An Assessment of Forest Loss Using Remote Sensing in Akpaka Forest Reserve Onitsha North L.G.A. of Anambra State, Nigeria

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Abstract: Akpaka community in Onitsha North Local Government Area, Anambra State of Nigeria emerged from the ancient city of Onitsha. Population rise and economic/urban growth in Onitsha city forced housing development to extend into Akpaka Forest Reserve (AFR). However, there is no up to date information on forest resources loss in Akpaka Forest Reserve. Investigations at the Local Government Administrative Head Quarters revealed that there are no statistics on spatial extent of forest loss in the reserve for planning, policy formation, re-formation and further decision making. Hence, this study assessed the spatial extent of forest loss in Akpaka Forest Reserve (AFR), Onitsha North Local Government Area of Anambra State Nigeria to cover that gap. The study used Remote Sensing to map and determine the spatial extent of forest loss in AFR from year 2000-2020. To map forest loss in Akpaka forest Reserve between 2000 and 2020, four Landsat images (Landsat 5 thematic mapper, Landsat 7 enhanced thematic mapper, Landsat 8 operational, and imager covering years 2000-2005, 2005-2010, 2010-2015, 2015-2020, were downloaded from www.earthexplorer.usgs.gov. Image pre-processing was done to correct for atmospheric errors and to correct for scan line error in the Landsat 7 enhanced thematic mapper for 2005 and 2010 using focal statistics. To effectively map the Landcover/Landuse distribution in Akpaka forest reserve, a classification scheme level I was developed for the study due to resolution of images and to ensure that the features are discriminated adequately. The next process was to identify the class features on the scene before going for a familiarization visit to the site. Thus, open forest, water body and built up area were identified and defined according to level I classification scheme. Result showed a continuous decline in forest cover, increase in built up area and slight decline in water body for the period studied. For year 2000, 2005, 2010, 2015 and 2020 forest cover showed 49.19%, 45.78%, 43.81%, 41.97% and 37.05% respectively. Built up area showed 37.77%, 40.90%, 42.80%, 44.60%, and 49.53% for year 2000, 2005, 2010, 2015 and 2020 respectively. This study made recommendations which include-use of advanced technology for monitoring and evaluation, community participation, institutional strengthening, public awareness and re-afforestation programmes.

Keywords: Forests, Forest Resources, Forest Loss, Conservation, Land Use

1. Introduction

Akpaka community emerged from the ancient Onitsha city. Population rise and economic/urban growth in Onitsha North L.G.A forced housing development to extend into Akpaka Forest Reserve [1]. The entire Akpaka community used to be a forest reserve originally. The British colonial administration spearheaded the creation of the reserve to conserve nature and also maintain equilibrium in the environment and for posterity too. However as time went on, humans started encroaching upon the forest reserve, and today the forest reserve has become a shadow of itself. The benefits of forest to the environment have been under estimated over the years [2]. Forests play major role in the resilience and green growth of local, national and world economy [3]. Forests help maintain conditions that makes life possible, from regional hydrological cycle to global climate change [4]. Forests products provide medicinal

plants and forests serve as home to millions of biological species [5]. Forests conserve biodiversity. Carbon oxidises with oxygen to form carbon dioxide which is a green-house gas in the atmosphere with a net effect of global warming [6], forests fights this process by absorbing carbon from the atmosphere through the process of photosynthesis. Forest resource are important tool for combating global warming [7]. Forests also regulate the water cycle by absorbing and re-distributing rain water [8]. Forests are a vital tool in fighting air pollution and consequently global warming [9]. The benefit of Forests to man and his environment can never be over emphasized; hence some areas are mapped out as forest reserves. The annual cost of forest loss globally is between two trillion dollars and five trillion dollars [10]. This was calculated by taking into account the various functions that forest perform [11]. Africa has the largest annual rate of forest loss from 2010 to 2020 [12]. Forest loss in Africa is at 3.9 million/ha [13]. The aim of this study is to investigate the loss of forest cover in Akpaka Forest Reserve (AFR) with the objective of determining the spatial extent of forest loss in AFR from 2000-2020 using Remote Sensing and to suggest measures for preventing human encroachment on other Forest Reserves within the study area.

