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Comparison of the Landsat-7ETM+ and NigeriaSat-1 Imagery for the Revision of 1: 50000 Topographic Map of Onitsha Metropolis, Anambra State, Nigeria

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Abstract
Topographic maps are needed almost in every aspect of public and private sector activities, including general engineering and construction works, economic and physical planning regulation, environmental management, general planning and as a base map for land use/land cover mapping. Most of the topographic maps available in Nigeria are outdated including that of Onitsha and its environs. Consequently, they cannot be used for the desired needs. This study focused on the use of Remote Sensing and Geographic Information System (GIS) in revising and analyzing 1:50000 topographic map of Onitsha metropolis. Two satellite images (Landsat-7 ETM+ and NigeriaSat-1) of the same date (2006) were used respectively to revise 1964 topographic map of Onitsha metropolis. The two imageries which have been georeferenced, in UTM Coordinate System of WGS 84 Zone 32 were sub mapped using the bounding coordinate of the study area. The NigeriaSat-1 and the digitized and georeferenced topographic map of the study area were co-registered to the 28.5m resolution of Landsat-7 ETM+ using ILWIS 3.3 software. The satellite imageries were classified and the classified images were vectorized in ArcGIS 9.3 Software and integrated with contour generated from SRTM data of 2000 to produce revised topographic map of Onitsha Metropolis (2006). The SRTM data of 2000 was used despite the difference in years (6years), because a sample survey revealed that the topography has not changed significantly between 2000 and 2006 within the study area. Pixel-based image analysis revealed that NigeriaSat-1 has better descriminability than landsat-7ETM+ based on the overall classification accuracy obtained from each image; 86.90% for NigeriaSat-1 and 85.77% for landsat-7ETM+. The NigeriaSat-1 was recommended to be used in revising Medium-Scaled topographic maps of Nigeria. The study recommends among others that Medium-scaled topographic map coverage of the entire country should be carried out without further delay. Furthermore, the study recommends that Nigeria should now adopt topographic map of scale 1:25000 as the base map for the whole country.
Keywords: Topographic Map, GIS, Remote Sensing, Satellite Imagery

1. Introduction

Most topographic map in Nigeria is grossly inadequate and outdated to reflect tremendous development in the country. A lot of changes have taken place in Onitsha and it's environ since the 1964 topographic map was adopted. Efforts have not been made to reflect these changes. This is why any planning especially urban planning, based on the 1:50000 topographic maps would face serious implementation problems, since most of the information on features are now outdated (Ejikeme 2013). This inadequacy and out-datedness of 1:50000 topographic map series is indeed a major setback to physical development in Nigeria. These changes can be reflected on the map through the process of revision. Due to high cost of revision of topographic map using aerial photograph, all the Nigerian 1:50000 topographic maps are still being used today without revision against the United Nations Organization (UNO's) recommended revision period of 10 years for areas of high human activities and 15 years for remote areas. This means that the 1964 topographic map of Onitsha and environs is 48 years old without revision. The recent availability of satellite imageries have made updating of map easier, faster and cost effective.

1.1 The Study Area

The study area selected for this study is located between Latitudes $06^{0}02^{1}56^{11}$N and $06^{0}38^{1}34^{11}$N and Longitude $06^{0}37^{1}30^{11}$E and $06^{0}59^{1}30^{11}$E and covers Onitsha North and South Local Government Area and part of Obosi, Nkpor and Iyiowa Odekpe of Anambra State. It is bounded by Anambra West/East L.G.A. and Oyi in the North, Idemili-North/South in the East, Ogbaru L.G.A in the South and in the West by the River Niger (See fig. 1a, 1b and Ic). Onitsha is the largest urban center in Anambra state and is also a major commercial town east of the Niger.

