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# MAPPING FOREST LOSS AND CARBON-DIOXIDE SEQUESTRATION RATE BETWEEN 2000 - 2015 USING REMOTE SENSING IN AKPAKA FOREST RESERVE, ONITSHA NORTH L.G.A OF ANAMBRA STATE

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**ABSTRACT:** *This study investigated the extent of forest resource loss in Akpaka Forest Reserve through mapping forest loss and rate of carbon-dioxide sequestration from year 2000-2015 using remote sensing. To map forest loss in the study area between year 2000 - 2015, four Land-sat images (Land-sat 8 thematic mapper; Land-sat 7 enhanced thematic; Land-sat 8 operational and Imagery covering four epochs years 2000, 2005, 2010 and 2015 respectively) were downloaded from www.earthexplorer.usgs.gov. Image pre-processing was done to correct for atmospheric errors and scan line errors, after which an image subset was done to cut out the extent of open forest, water body and built up areas from the images. Normalized differential vegetation index was calculated from the red and near infra-red bands of the Land-sat images and used to determine carbon-dioxide sequestration in open forest in the study area. Results showed that in year 2000 open forest; water body and built up area covered 49.19%, 13.04% and 37.77% of the study area respectively. In year 2005, open forest water body and built up area covered 45.78%, 13.31% and 40.50% respectively. In year 2010 open forest was 43.81%, water body was 13.39%, and built up area was 42.80%. In year 2015 open forest decreased further to 41.97%, water body was 13.43% and built up area increased to 44.60%. This implies that there was a continuous loss of forest resources in the reserve while built up area increased steadily. Rate of carbondioxide sequestration indicated that for open forest 11.13kg/ha of carbon dioxide sequestrated between 2000 and 2005; 10.66kg/ha between 2005 and 2010 and 10.54kg/ha between 2010 and 2015. This implies that rate of carbon dioxide sequestration for the period under study is on steady decline due to forest loss and upsurge of built up area in Akpaka Forest Reserve. The study recommended Protection, Production and Legal Initiatives as means of preventing and repairing forest loss in the study area among other suggestions.*

**KEY WORDS**: forest reserve, forest loss, environment, carbon sequestration

## INTRODUCTION

Akpaka Forest Reserve in Onitsha North L.G.A. of Anambra State has been exposed to extreme pressure as a result of increasing urbanization and uncoordinated developments. Forest loss through deforestation started in the reserve in the year 1995 and has continued even in recent time. Portions of the land were sold out bit by bit until the major Land use of the area was transformed from a densely forested area to a built up area. The quest to make more space available for housing due to increasing population and enrichment of a few individuals through sales of land led to massive forest loss in the forest reserve. This loss resulted to several environmental problems in

the area, among which are degradation of land through erosion, flooding, change in local climatic condition, change in soil quality, siltation of the famous Nkissi River, extinction of both plant and animal species. Human interference on Akpaka Forest Reserve has destabilised ecological balance that existed in the reserve in the past. The aim of this study is to find out the extent of forest loss in the study area through mapping forest loss and carbon dioxide sequestration rate between year 2000 and 2015 using remote sensing.

## METHODOLOGY

To map forest loss in Akpaka Forest Reserve between 2000 and 2015, four Landsat images (Landsat 5 Thematic Mapper, Landsat 7 Enhanced Thematic Mapper and landsat 8 Operational Land Imager covering four epochs 2000, 2005, 2010 and 2015 respectively were downloaded from www.earthexplorer.usgs.gov. Image preprocessing was done to correct for atmospheric errors and to correct for scan line error for Landsat 7 Enhanced Thematic Mapper for 2005 and 2010 after which an image subset was done to cut out the extent of the study area from the images.
To effectively map the landcover/landuse distribution in Akpaka forest reserve, a classification scheme level 1 was developed for the study area after Anderson *et al* (1967), this was due to the resolution of the images and to ensure that the features are discriminated adequately. The next process was to identify the class features on the scene before following a familiarization visit to the site. Thus, the following class features in Akpaka forest reserve were identified and defined according to level I classification scheme, t

1. open Forest
2. water Body
3. Built up area

A method of calculating and comparing the area of the resulting landcover/landuse types of each year by Long *et al* (2007) was adopted for data analysis. The comparison of the land cover/land use statistics will assist in identifying the percentage change, trend and rate of change between 2000 and 2015. To determine the rate of change of landcover/landuse change, the year period 2000-2015 was divided into three sub-periods 2000 - 2005, 2005 – 2010 and 2010 – 2015, and then compared against each other.