2. Methodology

To map and determine spatial extent of forest loss in Akpaka forest Reserve between 2000 and 2020, four Landsat images (Landsat 5 thematic mapper, Landsat 7 enhanced thematic mapper, Landsat 8 operational, and imager covering 2000-2005, 2005-2010, 2010-2015, 2015-2020) were downloaded from www.earthexplorer.usgs.gov. Image pre-processing was done to correct for atmospheric errors and to correct for scan line error in the Landsat 7 enhanced thematic mapper for 2005 and 2010 using focal statistics. To effectively map the land cover/land use distribution in Akpaka forest reserve, a classification scheme level I was developed for the study after [14], 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,

1. Open forest
2. Water body
3. Built up Area

3. Result and Discussion

3.1. Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve in 2000

The landcover/landuse distribution of Akpaka in 2000 as shown in figure 1 and table 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 *Landcover/Landuse distribution for Akpaka Forest Reserve in 2000.*

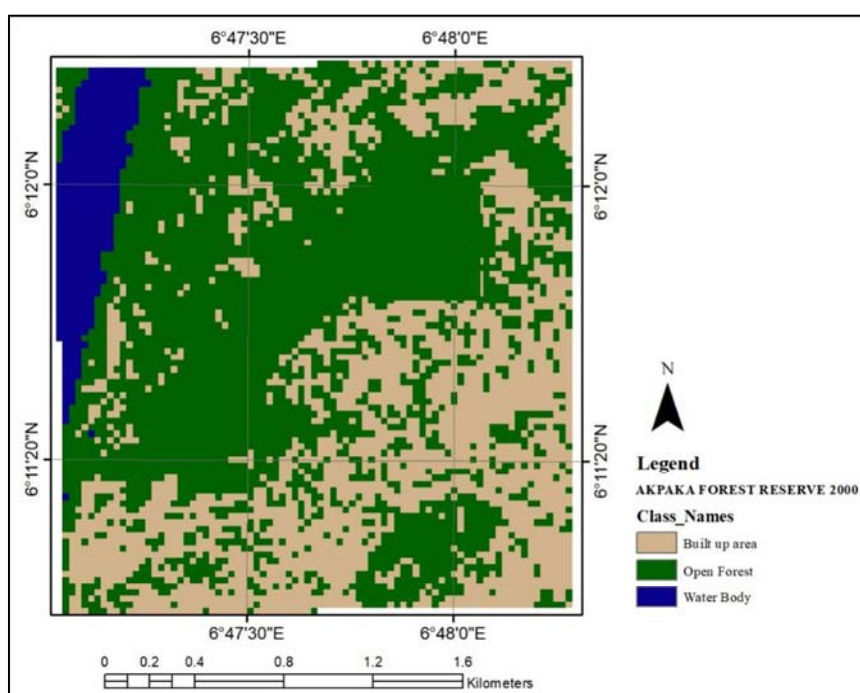| Class Name	Area (Hectares)	Percentage
Open Forest	9543.00	49.19
Water body	2530.00	13.04
Built Up Area	7327.00	37.77
Total	19400.00	100.00

Figure 1. *Landcover/landuse map of Akpaka Forest Reserve 2000.*

A confusion matrix was calculated to determine the accuracy of the landcover/landuse classification, the confusion matrix is an indication of major problems in situation where spectral responses of scene features overlap, where categories shares identical spectral signatures [3].

The precision of the classified images was ascertained and accuracy assessment was carried out by comparing the classified Landsat image with known reference pixels. Table for accuracy assessment was prepared as shown in table 2.

