PRINT ISSN 1119-8362
Electronic ISSN 1119-8362

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://ww.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 25 (6) 1059-1064 June 2021

Human Settlements Interactions and Deforestation in Gambari Forest Reserve located in Oluyole Local Government Area (LGA) of Oyo State, Nigeria

***[1]TOYINBO, EO; [2]FASASI, RA; [1]AGBOR, CF; [2]FAKOREDE, CO**

*[*1]Environmental Modeling and Biometrics, Forestry Research Institute of Nigeria, Jericho Ibadan, Oyo State, Nigeria*
[2]Department of Social and Environmental forestry, University of Ibadan, Oyo State, Nigeria
**Corresponding Author Email: chukwuka_friday@yahoo.com; Tel: +234 814 705 7828, +234 805 544 6960*

ABSTRACT: This study was designed to examine changes in land cover types and the interaction of human settlements with the forest and impact of such interaction on the reserve. Community leaders and randomly selected community dwellers in each of the selected settlements were sampled for group discussion to obtain information on population and services of the forest that attract them to the reserve. Landsat images of 1984 and 2019 were used to extract land cover types using maximum likelihood classifier in Idrisi environment. The level of attractiveness and Interactions of the communities with the reserve were determined employing gravitational model. Results show that there was an increase in the size and number of settlements within the study area and decrease in in forest cover by 34% and 6.02% respectively. It was also revealed from the study that about 39% of the total area was taken over by development (building, roads and other classes) within the forest reserve, while 3% of the developed area gave way to forest cover. The degraded parts of the reserve in recent time was about 16% of the total reserve area and about 78% remained forest cover. From the results it is obvious that the level of interaction and imparts of such interaction depends on the community's population size rather than distance. It is therefore imperative to regulate the activities of adjoining communities and those within the Gambari forest reserve by appropriate authorities.

DOI: https://dx.doi.org/10.4314/jasem.v25i6.26

Dates: Received: 20 March 2021; Revised: 27 April 2021; Accepted: 07 May 2021

Keywords: Landsat images, Forest reserve's distance, Gravitational model, and Maximum likelihood