The comparative analysis in landcover/landuse change focuses on the three sub-periods and the spatial distribution of the average (annual) rate of land cover/land use change between the three periods, (Long *et al*, 2007).
Percentage change to determine the trend of change was calculated by dividing the observed change by the sum of the area of the particular landcover/landuse type in that period multiplied by 100

(Trend) % change = Observed change x 100

Total Area

Where Observed change = (Area of before year – Area of after year)
Total Area = Sum of the total area of both years
The annual percentage rate = Trend divided by N. where N= (number of years).
A trend percentage with a positive value means that the landcover/landuse type has increased over the period of years while a negative value shows a decrease in the landcover/landuse type over a period of time.
In order to calculate carbon sequestration in open forest in Akpaka forest reserves, normalized differential vegetation index was calculated from the red and near infrared bands of the LANDSAT images. The normalized differential vegetation index (NDVI) is a standardized vegetation index which was calculated using the formula.

NDVI = (NIR – RED) / (NIR + RED)

Where:
RED= Digital No values from the RED band

NIR= Digital No values from Near-Infrared band

After which net primary production of open forest was calculated with

NPP = APAR * LUE

Where,
NPP = net primary production

APAR = Absorbed Photo-synthetically Active Radiation

LUE = Light Use Efficiency factor

PAR = Photo-synthetically Active Radiation

Having calculated the NDVI and NNP, a method of calculating carbon sequestration associated with vegetation NPP was used. NPP, a key component of the terrestrial carbon cycle, that represents the net carbon accumulation by the stand and accounts for most of the annual carbon fluxes between the atmosphere and biosphere by (Pavel and Martin, 2009) was adopted and calculated using the formula of photosynthesis is as follows:

$$CO2(264g) + H2O(108g) \rightarrow C6H12O6\,(180g) + O2(193g) \rightarrow Amylase\,(162g)$$

As shown in the Equation, plants absorb 6772cal solar energy and 264 g CO2 for producing 193g O2 and 162g dry material stored as fibre and starch in the plants (GuoZW et, al. 2001). And at a molecule level, the ratio of carbon, hydrogen and

oxygen of vegetation fibre is 1.5:2:1 and most trees keep the same ratio (Raj and Venkata, 2017). On the basic of relative atomic mass of carbon, hydrogen and oxygen, the carbon sink which equals to half of the forest biomass volume was estimated as in (Brown and Lugo, 1984), a ratio of 0.5 adopted from (GUO, 2010) was used to convert biomass to carbon storage for the study area

## RESULT AND DISCUSSION

### Extent of Landcover/Landuse of Akpaka in 2000

The landcover/landuse distribution of Akpaka in 2000 as shown in figure 1.1 and table 1.1 indicate that open forest accounted for the largest land cover/use with 49.19% and an area of 9543 hectares. Built up area had 37.77 % and a coverage area of 7327 hectares. Water body had the lowest turnout with 13.04% with an area of 2530 hectares.