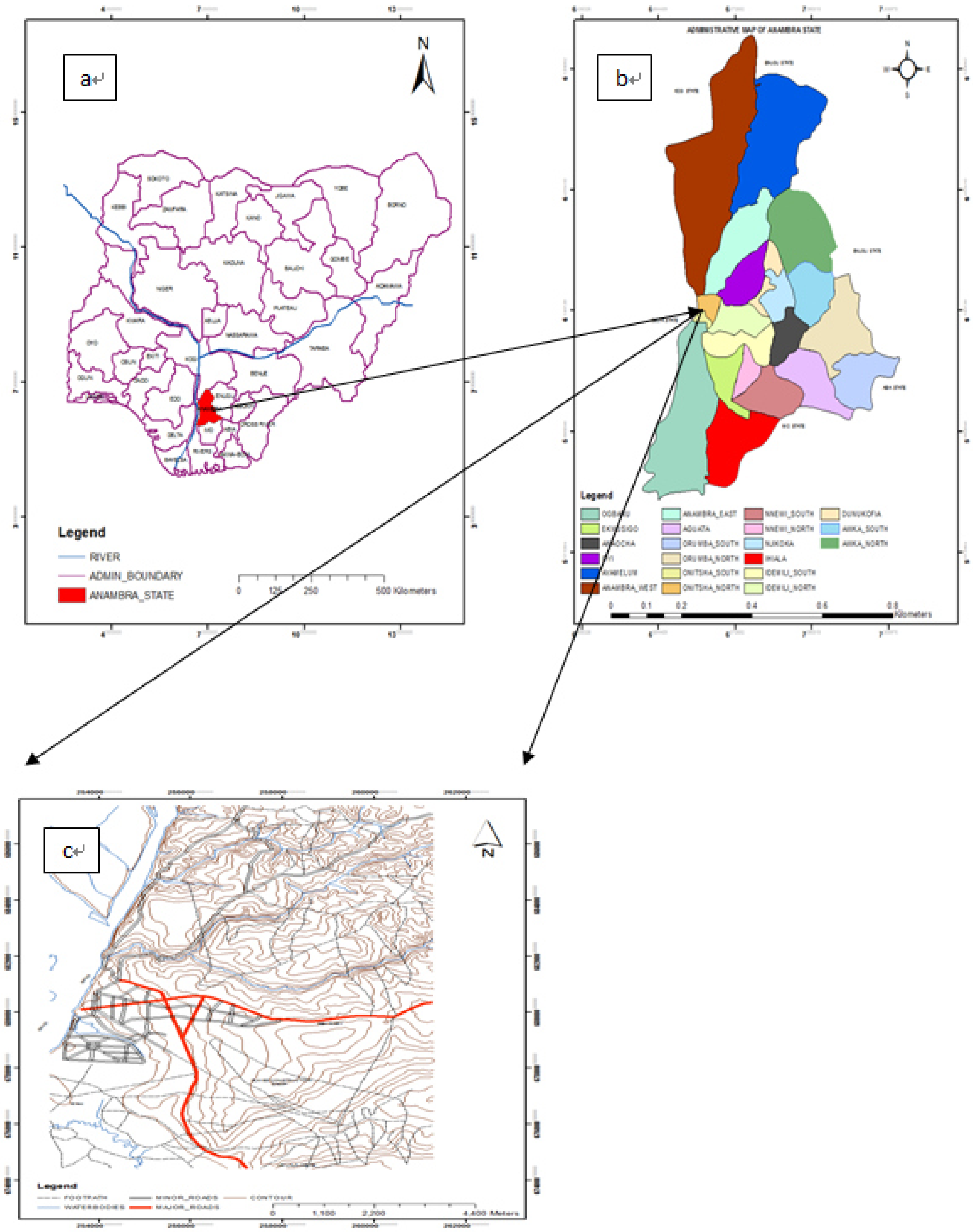

Fig. 1(a): Map of Nigeria Showing Anambra State. Fig. 1(b): Map of Anambra State Showing Onitsha metropolis, the Study Area. Fig. 1(c): 1964 Digitized Topographic Map of Onitsha Metropolis, the Study Area.

2. Methodology

The flow chart of the methodology adopted is represented in the figure 2.0.