Forest can be defined as an intricate system made up of plants and trees that protect biodiversity, providing home to terrestrial biodiversity and improving the quality of life forms on earth (Popoola, 2014). The functionalities of forest ecosystems to the sustainability of the earth are quite diverse. They can be broadly categorized into environmental functions and socio-cultural/economic functions. Therefore, the depletion of forests all over the world is predicated on the services that are derivable from forests. Deforestation is basically the conversion of forested areas to non-forested land for several purposes basically agricultural, industrial and urbanization (Olagunju, 2015). The net loss of forest area has decreased substantially since 1990, but deforestation and forest degradation continue to take place at alarming rates resulting in significant loss of biodiversity (FAO, 2020). Ladipo (2010), put the rate of deforestation in the Country at between 250,000-350,000 ha or 3.5% per annum. Today, report by the United Nation's Food and Agriculture Organization, FAO (2010) on deforestation trend in Africa, revealed that Nigeria has lost more than half of her forests within the last fifty years making it one of the countries with the highest rate of deforestation in the world. The world's population is increasing at an alarming rate. For instance, in 2015 the world population was about 7.3 billion, and it is expected to reach 9.7 billion in 2050, and 11.2 billion in 20100 (UN 2015). Settlements that are contiguous to forests are usually parts of the driver variables when it comes to deforestation. People's relationships with forest biodiversity vary from region to region and country to country, and also differ widely depending on the context – from protected areas with limited human activities, to communities deep inside forests, to farmed and ranched landscapes, to towns and larger urban centers, to the world's largest cities (FAO, 2020). Small holder farmers collect fuel wood, construction materials, wild foods, and other forest products for subsistence (Nerfa *et al*. 2020). Forest exploitation to a large extent, is dependent on the daily needs of livelihood of communities living close to it. For instance, rural populations depend most fundamentally on forests in terms of subsistence, health, income and culture (Adebisi, 2008). These services notwithstanding, forests are now at risk of disappearing due to several anthropogenic activities. Many people have migrated from urban areas to establish new villages in tropical forests, because of rapid population increase in cities for the last several decades (Mackenzie *et al*., 2012). The rapid expansion of these existing communities into protected areas is expected to cause severe anthropogenic degeneration and fragmentation of natural forests, further deteriorating the forest structure and biodiversity of important natural tropical forests (Ellis *et al*., 2010). Agricultural expansion into the forest land, timber logging, charcoal production and firewood harvesting are the major drivers of deforestation in Africa (Muhati *et al.* 2018). Change detection is an important tool in investigating the extent of land cover loss and gain over time. This is because the extent and pattern of land use land cover change (LULCC) is an important supporting tool for decision making processes (Armenteras *et al*. 2019; Abebe *et al.* 2019). Substantial research has been conducted to investigate the extent of land use land cover change (LULCC) in several countries at various times (Ru-Mucova *et al.* 2018; Lei and Zhu, 2018). Detecting land use change over time has become increasingly important consideration for environmental management (Mensah et al. 2019). Changes in LULC can alter the supply of ecosystem services and affect the well-being of humanity (Rimal *et al.* 2019). From the existing land use land cover class, forest is the most threatened by anthropogenic driven deforestation (Fokeng *et al.* 2019). Methodologies to examine and quantify land use and land cover change (LULCC) have been evolving due to advances in remote sensing technology and the techniques used to combine these data with household survey data. In recent years, researchers in various academic areas, ranging from those who favor modeling (Han *et al.,* 2015), to those concerned with the causes and consequences of LULC dynamics (Porter-Bolland *et al*., 2007), have been greatly attracted to the issues of LULC changes. The consequence of this could be severe environmental degradation and low agricultural productivity, especially in sub-Saharan African countries, which are facing food insecurity problems. To examine the extent and impact of human settlements on forest in Gambari forest reserve, this study is therefore set to empirically evaluate the status of Gambari forest reserve and the imparts of surrounding settlements by assessing the forest cover changes of the forest reserve, attractiveness and interaction possibilities between the forest and surrounding communities.

MATERIALS AND METHOD

This study was carried out in Gambari Forest Reserve located in Oluyole Local Government Area (LGA) of Oyo state. The Forest Reserve is located within latitude 7^{o} 81’ N and 7^{o} 31’N; longitude 3^{o} 49’E and 3^{o} 221’E (Fig1). It lies within 17 km South-east of Ibadan on the Idi-Ayunre-Ijebu-Ode road, Oyo State (Haastrup *et al*, 2020). The adjoining communities considered for this study include those listed in table 4. The Gambari Forest Reserve was declared from Ibadan Forest Reserve by a resolution of the Ibadan city council passed in September 1899 (Ajibode, 2002). Both dry and wet season are experienced in the reserve. Dry season lasts for 3 months (December to February). The average annual rainfall is about 1140mm and average annual temperature is about 26.40 oC (800 F) (Larinde *et al*, 2011). The inhabitants of the area are predominantly farmers and hunters (Ajibode *et al*., 2002). Some of the forestry practice includes; Planting of trees for both timber and fuel wood production; Collection and sales of non-wood products such as leaves and bark for herbs, rattan (cane), One of the main feature of this forest is that most of the plants, climbers and epiphytes are woody and of the sizes of trees. The reserve provides 5 major NTFPs namely fuelwood, sponge, snails, leave and ropes. There is an outstanding diversity of flora and fauna.