Table 1.1: Landcover/Landuse distribution for Akpaka in 2000

| Class Name | Area (Hectares) | Percentage |
|---|---|---|
| Open Forest | 9543.00 | 49.19 |
| Water body | 2530.00 | 13.04 |
| Built Up Area | 7327.00 | 37.77 |
| Total | 19400.00 | 100.00 |

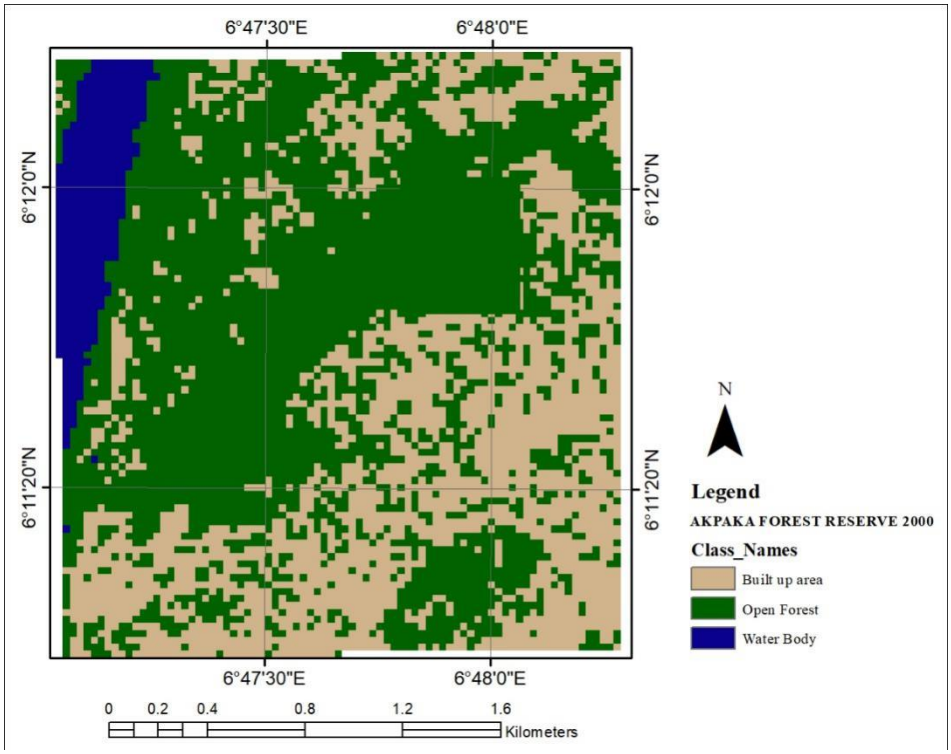



Figure 1.1: Landcover/landuse map of Akpaka Forest Reserve 2000

**Extent of Landcover/Landuse of Akpaka in 2005**

The landcover/landuse distribution of Akpaka in 2005 as shown in figure 1.2 and table 1.2 indicated that open forest decreased to 45.78% to an area of 8882 hectares. While built up area increased to 40.90% to a coverage area of 7935 hectares. Water body also increased slightly to 13.31% with an area of 2583 hectares.

Table 1.2: Landcover/Landuse distribution for Akpaka in 2005

| Class Name | Area (Hectares) | Percentage |
|---|---|---|
| Open Forest | 8882.00 | 45.78 |
| Water body | 2583.00 | 13.31 |
| Built Up Area | 7935.00 | 40.90 |
| Total | 19400.00 | 100.00 |