***Table 2.** Accuracy assessment for 2000 Landsat 7 ETM (supervised classification).*

ACCURACY TOTALS						KAPPA (K^) STATISTICS
Class	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Open Forest	82	86	76	95.34%	92.68%	0.9139
Water body	74	68	65	91.89%	83.33%	0.9054
Built Up Area	100	102	100	100.00%	98.03%	0.9334
Totals	256	256	241			Overall K^ =
Overall Classification Accuracy = 94.14%						0.9175

In table 2, the total reference points used was 256 and total number of points classified was 256, the total number of correctly classified points was 241.

Open forest had a total reference of 82 points, total classified of 86 points and number of correctly classified points as 78. This gives the producer's accuracy for open forest as 95.34% and user's accuracy as 92.68%. The kappa for open forest was at an agreeable value of 0.9245. Water-body had a total reference of 74 points, total classified of 68 points and number of correctly classified points as 65. This gives the producer's accuracy for water-body as 91.89% and user's accuracy as 83.33%. The kappa for water-body was at an agreeable value of 0.9054.

Built up area had a total reference of 100 points, total classified of 102 points and number of correctly classified points as 100. This gives the producer's accuracy for built up area as 100.00% and user's accuracy as 98.03%. The kappa for built up area was at an agreeable value of 0.9334. The overall classification accuracy gotten was 94.14% and the overall kappa was 0.9175.

3.2. Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve in 2005

The landcover/landuse distribution of Akpaka in 2005 as shown in figure 2 and table 3 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. Accuracy assessment for landcover/landuse of Akpaka forest reserve in 2005 is shown in table 4.

***Table 3.** Landcover/Landuse distribution for Akpaka forest reserve in 2005.*

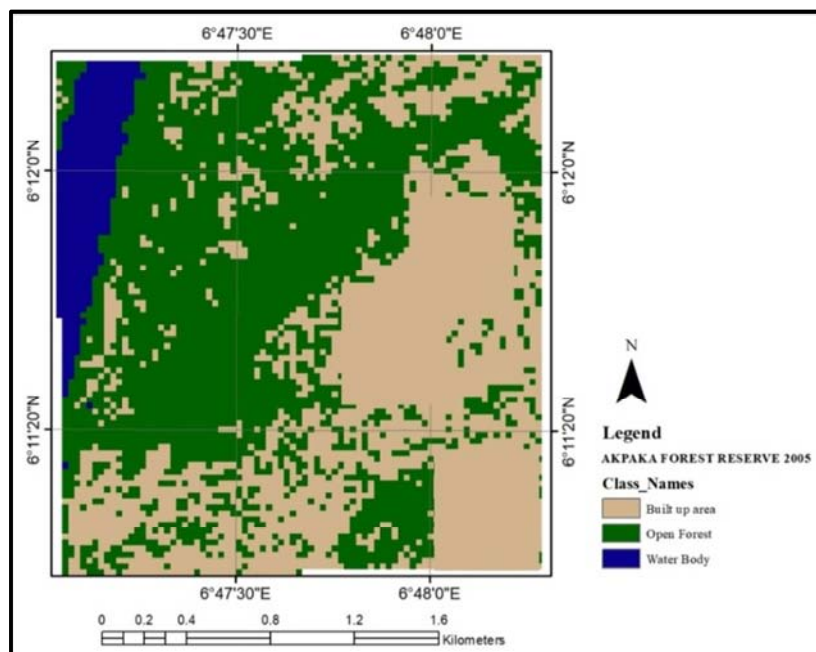| Class Name	Area (Hectares)	Percentage
Open Forest	8882.00	45.78
Water body	2583.00	13.31
Built Up Area	7935.00	40.90
Total	19400.00	100.00

***Figure 2.** Landcover/landuse map of Akpaka Forest Reserve 2005.*

***Table 4.** Accuracy assessment for 2005 Landsat 7 ETM (supervised classification).*

ACCURACY TOTALS						KAPPA (K^) STATISTICS
Class	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Open Forest	73	70	68	95.89%	93.15%	0.9041
Water body	66	66	60	100.00%	90.90%	0.9215
Built Up Area	117	120	100	100.00%	85.47%	0.8925
Totals	256	256	228			Overall K^ =
Overall Classification Accuracy = 89.06%						0.9060

In table 4. the total reference points used was 256 and total number of points classified was 256, the total number of correctly classified points was 228.

