reconnaissance, sampling design, preparation of transects and physical measurements. Twelve transects were designed for the study, each has a dimension of 50m by 500m. They were systematically selected to reflect the dynamics of the area and to represent the area as much as possible. Physical measurements were carried out by 1200 hours in other to capture the tree crown fullness using the sunshine and shadow casted on the ground. The data was collated and presented in a tabular format which was later subjected to correlation analysis using SPSS software.

Data collection
From each transect, the following vegetation indices was collected; Surface Cover Index (SCI), Leaf Cover Index (LCI), Tree Density (TD), Tree Crown Fullness (TCF), Area Cover by Litter (ACL) and size of Area Degraded (AD) by physical measurement on the field using tape, pegs and ranging poles.

Data analysis
The data collected was presented in a tabular format and descriptive statistical methods of total, mean, maximum and minimum was carried out to characterised the data which was followed by correlation analysis in an SPSS environment.

RESULTS AND DISCUSSION

The various values of vegetation cover indices measured from the twelve selected transects are presented in Table 1. Their total, average, maximum and minimum were computed to provide a description of the results of the measurements at a glance. From the descriptive perspective, all the values had wide ranges, indicating that the transect selected had very dynamic vegetation cover around the peri-urban area of Kaduna metropolis. Some of the implications of this are: that there are different land uses and covers, the pressure from the people for vegetal resources is not the same and the presence of River Kaduna could also be a factor.

Examining them closely, transect 12 was purposely selected as control and it is a place with no indication of any land degradation, in particular soil erosion. It also has all other indices in sufficient positive level except for surface cover index, that the value for the transect is below the average.

Table 1: Data on vegetation indices from the sampled transect

Transect	Area Degraded (%)	SCI (%)	Tree Crown Fullness (%)	Area Cover by Litter (%)	Tree Density	LCI (%)
TP1	1.5	13	40	70	13	1.5
TP2	20	2	45	23	11	1
TP3	2	18	21	37	3	1
TP4	1.5	50	60	3	125	12
TP5	1	1.3	68	22	72	6
TP6	8	1.6	63	18	20	1.7
TP7	1.1	1.5	59	34	230	24
TP8	0.5	3	70	85	200	15
TP9	15	16	73	40	69	6
TP10	4	33	63	34	121	8
TP11	30	2	52	28	4	1
TP12	0	2.93	93	100	316	68
Total	84.6	144.3	707	494	1184	145.2
Average	7.05	12.0275	58.91667	41.16667	98.66667	12.1
Maximum	30	50	93	100	316	68
Minimum	0	1.3	21	3	3	1

Other transects have areas degraded ranging from 1% to 30%.Transect 11, with the highest, was actually used for soil mining to make local blocks for building. So also was the value for other vegetation indices, they reflected the type of land uses of the transects which range from crop farming, refuse dump, soil mining and forestry. Consequently, some transects have crops, grasses, solid waste and trees at different percentages as their cover. Figure 3 further displays the various vegetation indices using a bar chart to show there variation across the transects.

Correlation of Vegetation Cover Indices with Land Degradation

The size of land degraded has inverse relationship with all the vegetal indices (Table 2). While they all have various level of relationships, Tree Density (TD) was seen here as the most important factor contributing to land degradation among them. With a correlation of -0.521, it implies the lower the numbers of trees in the area, the more the degradation. The next vegetation index is the leaf cover index (LCI). The LCI has a correlation of -0.387, which is expected because when the TD decreases, the LCI will decrease too because it is the trees that carry the leaf, and vice versa, when the tree number increases, the LCI will also increase. That was why there is a positive correlation of 0.886 (very singnificant at the level of 0.01) between them. The LCI has similar relationship with Tree Crown Fullness (TCF) (0.684) and Area Covered by Litter (ACL) (0.632).

The size of ACL is the third in the order of rate of correlation with land degradation. It has a correlation value of -0.332, and just as it was explained for LCI, ACL has a direct relationship with TD, which implies the more the trees, the more the size of the area that will be covered by the litters. This was also justified by a correlation value of 0.557 between TD and ACL. Therefore the trend established by this study so far is that increase in tree density will lead to increase in leaf cover which in turn will lead to increase in the size of the area covered by litter on the ground.