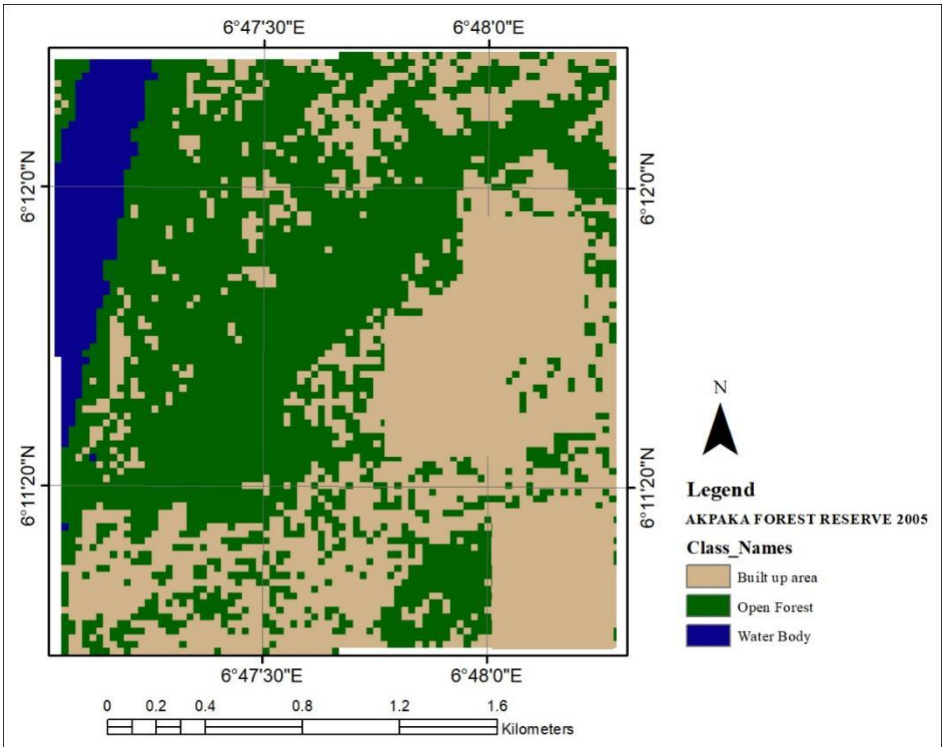



Figure 1.2: Landcover/landuse map of Akpaka Forest Reserve 2005

**Extent of Landcover/Landuse of Akpaka in 2010**

The landcover/landuse distribution of Akpaka in 2010 as shown in figure 1.3 and table 1.3 also indicated that open forest decreased further to 43.81% to an area of 8499 hectares. While built up area increased to 42.80% to a coverage area of 8303 hectares. Water body also increased slightly to 13.39% with an area of 2598 hectares.

Table 1.3: Landcover/Landuse distribution for Akpaka in 2010

| **Class Name** | **Area (Hectares)** | **Percentage** |
|---|---|---|
| Open Forest | 8499.00 | 43.81 |
| Water body | 2598.00 | 13.39 |
| Built Up Area | 8303.00 | 42.80 |
| Total | 19400.00 | 100.00 |