Open forest had a total reference of 73 points, total classified of 70 points and number of correctly classified points as 68. This gives the producer's accuracy for open forest as 95.89% and user's accuracy as 93.15%. The kappa for open forest was at an agreeable value of 0.9041.

Water-body had a total reference of 66 points, total classified of 66 points and number of correctly classified points as 68. This gives the producer's accuracy for water-body as 100.00% and user's accuracy as 90.90%. The kappa for water-body was at an agreeable value of 0.9215.

Built up area had a total reference of 117 points, total classified of 120 points and number of correctly classified points as 100. This gives the producer's accuracy for built up area as 100.00% and user's accuracy as 85.47%. The kappa for built up area was at an agreeable value of 0.8925. The overall classification accuracy gotten was 89.06% and the overall kappa was 0.9060.
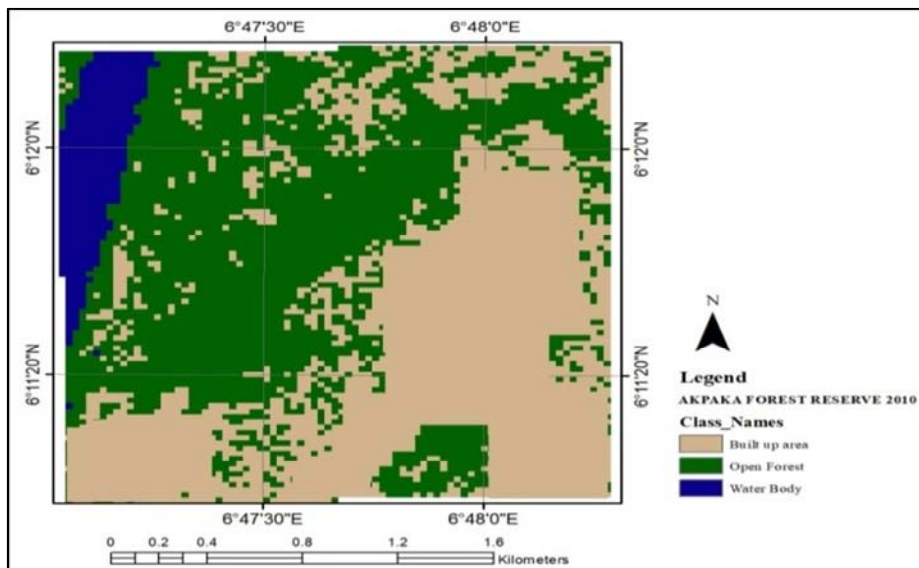
3.3. Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve in 2010

The landcover/landuse distribution of Akpaka in 2010 as shown in figure 3 and table 5 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. Accuracy assessment for landcover/landuse of Akpaka forest reserve in 2010 is shown in table 6.

***Table 5.** 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 3.** Landuse/Landcover map of AFR in 2010.*

***Table 6.** Accuracy assessment for 2010 Landsat 7 ETM (supervised classification).*

ACCURACY TOTALS						KAPPA (K^) STATISTICS
Class	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Open Forest	71	66	62	92.95%	87.32%	0.9169
Water body	60	60	60	100.00%	100.00%	1
Built Up Area	125	130	104	100.00%	83.20%	0.8673
Totals	256	256	226			Overall K^ =
Overall Classification Accuracy = 88.28%						0.9280

In table 6, the total reference points used was 256 and total number of points classified was 256, the total number of correctly classified points was 226.

Open forest had a total reference of 71 points, total classified of 66 points and number of correctly classified points as 62. This gives the producer's accuracy for open forest as 92.95% and user's accuracy as 87.32%. The kappa for open forest was at an agreeable value of 0.9169.

Water-body had a total reference of 60 points, total classified of 60 points and number of correctly classified points as 60. This gives the producer's accuracy for water-body as 100.00% and user's accuracy as 100.00%. The kappa for water-body was at an agreeable value of 1.