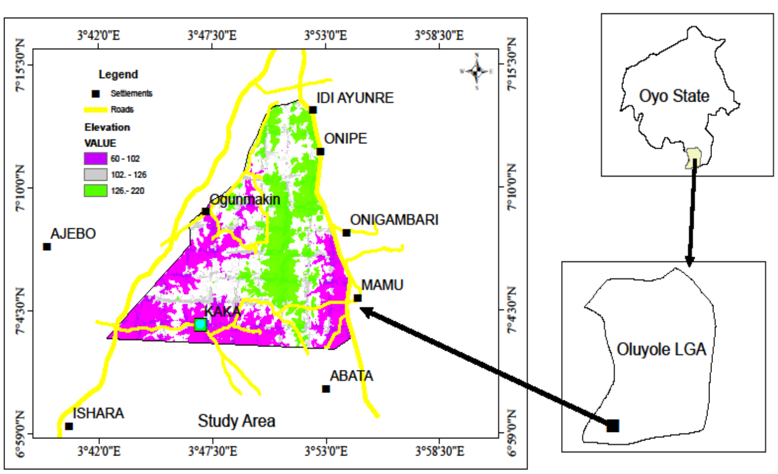


Fig 1. Gambari Forest Reserve

Data Collection: This study employed field and remote sensing data to achieve its objectives. The field data include direct Interview-Key Informant Interview (KII), with dwellers of selected adjoining communities and field observations. The remote sensing Landsat images of 191/55 path and row acquired from the official web site USGS were used to assess the status of forest cover in the reserve for 35years (from 1984 to 2019). The images were processed in Idrisi software environment to group the pixels into three broad classes: settlements, non-forest and forest areas using maximum likelihood classifier (Rawat *et al* 2015)). To ensure effective image classification no fewer than 30 pixels were selected randomly to produce a single class (John *et al*, 2006). Focused group discussions were used to obtain information from respondents in each of the eight selected communities around Gambari Reserve and a forestry personnel working within the reserve on his perceived pressure and threats posed by various human activities to the forest reserve. This made a total of 9 key informants who revealed the challenges faced by the communities and their needs. To estimate the population of the communities, buildings within an area of 0.01km^2 sample size randomly selected were counted with 20 buildings on the average.

Data analysis: This study used the gravity concept of Newtonian law to assess and analyze the degree of interactions between each of the selected settlements and the reserve. The law states that two bodies in the universe attract each other in proportion to the product of their masses and inversely to the square of their distance apart (Field *et al*, 1993).

$$F = \frac{Gm_1.m_2}{d^2} \qquad 1$$

Where F = Force of attraction between the two bodies; m_1 and m_2= Masses of the two bodies; d= distance between the bodies; G = gravitational constant.

In the application of the gravity concept to the analysis of forest-settlement interaction the F is the amount of interactions between the bodies (forest and settlement), m_1 and m_2 were measured in terms of sizes (population) of the ettlement and d= distance between them. Similarly,

$$I_{ij} = \frac{KP_i.P_j}{d^2{}_{ij}} \qquad 2$$

Where I_{ij} = interaction between i and j; P_i and P_j= sizes of i and j (population/); d_{ij}= distance between i and j; K= a gravitational constant determined empirically

The attractiveness of forest reserve to each settlement: William Reilly applied the Newtonian law in evaluating the attractiveness of two locations or say cities x and y to those people living between the cities. Given the situation of choice of movement faced by the dwellers living between the two cities x and y, the attraction of city x with population P_x to individuals at y location, distance d_x from x, will be (Field *et al*, 1993).

$$G_x = \frac{p_i}{d_{ij}^2} \qquad 3$$

Where G_x = the force of attraction of x to j

Similarly,

$$G_y = \frac{p_y}{d_{ij}^2} \qquad 4$$

Where G_y = The force of attraction of y to j

K is determined by equation 7 given,

$$E_{(T_{ij})} = \frac{\sum T_{ij}}{n} = \frac{K\sum_j^n P_i H_j}{d_{ij}^2} \Big/ n \qquad 5$$

Then,

$$\sum_j^n T_{ij} = \left(K\sum_j^n P_i H_j d_{ij}^{-2}\right) \qquad 6$$

Therefore,

$$k = \frac{\sum_j^n T_{ij}}{\sum_j^n P_i H_j d_{ij}^{-2}} \qquad 7$$

The possibilities of interaction between the forest and surrounding communities: This is the probability of interaction between the reserve and each of the communities. This is calculated using equation 8.

$$Pr_{ij} = \frac{p_i / d_{ij}^2}{\sum p_i / d_{ij}^2} \qquad 8$$

To calculate the distance d_{ij}, relative mean distance as crow flight was estimated from each settlement to the surrounding degraded (non-forest) areas. H_j is the number of services that attract such settlement to the reserve, P_i is the population of each settlement given a household threshold of six persons per resident (Banjo *et al*, 2018). The population of the selected settlements was estimated by dividing the size of each community by sample size multiplied by the household size (equation 9).

$$y_e = \frac{A.x}{S} \qquad \mathbf{9}$$

Where y_e is the estimated population, A as the area of each selected settlement, x is the household size and S is sample size.