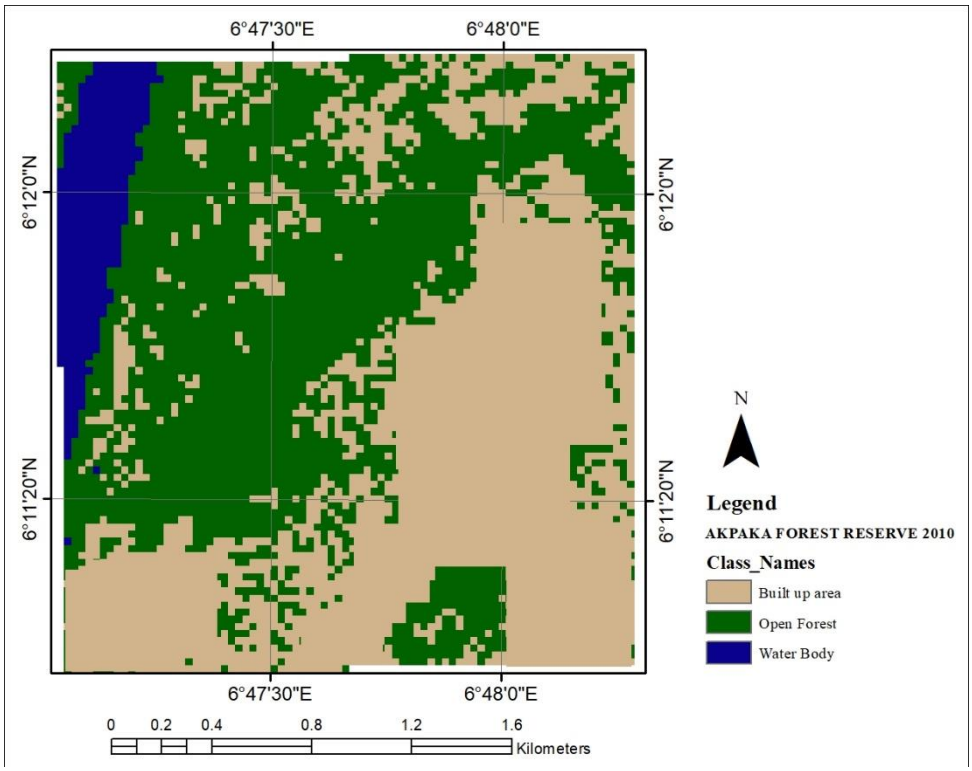



Figure 1.3: Landcover/landuse map of Akpaka Forest Reserve 2010

**Extent of Landcover/Landuse of Akpaka in 2015**

The landcover/landuse distribution of Akpaka in 2015 as shown in figure 1.4 and table 1.4 also indicated that open forest decreased further to 41.97% to an area of 8143 hectares. While built up area increased to 44.60% to a coverage area of 8652 hectares. Water body also increased slightly to 13.43% with an area of 2695 hectares.

Table 1.4: Landcover/Landuse distribution for Akpaka in 2015

| Class Name | Area (Hectares) | Percentage |
|---|---|---|
| Open Forest | 8143.00 | 41.97 |
| Water body | 2605.00 | 13.43 |
| Built Up Area | 8652.00 | 44.60 |
| Total | 19400.00 | 100.00 |

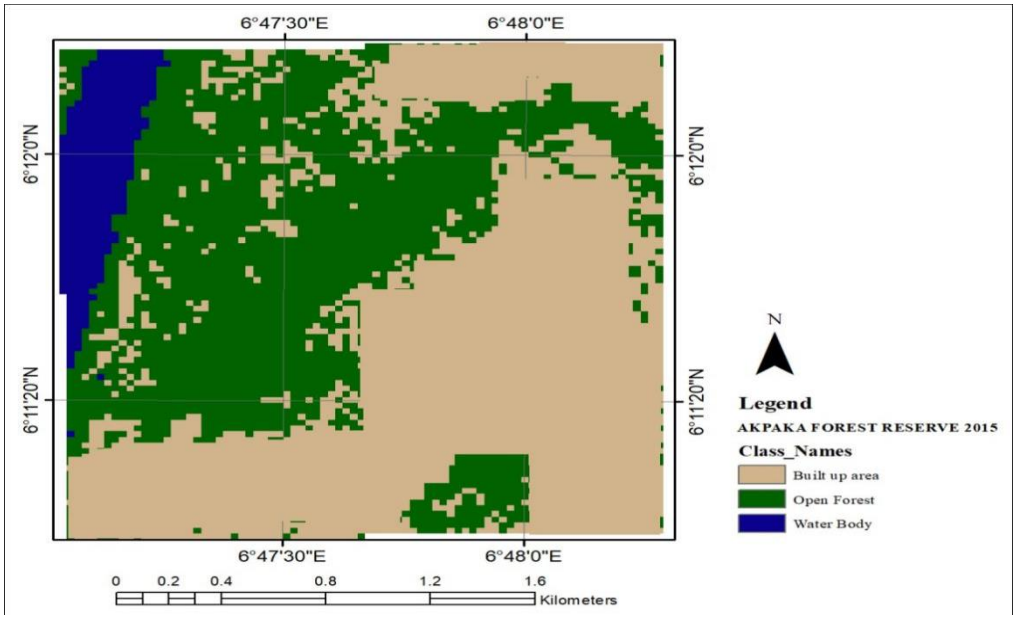
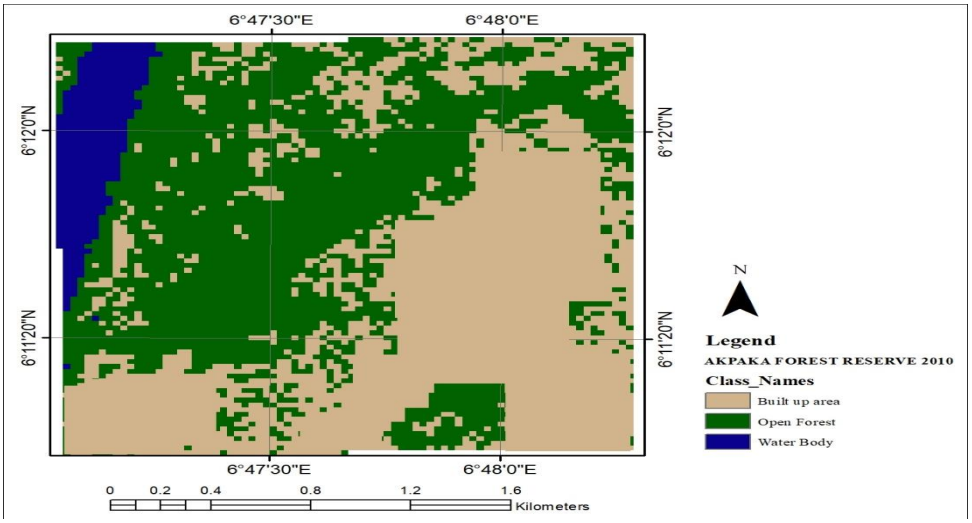



