© 2016 IJSRST | Volume 2 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Change Detection of Forestry Trees Sequestration of Carbon Dioxide is Falling : Case Study of Pasali-Kuje of the Federal Capital Territory, Nigeria

Badaru Yahaya Usman[*1], Nassir Yakubu Mohammed[2] Musa Yakubu[3]
[1]Remote Sensing Lab. Dept. of Geography, Federal University of Technology, Minna
[+1]School of Science and Technology, National Open University of Nigeria, Abuja
[2]DLN Tech & Consultants Limited, Abuja-Nigeria
[3]Department of Building, Ahmadu Bello University, Zaria-Nigeria

ABSTRACT

The forestry trees ability to sequester or remove carbon dioxide (CO_2) using geospatial and temporal analysis undergo critical evaluation. The removal of CO_2 by the Aspen and Pine trees species from the atmosphere during photosynthesis to form carbohydrates that are used in plant structure return oxygen back into the atmosphere as a by-product. Aspen Trees (species of the *Populus* Genus) and Pine trees (Species of the *Pinus* Genus) can be categorized into mature and the undergrowth of the mean average of 6m tall, stem-trunk of 0.35-0.55cm in diameter and circumference of 124cm, and the root areas spans between 9-15m^2. The studies was conducted in the month of May during the period of wet/rainy season and the percentage delineation of forest is estimated as 0.0904km^2 (92.02%) in 2008, 0.0769km^2 (83.98%) in 2012 and 0.0621km^2 (52.32%) in 2016. However, the study further states the actual arithmetic differences of 0.0283km^2 (40.67%) of forest areas that were removed accounting for 9.6tons of carbon dioxide expected to make the trees more resistant to extreme weather and improve photosynthesis. It is anticipated that remote-sensing data integrated from optical sensors could be used to supplement the study of sequestration or removal of carbon dioxide through the trees. It is therefore significant that government and relevant agencies adopts these findings to help in the monitoring, evaluating and control of future cutting down of trees. It's pertinent to conclude that cutting of trees is a serious threat for the climate and it could contribute to global warming.
Keywords : Change detection, CO_2, forestry trees, landsat-7 & 8 ETM+, OLI, TIRS

I. INTRODUCTION

Pacala and Socolow (2004), defines terrestrial sequestration as a means of using plants to capture CO_2 from the atmosphere and then storing it as carbon in the stems and roots of the plants as well as in the soil. However, sequestration does not store CO_2 as a gas rather stores the carbon portion of the CO_2. Forests are carbon central nervous system or stores (Apps, 1999). More importantly, forests produce oxygen (O_2) and store carbon dioxide in the form of carbon, which could help to control climate and play a huge role in the carbon cycle (Chatellier, 2010). According to David and Britton (2014), human carbon dioxide (CO_2) emissions is currently removed from the atmosphere through the allotropy of forest during photosynthesis, therefore, If the rate of forest absorption were to slow down, the rate of global warming would accelerate to establish an equilibrium. However, one-single mature tree can store 48Ibs (0.024tons) of CO_2 per year and give 260Ibs (0.13tons) of O_2 per year. In the same vein, forests can absorb 10 to 20 tons of carbon dioxide per hectare each year, through the process of photosynthetic conversion of starch, cellulose, lignin, and wooden biomass (Manguiat, *et al*. 2005).

A. Study Areas

The effective area under study is Pasali-Kuje of the Federal Capital Territory, lies within latitudes 8^{o}51′58.91″ N of the equator and longitudes 007^{0}14′39.37″ E (Figure 1). The study area is bordered to the north by Abuja Municipal Area Council, to the east by Nasarawa State, to the west by Gwagwalada

Area Council. The specific study area is situated at the southern part to the town of Kuje.