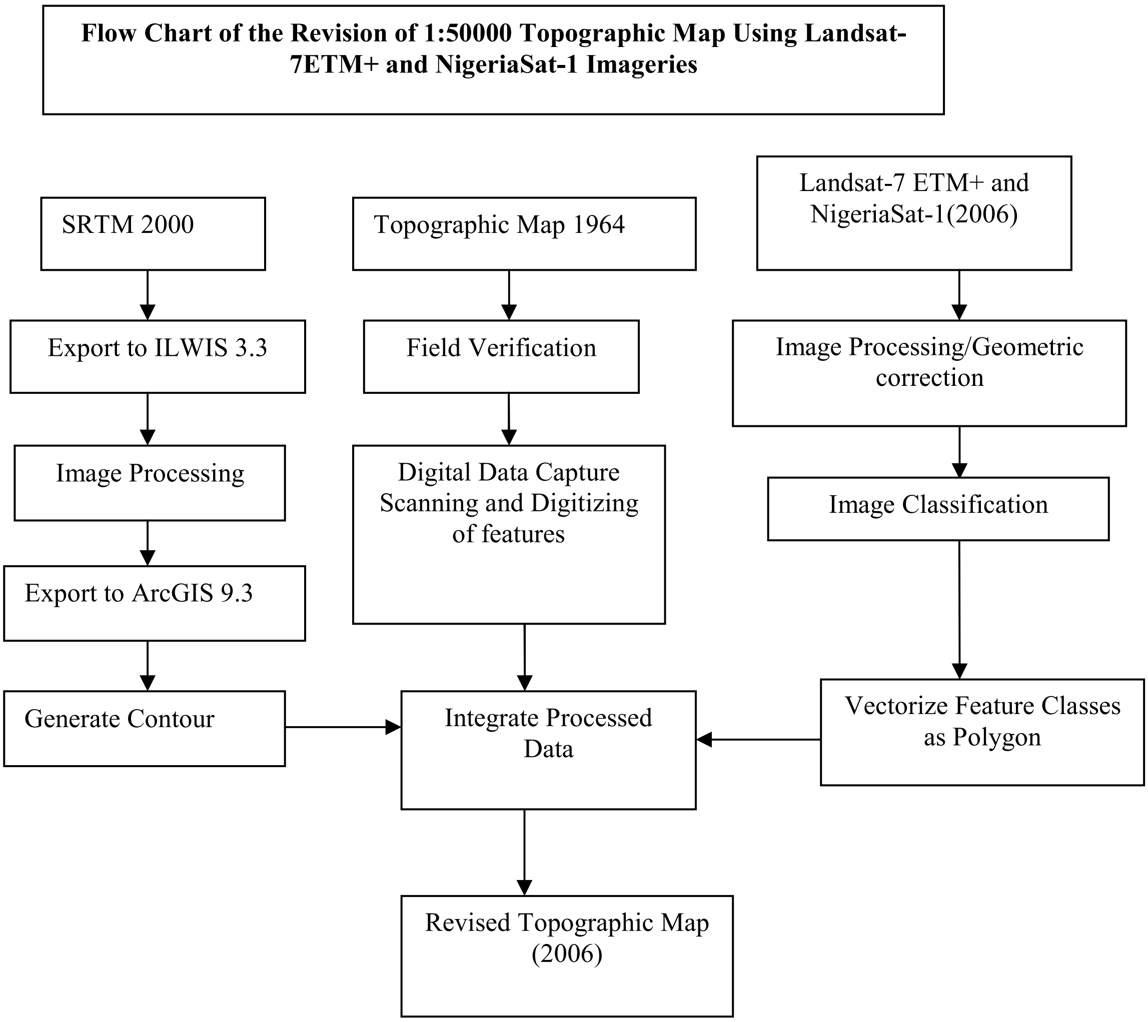

Figure 2.0: Flow chart for obtaining the revised topographic map of Onitsha metropolis:

The bounding coordinates of the 1964 Onitsha S.E topographic map which were in NTM were converted to UTM projected coordinate system of WGS 84 zone 32 using Geocalc software. The converted coordinate was used to georeferenced the scanned topographic map in ArcGIS 9.3 environment. The aim of converting the coordinate was to bring the topographic map to the same coordinate system of the satellite imageries which were in UTM coordinate.