Figure 1.4: Landcover/landuse map of Akpaka Forest Reserve 2015




The annual rate of change between 2000 and 2015 in open forest was given as 0.72% between 2000 and 2005, -0.44% between 2005 and 2010 and -0.43% between 2010 and 2015. For built up area, the annual change rate was given as 0.80% between 2000 and

2015, 0.45% between 2005 and 2010, and 0.41% between 2010 and 2015. For waterbody, the annual rate of change was given as 0.21% between 2000 and 2005, 0.06% between 2005 and 2010 and 0.03% between 2010 and 2015, these results are illustrated in table 1.5 and fig 1.6

Table 1.5: Annual rate of change 2000-2005

| **Class Name** | **Annual Rate of Change 2000-2005** | **Annual Rate of Change 2005-2010** | **Annual Rate of Change 2010-2015** |
|---|---|---|---|
| Open Forest | -0.72 | -0.44 | -0.43 |
| Water body | 0.21 | 0.06 | 0.03 |
| Built Up Area | 0.80 | 0.45 | 0.41 |

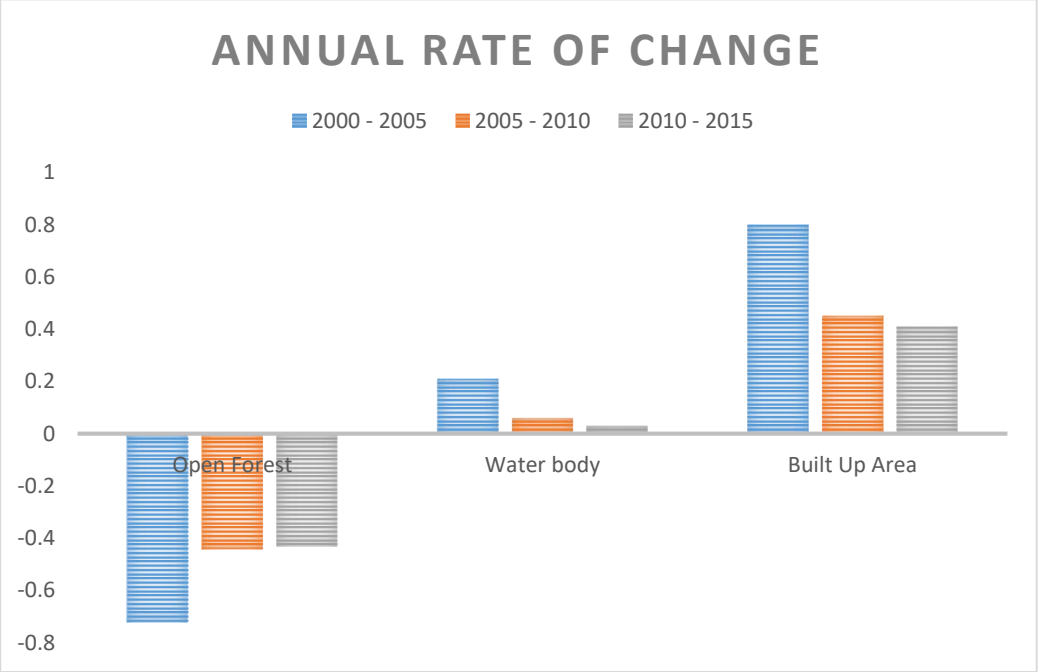



Fig 1.6: Annual rate of change of landcover/landuse in Akpaka forest reserve between 2000 and 2015