The fourth in the order of correlation among the vegetation indices is the Surface Cover Index (SCI). It has a correlation of -0.244 with the size of area degraded. This has to do with vegetal cover such as crop or grasses. As a result, it has a very low negative relationship of -0.034 with tree density because the two cannot actually go together because of the competition for sunlight. Tree Crown Fullness (TCF) has the least correlation with the size of area degraded, which is -0.163 but has a strong positive correlation with tree density (0.718) and leaf cover index (0.684) which is already an established trend in this study.

Implications on land degradation

The findings of the study buttress the already known fact that vegetation plays a very important role in the ecosystem balancing as well as in the prevention of land from degradation (Talbot, 1947; Andreu et al., 1998; Adewuyi, Olofin and Falola, 2010; Adewuyi and Olofin, 2015 and 2017). Depletion in vegetation resources is also a symptom of land degradation because there absence implies the special services that they provide such as wind breaker, holding of soil together and prevention of soil from direct hit by sun will reduce (Kalema, Witkowski, Erasmus Mwavu, 2015; Mohawesh, Taimeh and Ziadat, 2015; Ochoa, Fries, Mejia, Burneo, Ruiz-Sinoga and Cerda, 2016; Adewuyi, 2016).

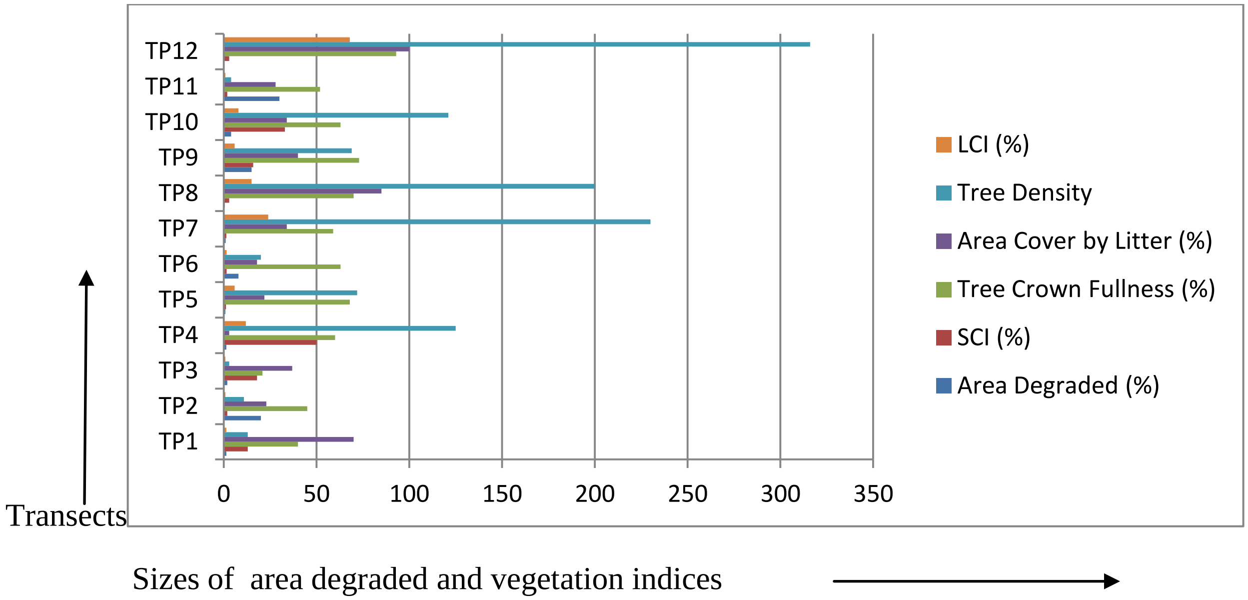

Figure 3: Display of Vegetation Indices from the Transect

Table 2: Correlations Between Vegetation Indices

Variables	**AD**	**SCI**	**TCF**	**ACL**	**TD**	**LCI**
AD	1	-.244	-.163	-.332	-.521	-.387
SCI	-.244	1	-.131	-.346	-.034	-.140
TCF	-.163	-.131	1	.362	.718**	.684*
ACL	-.332	-.346	.362	1	.557	.632*
TD	-.521	-.034	.718**	.557	1	.886**
LCI	-.387	-.140	.684*	.632*	.886**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Consequently, a correlation of -0.521 of the size of area degraded with tree density is on the high side and as a result, it is one of the major factors responsible for land degradation in the area, therefore it requires urgent attention to address the situation before it goes out of hand which is in line with the findings of Xue and Fennessy (2002).
As it was established from the field assessments in this study, that there is a very close relationship between tree density and leaf cover index, tree crown fullness and the area covered by litter which is at a level of 0.886, 0.718 and 0.557 respectively. As a result, what affects one of this vegetation indices will affect all the vegetal indices. Therefore, increase in the tree density will mean increase in the leaf cover index, tree crown fullness and areas covered by litters. Therefore, they all have inverse relationship with land degradation.The implication of this makes solving the effect of vegetation on land degradation an easy task, because once the tree density is improved, the impact will improve the values of the other three vegetation indices. This in turn will create

a chain reaction for the conservation of the area in a sustainable manner (Mohawesh *et al.*, 2015).