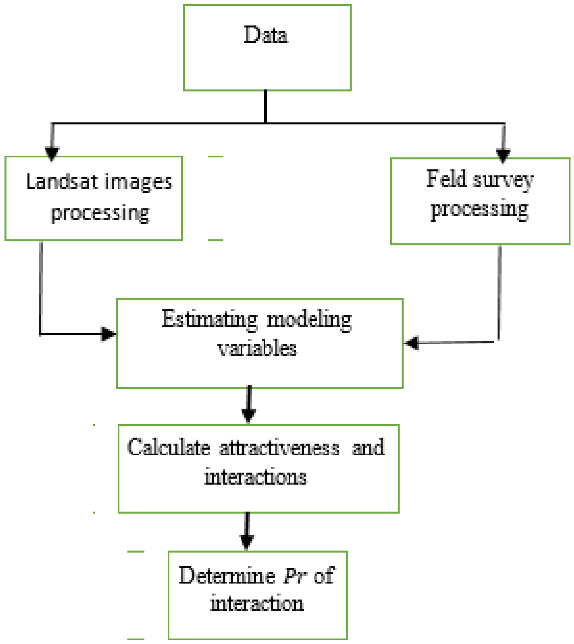


Fig 2. Flow chart for typical interaction model

RESULTS AND DISCUSSION

The distribution of settlements, non-forest and forest cover is shown and their changes are shown in tables 1 and 2 respectively. There was an increase in the size of settlements within the study area and decrease in forest cover by 34% and 6.02% respectively (figure 3). About 39% of the total area was taken over by development (building, roads and other classes) within the forest reserve, while about 3% of the developed area gave way to forest cover. The degraded parts of the reserve in recent time was about 16% of the total reserve area and about 78% remained forest cover. (Figure 4). Table 3 shows the calculated attractiveness, estimated population, forest services, degree of interactions and possibility of interaction and estimated distances from selected communities to the forest reserve with k as 0.095. Onigambari and Ogunmakin visit the forest for all the services, while Akaka and Ajebo are attracted to the forest for two services based on the information derived from field survey (Table 3). From figure 4, it is obvious that the interaction of the communities with the reserve is highly dependent on the services provided by the forest irrespective of the distances. As shown in figure 5. The level of attraction of the forest reserve has strong relationship of about 99% with the degree of interaction by the communities.

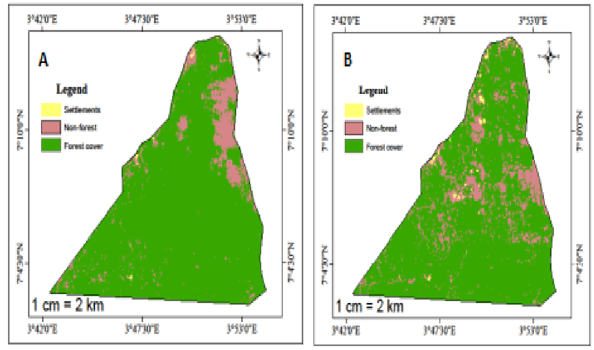
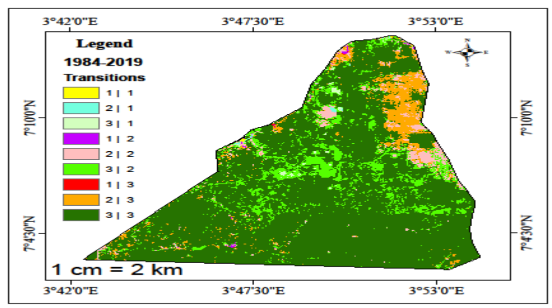


Fig 3. Land cover distribution in Gambari forest reserve in 1984(a) and 2019(b) respectively

Table 1: Land Cover statistics

LCT	1984		2019	
	Area (Km^2)	%	Area (Km^2)	%
Settlements	0.56	0.23	1.35	0.57
Non-Forest Cover	23.56	9.90	37.09	15.58
Forest Cover	213.90	89.87	199.58	83.85
TOTAL	238.01	100.0	238.01	100.0



1=Settlements, 2=Non-forest and 3=Forest cover

Fig 4. Land cover changes between 1984 and 2019 in Gambari forest reserve.