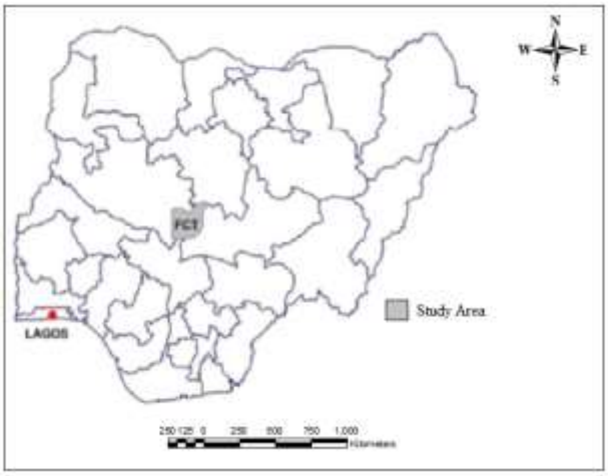

Figure 1: The study area

B. Aim and Objectives

The aim is to estimate the expected quantities of carbon dioxide (CO_2) from the fallen forestry trees using change detection techniques.

a) To demonstrate the ability of Landsat images in monitoring forestry trees
b) To identify changes in carbon cycle as purported by the reduction of forest using Landsat Satellite Imagery in Abuja

C. Related Literatures

The expected rate of carbon sequestration depends on the types, growth pattern and characteristics of the tree species of which (Rosenbaum, 2004) 20 to 50 years can be considered as the stages of maximum tree growth. In his experimental research on absorption and removal classification, McAliney (1993) pointed out that a single mature tree can store 21, 7724 kg (240 ton) of Carbon dioxide (CO_2) per year and give 118 kg (0.13ton) of Oxygen (O_2) per tree per year, therefore, the same single tree can absorb CO_2 at a rate of 0.024 tons (48 lbs) per year and release enough O_2 back into the atmosphere to support two human beings. When carbon dioxide (CO_2) builds up in the atmosphere, plants actually thrive, become larger, and are able to soak up more CO_2 (IPCC, 2011). According to CSIRO and CCS (2013) plants capture CO_2 to help them grow and then release oxygen as a waste product. However, remote sensing has a core occupation into the delineation of the study areas, therefore, Thanapura, et al. (2005) used satellite images combined with fieldwork and ground truthing to identify and estimate the distribution of land use and land cover.

II. METHODS AND MATERIAL

The methodology of research is principally by remote sensing and experimental research validation.

A. Landsat series

Landsat satellite images were used in these studies which are Landsat-7 ETM+ and Landsat-8 OLI/TIRS sensor images for 2008, 2012 and 2016. However, the reason for using these images from different Landsat sensors is due to the effectiveness of acquiring real image of the same sensor of the study area. The process and analyses of this image was done using ARCmap-10.1 and Erdas.

B. Method of Sequestration

To determine the total (green) weight of the tree: The trees with D greater than 11: $W = 0.25D^2H$, while trees with D greater and equal to 11: $W = 0.15D^2H$**,** where; W = Above-ground weight of the tree in pounds, D = Diameter of the trunk in inches, H = Height of the tree in feet and the coefficient constant of 0.25 (Alexander, et al. 1986).

To determine the dry weight of the tree: According to Scott, et al. (2005), the average tree is 72.5% dry matter and 27.5% moisture. Therefore, to determine the dry weight of the tree, multiply the weight of the tree by 72.5%.

To determine the weight of carbon in the tree: the average carbon content is generally 50% of the tree's total volume. Therefore, to determine the weight of carbon in the tree, multiply the dry weight of the tree by 50% (Richard, 1992).

To determine the weight of carbon dioxide sequestered in the tree: Carbon dioxide (CO_2) is composed of one molecule of Carbon and 2 molecules of Oxygen. The atomic weight of Carbon is 12.001115 and Oxygen is

15.9994, therefore, Weight of CO_2 is $C+O_2 = 43.999915$. However, the ratio of CO_2 to C is 43.999915/12.001115=3.6663.

To determine the weight of CO_2 sequestered in the tree per year: Divide the weight of carbon dioxide sequestered in the tree by the age of the tree (Richard, 1992).

III. RESULT AND DISCUSSION

A. Analysis of Third-order Delineation

The two images are multispectral and panchromatic images of the study area, these images are the result obtained from unsupervised classification and projection correction. The images clearly identify a lot of changes that has taken place; Active vegetation 52.32%, Grassland 16.33%, Clear land 10.14%, Bare land 10.27% and Built-up areas 10.94% (Figure 2).