**Carbon Dioxide Sequestration**

The results obtained from analyzing amount of carbon dioxide sequestrated between 2000 and 2015, indicated that for open forest biomass, 957 kg/ha of $CO_2$ was sequestered in 2000, 763 kg/ha of $CO_2$ sequestered in 2005, 669 kg/ha of $CO_2$ sequestered in 2010 and 601 kg/ha of $CO_2$ sequestered in 2015, as illustrated in table 1.7 and fig 1.7, this means that the total amount of $CO_2$ sequestered between 2000 and 2015 was 1720 kg/ha between 2000 and 2005, 1432 kg/ha between 2005 and 2010 and 1270 kg/ha between 2010 and 2015, indicating a decline in the amount of carbon dioxide removed from the atmosphere within Akpaka Forest Reserve.

Table 1.7: Amount of Carbon Sequestrated from Forest Reserves between 2000 and 2015

| | Amount of Carbon Dioxide Sequestration between 2000 and 2015 in Akpaka Forest Reserve | | | |
|---|---|---|---|---|
| Class Name | 2000 | 2005 | 2010 | 2015 |
| Open Forest | 957 Kg/ha | 763 Kg/ha | 669 Kg/ha | 601 Kg/ha |

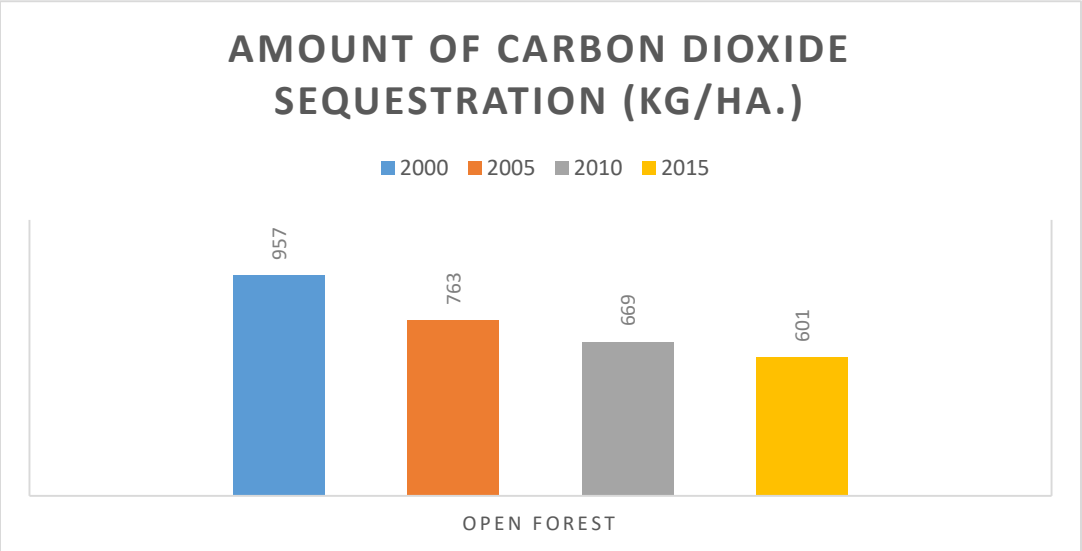



**Fig 1.7: Amount of $C0_2$ sequestration between 2000 and 2015 in Akpaka Forest Reserve**

**Annual Rate of Carbon Dioxide Sequestration Between 2000 and 2015**

The results from analyzing the annual rate of $CO_2$ sequestration between 2000 and 2015 indicated that for open forest, 11.13 kg/ha of $CO_2$ was sequestered annually between 2000 and 2005, 10.66 kg/ha between 2005 and 2010 and 10.54 kg/ha between 2010 and 2015, this implies that the rate of carbon dioxide sequestered annually is on steady decline due to the deforestation activities and the up surge of built up areas in Akpaka Forest reserve. These results are illustrated in table 1.8 and fig 1.8