The satellite imageries were of different spatial resolution; 28.5m for Landsat-7ETM + (Resampled) and 32m for NigeriaSat-1. Hence, they were not spatially compatible. The resampled and georeferenced Landsat-7 ETM + of pixel size of 28.5m was used as a reference image to co-register the target image (NigeriaSat-1) to the coordinate system of Landsat-7ETM+ image. The essence of co-registration and resampling operation was to make the imageries compatible in spatial resolution and pixel size as well as in band and at nadir (Gibson et al. 2000). Sub mapping, Resampling, color separation, maplist, sample set and Domain creation as representation of LULC was carried out in ILWIS 3.3.

Each image set (Landsat-7ETM+ (2006) and NigeriaSat-1(2006)) was classified using the maximum likelihood classifier. The results are shown in figure 3.1 and 3.2. This produced the landcover and landuse map for each of the image set. To ensure correct classification, the geographic coordinates of each of the landcover representative class were plotted into the images and identifies before training. The classified image was exported into ArcGIS 9.3 where the classes; Waterbodies, Farmland, Built-up area, Vegetation and Open space were vectorized as polygon.

The use of contour lines generated from topographic map is undoubtedly more accurate than using SRTM data. Unfortunately, the Nigerian topographic maps which were produced 50 years ago have not been revised till date (Ihejirika, 2011). Both SRTM elevation and elevation from available 1:50000 topographic maps could be used to create a good representation of the terrain given the high positive correlation with the more accurate GPS height data of points within the study area (Ozah & Kufoniyi 2008). Thus, the SRTM Imagery was the source of elevation points for this study. The downloaded SRTM was used to produce contour of the study area. The topography of the study area was validated using Ground Control Points (GCPs). The Latitude, Longitude, Height of randomly selected GCPs within the study area was obtained using handheld GPS. The z or height value which is in ellipsoidal height was converted to orthometric height using the Global Geoid calculator available at.

The topography was validated by comparing contour obtained from the SRTM and contour obtained from Ground Control Points (GCPs) within the area. The result shows that the there is no significant change in the topography from 2000 to 2012.