Built up area had a total reference of 125 points, total classified of 130 points and number of correctly classified points as 104. This gives the producer's accuracy for built up area as 100.00% and user's accuracy as 83.20%. The kappa for built up area was at an agreeable value of 0.8673. The overall classification accuracy gotten was 88.28% and the overall kappa was 0.9280.

3.4. Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve in 2015

The landcover/landuse distribution of Akpaka in 2015 as shown in figure 4 and table 7 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. Accuracy assessment for landcover/landuse of Akpaka forest reserve in 2015 is shown in table 8.

Table 7. Landcover/Landuse distribution for Akpaka in 2015.

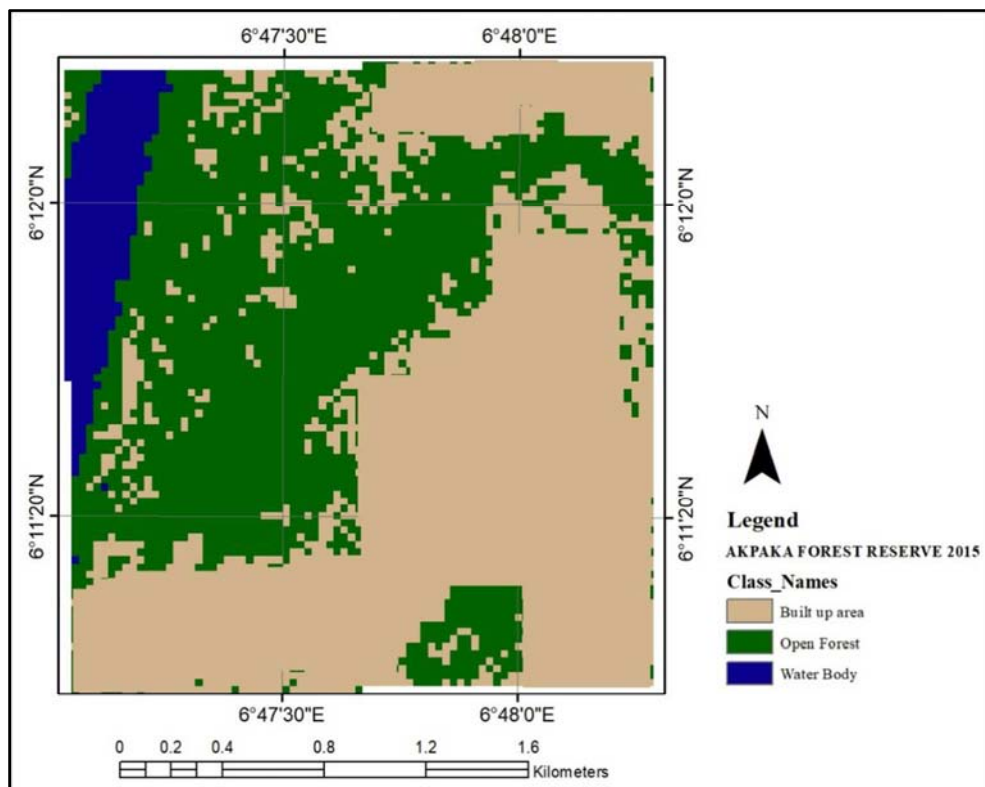| Class Name	Area (Hectares)	Percentage
Open Forest	8143.00	41.97
Water body	2605.00	13.43
Built Up Area	8652.00	44.60
Total	19400.00	100.00

Figure 4. Landcover/landuse map of Akpaka Forest Reserve 2015.

Table 8. Accuracy assessment for 2015 Landsat 7 ETM (supervised classification).

ACCURACY TOTALS						KAPPA (K^) STATISTICS
Class	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Open Forest	68	65	63	95.58%	96.92%	0.9439
Water body	53	50	49	94.33%	92.45%	0.9143
Built Up Area	135	141	120	100.00%	90.90%	0.9178
Totals	256	256	232			Overall K^ =
Overall Classification Accuracy = 90.62%						0.9253

In table 8 the total reference points used was 256 and total number of points classified was 256, the total number of correctly classified points was 232.