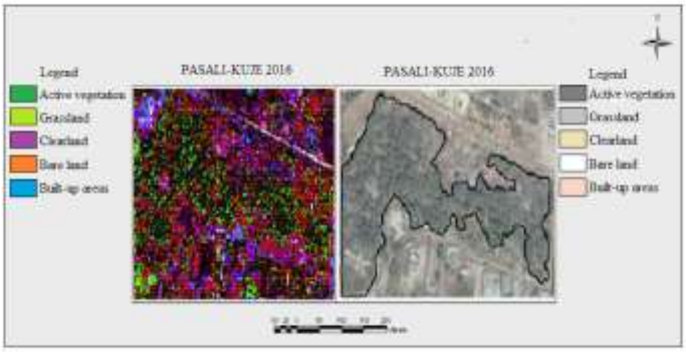

Figure 2: (a) Change detection (b) Delineation of protected forest area (1st of May, 2016) (Source: Author's fieldwork, 2012)

Table 1 indicates that in 2016, the remaining active forest existing within the study areas can be estimated to be $0.0621km^2$ accounting for vegetation 52.32%, built-up area 16.33%, grassland 10.14%, clear land 10.27% and bare land 10.94%.

Table 1: Percentage of land-use in 2016

Land cover	Descriptions	Area covered (%)
Vegetation	Areas covered with shrubs, forest woods, and other forms of vegetation	52.32
Built-up Area	Areas with local building such as clay, mud and sandcrete housing	16.33
Grassland	Areas covered with grass and other forms of grasses	10.14
Clear land	Clear Areas for farming and commercial	10.27
Bare land	Areas covered with access and commercial	10.94
Total		100.00%

B. Analysis of Second-order Delineation

The result of 2016 and 2012 varied greatly. The Figures 3 identify changes that have taken place in the month of May, 2016-2012; Active vegetation 83.98%, Grassland 4.03%, Clear land 1.10%, bare land 9.88% and Built-up areas 1.01%.

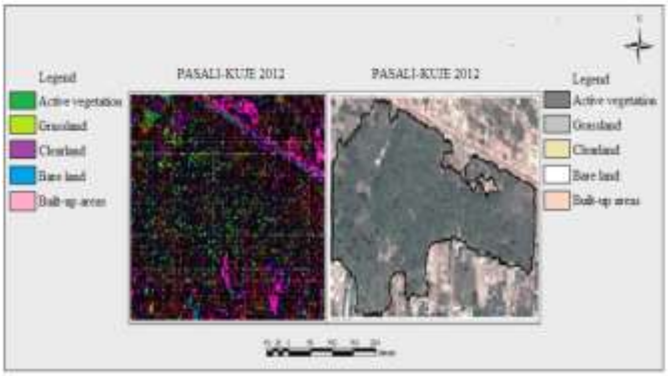

Figure 3: (a) Change detection (b) Delineation of protected forest area, 28th of May, 2012. (Source: Author's fieldwork, 2012)

Table 2 shows that in 2012, the existing forest covers $0.0768km^2$ land space accounting for vegetation 83.98%, built-up area 4.03%, grassland 1.10%, clear land 9.88% and bare land 1.01%.

Table 2: Percentage of land-use in 2012

Land cover	Descriptions	Area covered (%)
Vegetation	Areas covered with shrubs, forest woods, and other forms of vegetation	83.98
Built-up Area	Areas with local building such as clay, mud and sandcrete housing	4.03
Grassland	Areas covered with grass and	1.10

	other forms of grasses	
Clear land	Clear Areas for farming and commercial	9.88
Bare land	Areas covered with access and commercial	1.01
Total		100.00%

C. Analysis of First-order Delineation

Figures 4 identify changes that have taken place in the month of May, 2012-2008; Active vegetation 92.02%, Grassland 3.30%, Clear land 2.10%, bare land 1.50% and Built-up areas 1.08%.

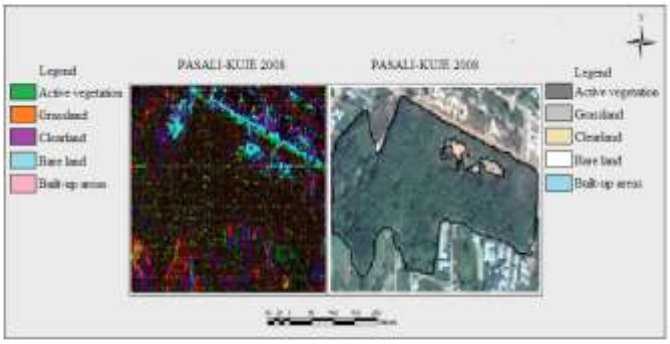

Figure 4: (a) Change detection (b) Delineation of protected forest area (12th of May, 2008) (Source: Author's fieldwork, 2012)

Table 3 indicates that in 2008, the entire forest covers $0.0904km^2$ accounting for vegetation 92.02%, built-up area 3.30%, grassland 2.10%, clear land 1.50% and bare land 1.08%.