The results explain that distance is not a barrier in determining the influence of the communities on the forest reserve. The results also revealed in figure 7 that the interaction depends on the community's population size. With a strong relationship of about 95%. The correlation that the study has identified between the settlements' population and interaction seems to have led to the pressure of the communities on the reserve resulting into serious loss of forest cover to settlements and other activities as shown in table 3. Again, the high level of interaction with Ogunmakin must have caused the springing up of enclaves within the reserve area in recent years (figure 3b).

Table 2: Cross classification of 1984 and 2019 images.

Land Cover	Area (Km^2)	%
Settlements	0.14	0.06
Non-Forest to Forest	0.29	0.12
Forest to Settlements	0.92	0.39
Settlements to Non- Forest	0.35	0.15
Non-Forest	8.80	3.70
Forest to Non-Forest	27.94	11.74
Settlements to Forest	0.07	0.03
Non-Forest to Forest	14.47	6.08
Forest Cover	185.04	77.74

Table 3: adjoining communities and their statistics

Settlements	(T_{ij})	(P_i)	(H_j))	(D^2ij)	I_{ij}	Pr_{ij}
Idi- Ayunre	2790.2	1476	3	5.29	793.4	0.041
Onipe	51.9	600	3	11.56	14.8	0.001
Onigambari	49.97	840	5	16.81	249.9	0.001
Mamu	203.1	4680	4	23.04	812.5	0.003
Abata	1.06	120	4	112.4	4.3	0.00002
Akaka	1.09	120	2	110.3	2.2	0.00002
Ogunmakin	1349.5	1560	5	11.56	6745	0.02
Ajebo	67.5	1380	2	204.5	135	0.001
Ishara	106	1764	4	166.4	424.0	0.002
Total	4620.3	6816	32	656.5	-	-