Open forest had a total reference of 68 points, total classified of 65 points and number of correctly classified points as 63. This gives the producer's accuracy for open forest as 95.58% and user's accuracy as 96.92%. The kappa for open forest was at an agreeable value of 0.9439.

Waterbody had a total reference of 53 points, total classified of 50 points and number of correctly classified points as 49. This gives the producer's accuracy for waterbody as 94.33% and user's accuracy as 92.45%. The kappa for waterbody was at an agreeable value of 91.43.

Built up area had a total reference of 135 points, total classified of 141 points and number of correctly classified points as 120. This gives the producer's accuracy for built up area as 100.00% and user's accuracy as 90.90%. The kappa for built up area was at an agreeable value of 0.9178. The overall classification accuracy gotten was 90.62% and the overall kappa was 0.9253.

3.5. Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve in 2020

The landcover/landuse distribution of Akpaka in 2020 as shown in figure 5 and table 9 also indicated that open forest decreased further to 37.05% to an area of 7189 hectares. While built up area increased to 49.53% to a coverage area of 9698 hectares. Water body retained its area of 2605 hectares at 13.43%.

Table 9. *Landcover/Landuse distribution for Akpaka in 2020.*

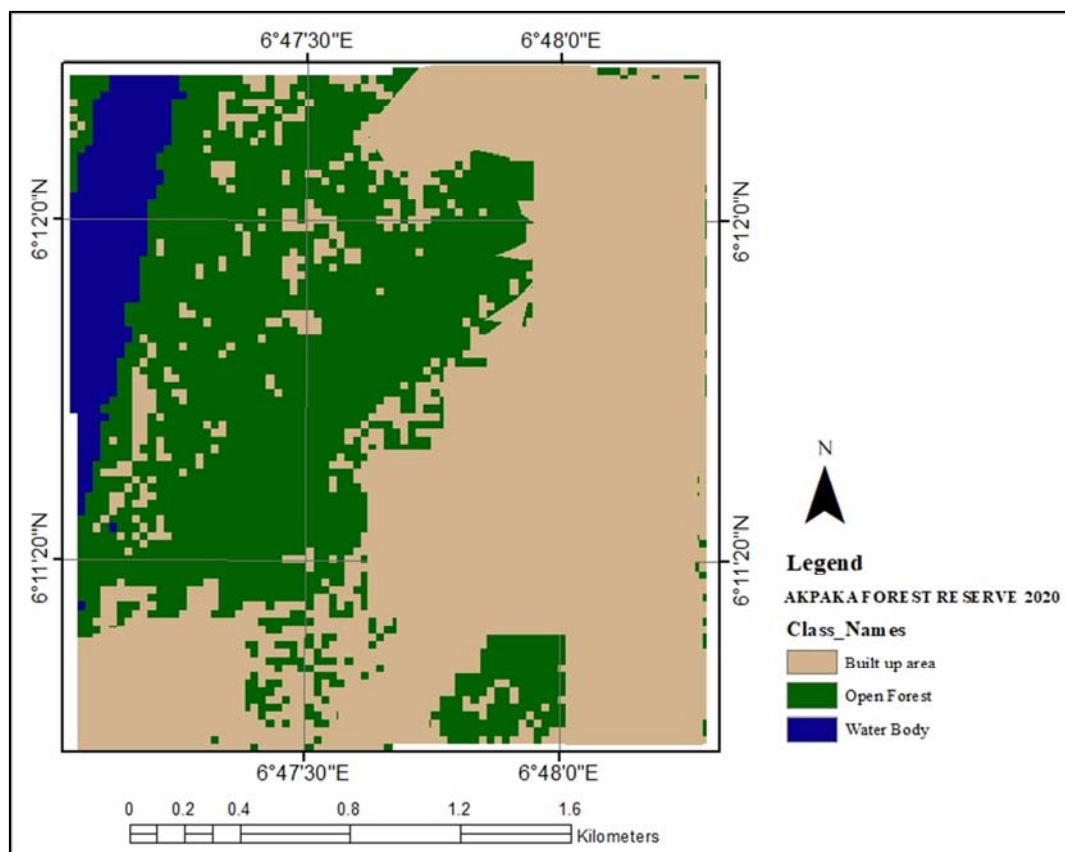| Class Name	Area (Hectares)	Percentage
Open Forest	7189.00	37.05
Water body	2605.00	13.42
Built Up Area	9698.00	49.53
Total	19400.00	100.00