Table 3: Percentage of land-use in 2008

Land cover	Descriptions	Area covered (%)
Vegetation	Areas covered with shrubs, forest woods, and other forms of vegetation	92.02
Built-up Area	Areas with local building such as clay, mud and sandcrete housing	3.30
Grassland	Areas covered with grass and other forms of grasses	2.10
Clear land	Clear Areas for farming and commercial	1.50
Bare land	Areas covered with access and commercial	1.08
Total		100.00%

D. The amount of CO_2 sequestered

The classified and estimated forestry trees are displayed in the qualitative formats indicating the study period of 8 year old. Based on the adequate prior knowledge of the study area, the ultimate calculation shows the best and better representation or results respectively (equation 1-6).The trees attain the height of about 6m or 19.7ft tall with a stem-trunk of about 0.45m (45cm) or 17.72inches in diameter.

Green weight above ground:

$$W = 0.25D^2 H \text{ ....eqn.1}$$
$$W = 0.25 (17.72^2) (19.7)$$
$$W = 0.25 * 314 * 19.7$$
$$W = 1546.44 \text{ lbs. } (0.7732 \text{ tons})$$

Green weight (roots included):
1546.44 lbs. * 120% ………….eqn.2
1855.73 lbs. (0.9279 tons)

Dry weight:
1855.73 lbs. * 72.5% …………eqn.3
1345.40 lbs. (0.6727 ton)
Carbon:
1345.40 lbs. * 50% …………eqn.4
672.70 lbs. (0.3364 ton)

CO_2 sequestered :
672.70 lbs * 3.6663…………eqn.5
2466.33 lbs. (1.2332 ton)

CO_2 sequestered per year:
2466.33 lbs. (1.2332 ton)/ 8 years……eqn.6
308.30 lbs. (0.1542)

Using the basis of 1000 tree per hectare, meaning 10 tons per hectare (McAliney, 1993)

Therefore,
0.0904km^2 equal 9.04 hectare, 0.0769 km^2 equal 7.69 and 0.0621 km^2 equal 6.21.

For 2008:
1000 * 9.04 = 9040 trees
0.1542*9.04*10 = 13.94 tons of CO_2 …eqn.7

For 2012:
1000 * 7.69 = 7690 tree
0.1542*7.69*10 = 11.86 tons of CO_2 …eqn.8

For 2016:
1000 * 6.21 = 6210 trees
0.1542*6.21*10 = 9.58 tons of CO_2…...eqn.9
therefore,

For the period 2008-2012:
13.98 -11.86 = 2.12 tons of CO_2

For the period 2012-2016:
11.86 - 9.58 = 2.28 tons of CO_2

Total arithmetic differences of 2008, 2012 and 2016:
4.40 tons CO_2 ………………………eqn.10

E. Change Detection

The table 4 shows the result obtained after running the change detection tool in Erdas. The arithmetic differences highlighting changes detected between 2016-2012 accounting for 31.66% and between 2012-2008 records 9.01%, while the total difference detected is 40.67%. These results, therefore, indicate that there are differential changes in vegetation during the period of 2008-2016.

Table 4: Percentage of Arithmetic Difference of 2008, 2012 and 2016

Years	Specific variables	% areal	Features	% Arithmetic's differences
2008	Vegetation	92.02	Polygonal	9.01%
2012	Vegetation	83.98	Polygonal	31.66%
2016	Vegetation	52.32	Polygonal	40.67%

E. Discussions

This result has shown that, a single tree can store 308.30 lbs. (0.1542 ton) of Carbon dioxide (CO_2) per year, clearly indicate satellite imageries having a capacity to calculate, identify and enumerate forestry changes. However, the second aspect of the research premises on the carbon dioxide sequestration through the forest tree of which in 2008 13.94 tons of CO_2 is absorb. While, in 2012 and 2016, 11.86 and 9.58 tons of CO_2 is also absorb respectively. Therefore, the result shows the extent of reduction of the forest rates and sizes based on the delineation of the forest areas using satellite imagery. This study also reveals the trend in forest trees reduction from the year 2008 (92.02%), 2012 (83.98%) and 2016 (52.32%) accounting for arithmetic differences of 40.67%. Therefore, the period of 2016 witness the worst forest tree reduction of the CO_2 absorption rate of 9.58 tons, 11.86 tons in 2012 and 13.94 tons for the period of 2008.