Table 1.8: Rate of Carbon Sequestration in Akpaka Forest Reserve

| Rate of Carbon Sequestration | 2000-2005 | 2005-2010 | 2010-2015 |
|---|---|---|---|
| Open Forest | 11.13 | 10.66 | 10.54 |

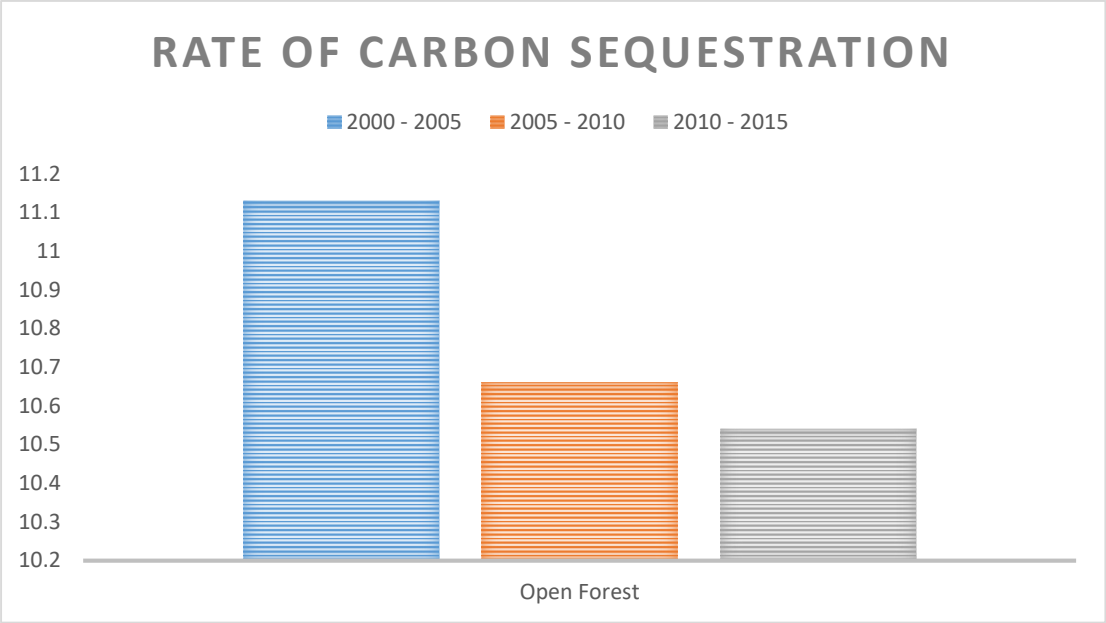



Fig 1.8 Annual rate of $CO_2$ sequestration between 2000 and 2015

**Recommendations**

Considering the various benefits of forest resource to man and the environment and the role of forest in combating the problem of climate change through carbon sequestration, it is imperative to find a sustainable solution to forest loss. This study categorised management procedures of Forest Reserve Loss into Protection, Production and Legal initiative. Protection involves guarding the remaining part of the reserve from further loss. Production means massive planting of new trees to replace the lost ones and Legal initiative implies enactment, implementation and adequate enforcement of forest policies in affected areas. These categories are further resolved into other factors as shown below-

**Protection** involves community participation; awareness; poverty alleviation; population control; use of advanced technology for monitoring e.g GIS.

**Production** involves re-afforestation programmes; recycling,re-use and reduction as alternatives; plant a tree initiatives; already existing structures should plant at least four trees around it with flowers.

**Legal Initiatives** involves enactment, implementation and adequate enforcement of forest policies; amendment of existing laws that has no impact on forest conservation; sustainability should be the guide for all forest actions.

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