Figure 5. *Landcover/landuse map of Akpaka Forest Reserve 2020.*

Table 10. *Accuracy assessment for 2020 Landsat 8 OLI (supervised classification).*

ACCURACY TOTALS						KAPPA (K^) STATISTICS
Class	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa
Open Forest	63	60	58	95.23%	92.06%	0.9395
Water body	53	50	47	94.33%	88.67%	0.9065
Built Up Area	140	146	130	100.00%	92.85%	0.9376
Totals	256	256	235			Overall K^ =
Overall Classification Accuracy = 91.79%						0.9278

In table 10, the total reference points used was 256 and total number of points classified was 256, the total number of correctly classified points was 235.

Open forest had a total reference of 63 points, total classified of 60 points and number of correctly classified points as 58. This gives the producer's accuracy for open forest as 95.23% and user's accuracy as 92.06%. The kappa for open forest was at an agreeable value of 0.9395.

Waterbody had a total reference of 53 points, total classified of 50 points and number of correctly classified points as 47. This gives the producer's accuracy for waterbody as 94.33% and user's accuracy as 88.67%. The kappa for waterbody was at an agreeable value of 0.9065.

Built up area had a total reference of 140 points, total classified of 146 points and number of correctly classified points as 130. This gives the producer's accuracy for built up area as 100.00% and user's accuracy as 92.85%. The kappa for built up area was at an agreeable value of 0.9376. The overall classification accuracy gotten was 91.79% and the overall kappa was 0.9278.

3.6. Summary of Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve between 2000 and 2020

The summary of Spatial Extent of Landcover/Landuse of Akpaka Forest Reserve between 2000 and 2020 is displayed in table 11 and figure 6 and summarily discussed below.

Table 11. *Landcover/landuse distribution of Landcover/Landuse of Akpaka Forest Reserve between 2000 and 2020.*

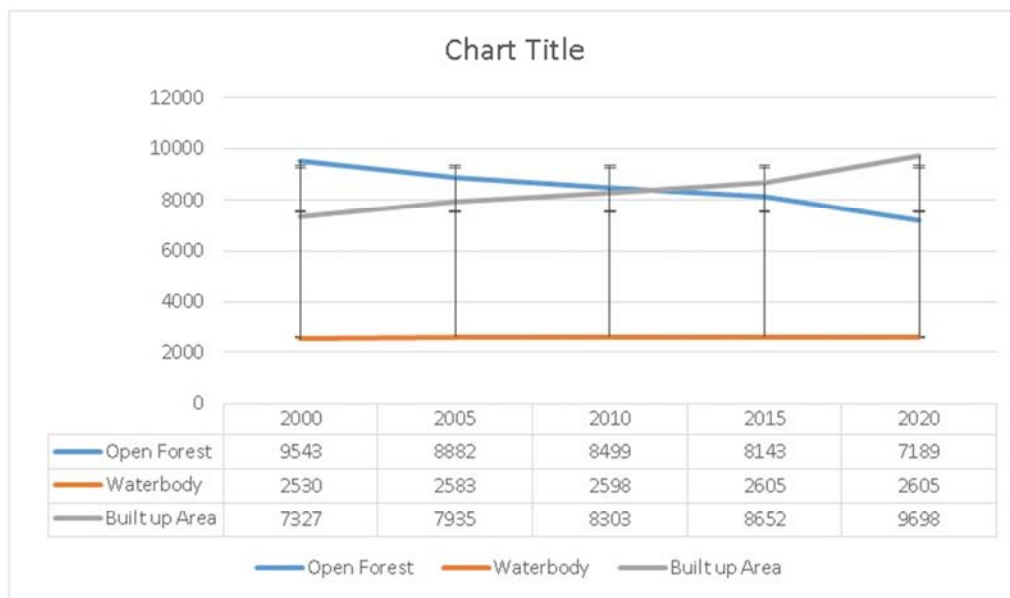| Class Name	2000		2005		2010		2015		2020	
	Area	%	Area	%	Area	%	Area	%	Area	%
Open Forest	9543.00	49.19	8882.00	45.78	8499.00	43.81	8143.00	41.97	7189.00	37.05
Waterbody	2530.00	13.04	2583.00	13.31	2598.00	13.39	2605.00	13.43	2605.00	13.42
Built up Area	7327.00	37.77	7935.00	40.90	8303.00	42.80	8652.00	44.60	9698.00	49.53
Total	19400.00	100.00	19400.00	100.00	19400.00	100.00	19400.00	100.00	19400.00	100.00