IV. CONCLUSION

However, the conclusion drowns from this study shows that, forestry trees as we know, are renewable resource, sustainable management allows regeneration of the forest and ensures that the forest carbon rebuilds. The result of this study has shown clearly that Landsat satellite imageries have a capacity to identify changes resulting from the cutting down of trees. Although forests alone can't sequester all of the excess carbon added by burning fossil fuels, they can make a difference, especially if we help and encourage them. Wisely managed forests can sequester carbon and also provide a sustainable source of fuel and lumber, help clean our air and water, preserve wildlife habitat, provide recreation opportunities and preserve the beauty of trees in their natural home for generations to come.

V. ACKNOWLEDGMENT

We would like to acknowledge the Almighty Allah for giving us the strength, capacity and knowledge. Our appreciation also goes to staffs of the DLN and YAMIZA, Abuja-Nigeria for assisting with attribute data of the study area, their educative contributions and concern towards this journal particularly in the provision of image classification algorithms.

VI. REFERENCES

[1] Alexander, C., Joseph, R., Saucier, W. & Henry, M. (1986). “Total-Tree Weight, Stem Weight, and Volume Tables for Hardwood Species in the Southeast, “Research Division, Georgia Forestry Commission.

[2] Apps, M.J., Kurz, W.A., Beukema, S.J., Bhatti, J.S (1999). Carbon budget of the Canadian forest product sector. Environmental science and policy.2 (25), 41

[3] Chatellier, J. (2010). The Role of Forest Products in the Global Carbon Cycle: From In-Use to End-of-Life (PDF). Yale School of Forestry and Environmental Studies.

[4] Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Global CCS Institute (2013). "Introduction to Carbon Capture and Storage - Carbon storage and ocean acidification activity"

[5] David, S. & Britton, S. (2014). NASA's Jet Propulsion Laboratory, Pasadena, California. Schimel is lead author of a paper on the new research, appearing online in the Proceedings of National Academy of Sciences.

[6] IPCC (2011). Special Report Carbon Dioxide Capture and Storage Summary for Policymakers". Intergovernmental Panel on Climate Change.

[7] Pacala, S. & Socolow, R. (2004). Stabilization wedges-solving the climate problem for the next 50years with current technologies: Science, V. 305, 968-972

[8] Manguiat, M. S. Z., Verheyen, R., Mackensen, J. & Scholz, G. (2005). "Legal aspects in the implementation of CDM forestry projects" IUCN Environmental Policy and Law Papers. 59.

[9] McAliney, M. (1993). Arguments for Land Conservation: Documentation and Information Sources for Land Resources Protection. Sacramento, CA: Trust for Public Land.

[10] Richard, A.B. (1992). “Carbon Storage and Accumulation in United States Forest Ecosystems, General Technical Report W0-59,” United States Department of Agriculture Forest Service, Northeastern Forest Experiment Station, Radnor, PA.

[11] Rosenbaum, K. L., Schoene, D. & Mekouar, A. (2004). "Climate change and the forest sector. Possible national and subnational legislation". FAO Forestry Papers. 144.

[12] Scott, D., Scott, J. & Becky, E. (2005). “Heating With Wood: Producing, Harvesting and Processing Firewood,” University of Nebraska Lincoln Extension, Institute of Agriculture and Natural Resources

[13] Thanapura, P., Burkhard, S., O’Neil, M., Glaster, D., & Warmath, E., (2005). Mapping Urban Land Use/Land Cover Using QuickBird NDVI Imagery for Runoff Curve Number Determination. PECORA 16 Symposium Tech. Session and Schedule, Oct. 25th. USGS Center for Earth Resources Observation and Science (EROS).