For the surface cover index, it has an inverse relationship with tree density because it will be difficult to have either sufficient crop or grasses cover of the soil where there is sufficient trees with good leaf cover index and tree crown fullness as a result of competition for sunlight which is a basic requirement for the growth of most plant. This is the reason why crop and grasses do not grow well under trees except when there branches are pruned to allow reasonable amount of sunlight to reach the crop/grasses. However, this short coming can be easily compensated by sufficient area covered by litter, so that the services that crop and grasses would have served such as slowing down surface runoff of water thereby reducing soil erosion and increasing water infiltration and reducing direct impact of sun on the soil will provide good environment for the soil and micro organism development will be enhanced as suggested by Olofin (2000).

The tree crown fullness is very good in breaking down wind speed which will be greatly useful in areas with little surface cover index and in the dry season when strong wind blow from the north east down to the southern part of the country. This agrees with the findings of Wang, Xue, Zhou and Guo (2015). The relationship is actually inverse with SCI because the more the crown is full, the less the leaf that is droping so also is the more difficult for crops and grasses to grow under them because of lack of access to sunlight, a major requirement for growth, impling that there will be little surface cover. Also known from Novera, Gristiana, Saladino, Santoro and Cerda (2011) was that the taller the tree the heavier will be the leaf drops on the soil which can lossen the soil and activate soil erosion processes. What this therefore implies is that there must be a balancing between these two vegetation indices to alleviate land degradation in the area.

Remediation

The best solution is as advocated by Adewuyi, 2011 and 2016; Adewuyi and Olofin, 2017; with a slight modification. Agroforestry and introduction of landscaping into our urban and regional planning still remain the best options because it will allow multiple land uses to go on concurrently as well as providing income to the land user all year round and it will definitely reduce the pressure on the usage of different components of the environmental resources such as vegetation and soil. Another modification is to adopt economic trees that are not too tall to forestall the negative effects of tall trees to the land through soil erosion while other functions such as tree density, leaf cover index, area covered by litters and surface cover index remain enhanced.

CONCLUSION

This study has confirmed that there exist relationships between the vegetation indices and land degradation for the peri-urban area of Kaduna metropolis to be inverse and they are consequently partly responsible for the land degradation in the area. It further brought to the fore the dynamic relationships that existed between the vegetation indices among themselves. Consequently, the study is recommending the adoption of agroforestry system of farming and landscaping in the regional planning for the area in order to improve the tree density. It is also advocated that shorter economic trees should be embraced so as to reduce the negative impactof rain water from very tall trees that could loosen the soil and cause soil erosion.

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