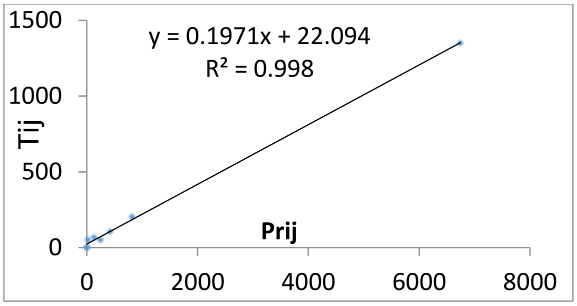


Fig 4. Relationship between attractions and interactions

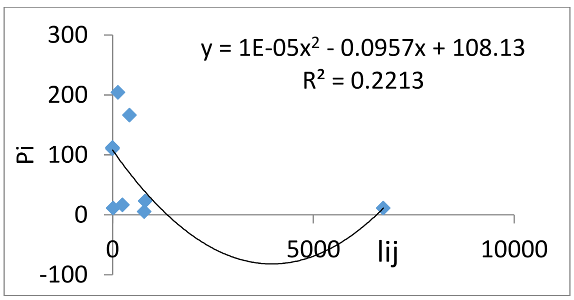


Fig 5. Relationship between interactions and distance

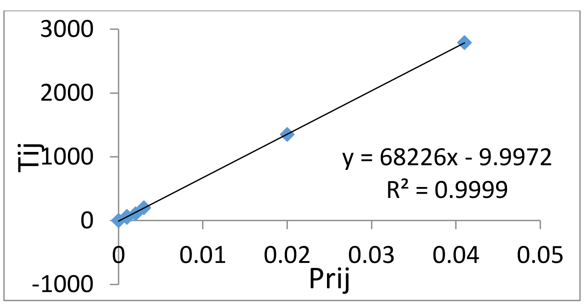


Fig 6. Probability of interactions and attractiveness

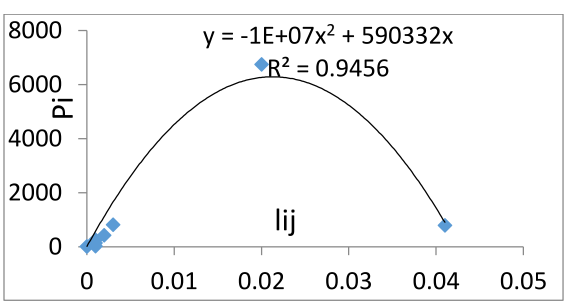


Fig 7. Population and interactions relationship

The transition of developed area to forest may not be unconnected to the efforts of the forest managers and other relevant authorities to discourage devastating human activities within the reserve (Faleyimu *et al*, 2012). The increase in the settlement area was so large that the impact represents an important fraction of deforestation within the forest reserve. This study equally identified that the possibility of the communities interacting with the forest for every forest service is very high and found an important effect of Idi-Ayunre and Ogunmakin settlements on deforestation. Quantitatively, the study also revealed that all the selected settlements are responsible for deforestation in the reserve, with Akaka and Abata with least possibilities.

Conclusion: This study depicts the relevance of geospatial techniques in assessing interactions between man and his environment. The results of this study show that all the communities selected are attracted to the forest for one service or the other at different degrees. It is also observed that interactions are not dependent on distance. The probability of interactions is generally low but relates strong with level of attractiveness, which means the communities' dwellers visit the reserve as much as they are attracted to it irrespective of distance, with population as the major determinant.

REFERENCES

Abebe MS, Derebew KT, Gemeda D.O (2019) Exploiting temporal-spatial patterns of informal settlements using GIS and remote sensing technique: a case study of Jimma City, Southwestern Ethiopia. Environ Syst Res. https://doi.org/10.1186/s4006 8-019-0133-5

Adebisi, L.A. (2008). Nature's Pharmacy in Man's Immediate Environment: Implicaations for Primary Health Care Delivery. 2007/2008 Faculty Lecture. Faculty of Agriculture and Forestry, University of Ibadan, 59pp.

Ajibode, M.O (2002).Wood species composition and regeneration potential of Onigambari Forest Reserve, Oyo state. A project submitted to the Department Forestry and Wildlife Management FUNNAB Pp.18.

Armenteras D, Murcia U, Gonzalez TM, Baron OJ, Arias JE (2019) Scenarios of land use and land cover change for NW Amazonia: impact of forest intactness. *Glob Ecol Conserv* 17:e00567

Banjo, A.A, Awe, F., Tokede, A.M., Oguntoye, T.O; Tewogbade, S.O (2018). Assessment of Factors Influencing Human Use of Gambari Forest Reserve in Oluyole Local Government Area of Oyo State. *J. For. Res. Manage.* 15(2). 44-55'

Ellis, E. C., Klein Goldewijk, K., Siebert, S., Lightman, D; Ramankutty, N. (2010). Anthropogenic transformation of the biomes, 1700 to 2000. *Global Ecol. Biogeogr.* 19**,** 589–606.

FAO. (2020). *State of the World's Forest.* Food and Agricultural Organization of the United Nations, Rome.

Field B, MacGregor BD (1993) Forecasting technique for urban and regional planning. Nelson Thornes Ltd, Cheltenham, United Kingdom

Field B, MacGregor BD (1993) Forecasting technique for urban and regional planning. Nelson Thornes Ltd, Cheltenham, United Kingdom

Faleyimu, OI; Agbeja B. O 92012). Constraints to Forest Policy Implementation in the Southwest Nigeria: Causes, Consequences and Cure. *Res. Environ.* 2(2): 37-44

Fokeng RM, Forje WG, Meli VM, Bodezemo BN (2019) Multi-temporal forest cover change detection in the Metchie-Ngoum Protection Forest Reserve. EJRS, West Region of Cameroon

FAO. State of the World's Forests, 2010. A global forest resource assessment report of the United Nation Food and Agriculture Organization. FAO 2010 Quarterly Bulletins on Forestry and Environment. 2010: 20-45.