Figure 6. *Histogram of landcover/landuse distribution of Akpaka Forest Reserve between 2000 and 2020.*

Table 11 and figure 6 revealed that in 2000, 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. In 2005, 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. In 2010, 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.

In 2015, 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.

In 2020, open forest continued its decrease to 37.05% with an area of 7189 hectares. While built up area increased to 49.53% to a coverage area of 9698 hectares. Water body retained its area of 2605 hectares at 13.43%.

The final land cover/land use distribution of Akpaka Forest Reserve in 2020 indicates gradual decrease of forest cover from 9543 hectares to 7189 hectares. The biggest gain in the study area is revealed to be built up areas, increasing from 7327 hectares to 9698 hectares. However, this gain is not a

sustainable one as it was at the expense of biodiversity which resulted to environmental degradation in the area.

4. Conclusion

This study identified the spatial extent of forest loss using remote sensing in Akpaka forest reserve from year 2000 to year 2020. With the aid of satellite remote sensing, the study captured landcover/landuse classes such as open forest, water body and built up area. These three features were extracted and how they change through time visualised. For year 2000, open forest, water body and built up area showed 49.19%, 13.04% and 37.77% respectively. In 2005 open forest, water body and built up area was 45.78%, 13.31% and 40.90% respectively. In 2010 open forest reduced further to 43.81% water body increased slightly to 13.39% while built up area increased to 42.80%. Year 2015 showed 41.97% for open forest, water body showed 13.43% while built up area showed 44.60%. In 2020 built up area increased to 49.53% while water body reduced again slightly to 13.42%, open forest declined to 37.05%.

This study concluded that for the period studied open forest reduced continuously while correspondingly built-up areas increased continuously. Hence, forest loss is rising in Akpaka Forest Reserve.

5. Recommendations

Forest loss produces tremendous impact on diverse yet fragile ecological condition [15]. Forest loss may produce many negative effects of varied implications but there is always a long term dangerous environmental consequences [16]. Therefore it is important to manage forests sustainably.

This involves use of community participation; awareness campaigns; protection through use of advanced technology like GIS for monitoring to protect the remaining parts of the forest from further deterioration. Adequate monitoring, evaluation, coordination and review should be carried out. When there are genuine efforts to protect a forest and members of the community are part of the process, it will be much easier to achieve the goal. Again a community that is fully aware of the implications of forest loss will voluntarily renege from cutting down forest trees and even contribute their own part for a better result in forest conservation. It is also important to control population growth because increased population of Onitsha city resulted to increased demand for forest land for settlement purpose. Intensive re-afforestation programmes, recycling, re-use and use of alternatives for forest products. In addition, built up areas should also be mandated to plant at least 5 trees for each house and plant flowers too. If this is done it will help make the entire Akpaka a green environment in the nearest future. It will also help to stabilise the local climate within the vicinity.

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