Haastrup, N O; Agboje, I; Lawal, M O; Fadimu, B O; Sangotoyinbo, O A; Mangodo, C; 3oripelaye, O S; Ganiyu, O A; Fadoyin, A S (2020). Composition of Tree Species in Onigambari Forest Reserve, Oyo State, Nigeria. *J. Appl. Sci. Environ. Manage.* 24 (10) 1815-1819

Han, H.; Yang, C.; Song, J (2015). Scenario simulation and the prediction of land use and land cover changein Beijing, China. *Sustainability* 7, 4260–4279.

John A. Richards · Xiuping Jia, (2006). Remote Sensing Digital Image Analysis. Springer-Verlag Berlin Heidelberg, 2006

Larinde, S.L. and Olasupo, O.O. (2011). Socio-economic Importance of Fuelwood Production in Gambari Forest Reserve Area, Oyo State, Nigeria. *J. Agric. Soc. Res. 11(1):201-210*

Lei C, Zhu L (2018) Spatio-temporal variability of land use/land cover change (LULCC) within the Huron River: effects on stream flows. CRM 19:35–47

Ladipo D. The State of Nigeria's Forest. In 45 IITA Research to Nourish Africa. R4D REVIEW; 2010.

Mackenzie, C. A., Chapman, C. A. & Sengupta, R. Spatial patterns of illegal resource extraction in Kibale National Park, Uganda. *Environ. Conserv*. 39, 38–50 (2012).

Mensah AA, Sarfo DA, Partey ST (2019) Assessment of vegetation dynamics using remote sensing and GIS: a case of Bosomtwe Range Forest Reserve, Ghana. Egypt J Remote Sens Space Sci (TSI) 22(2):145–154

Muhati GL, Olago D, Olaka L (2018) Land use and land cover changes in a subhumid Montane forest in an arid setting: a case study of the Marsabit forest reserve in northern Kenya. *Glob Ecol Conserv* 16:e00512

Nerfa L, Rhemtulla JM, Zerriffi H (2020) Forest dependence is more than forest income: development of a new index of forest product collection and livelihood resources. *World Dev*. 125:104689

Olagunju, Temidayo Ebenezer (2015). Impacts of Human-induced Deforestation, Forest Degradation and Fragmentation on Food Security. *New York Sci. J* 8(1)

Porter-Bolland, L.; Ellis, E.A.; Gholz, H.L. Land use dynamics and landscape history in La Montana, Campeche, Mexico. Landsc. Urban Plan. **2007**, 82, 198–207.

Popoola, L. (2014). Imagine a Planet without Forest. An inaugural lecture delivered at the University of Ibadan on Thurday, 24 July, 2014. Ibadan University Press, Nigeria. ISBN: 978-978-8456-56-8.

Rawat J S, Kumar M (2015). Monitoring land use/cover change using remote sensing and GIS techniques: a case study of Hawalbagh block, district Almora, Uttarakhand, India. *Egypt J Remote Sens Space Sci.* https://doi.org/10.1016/j.ejrs.2015.02.002\

Rimal B, Sharma R, Kunwar R, Keshtkar H, Stork NE, Rijal S, Rahman SA, Baral H (2019) Effects of land use and land cover change on ecosystem services in the Koshi River Basin, Eastern Nepal. *Ecosyst Serv* 38:100963

Ru-Mucova SA, Filho WL, Azeiteiro UM, Pereira MJ (2018) Assessment of land use and land cover changes from 1979 to 2017 and biodiversity and land management approach in Quirimbas National Park, Northern Mozambique. *Africa. Glob Ecol Conserv* 16:e00447

United Nations Department of Economic and Social Affairs. 2015. The World Population Prospects: 2015 Revision. https ://www.un.org/en/devel opmen t/desa/publi catio ns/world -popul ation -prosp ects-2015-revis ion.html. Accessed 7 Aug 2019