3.0 Results and Discussions

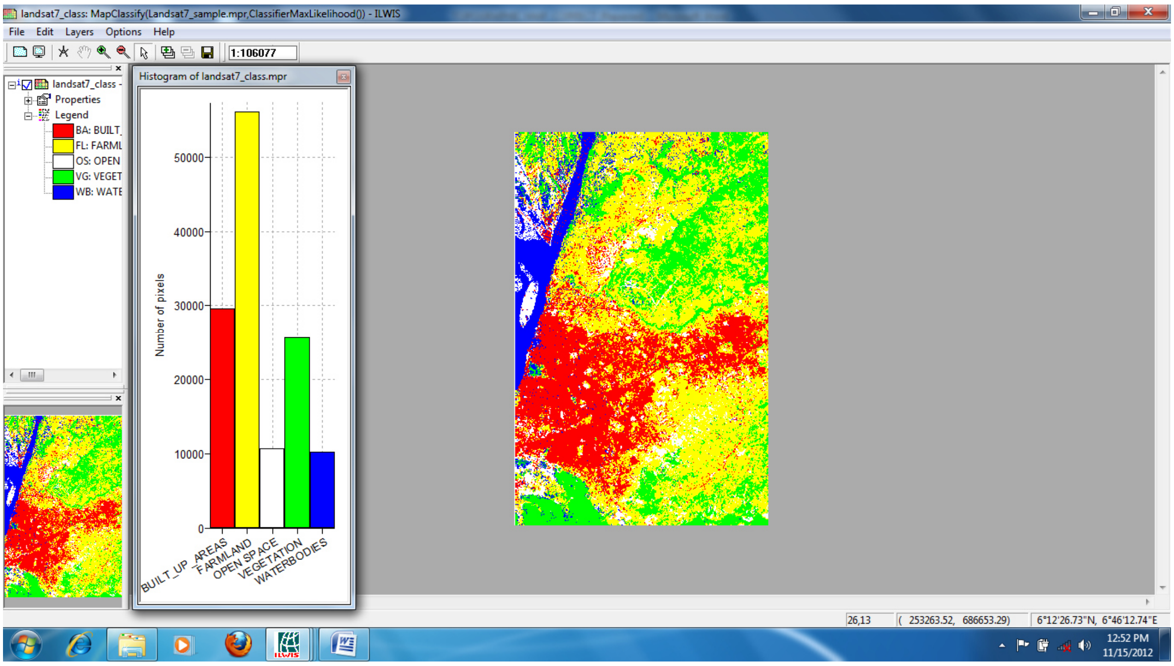

Figure 3.1: Classified image of Landsat-7 ETM + of the Study Area (2006)

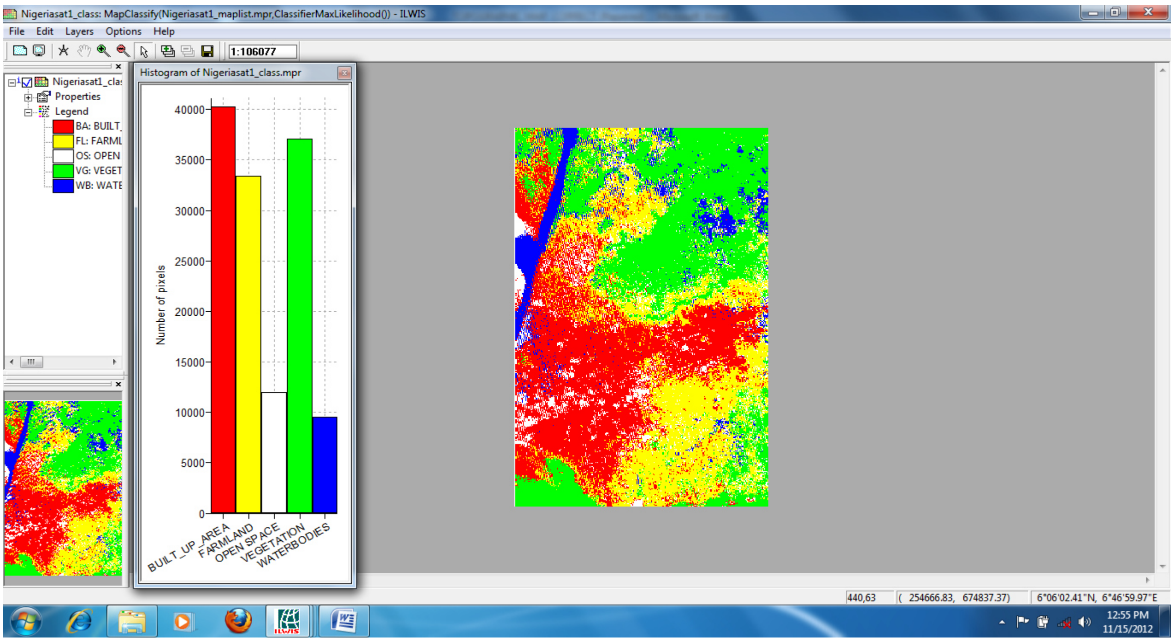

Figure 3.2: Classified Image of NigeriaSat-1 of the study Area (2006)

Table 1.0: Result of Landcover and Landuse Classification from Landsat-7 ETM + (2006) and NigeriaSat-1 (2006)

S/N	Class Type	Area in Hectares		Percentage (%)	
		Landsat-7 ETM+	NigeriaSat-1	Landsat-7ETM+	NigeriaSat-1
1	Built-up Area	85.500	114.000	22.46	30.05
2	Farmland	163.875	96.188	43.05	25.35
3	Open Space	28.512	35.625	7.49	9.39
4	Vegetation	74.813	105.094	19.65	27.70
5	Water bodies	27.989	29.782	7.35	7.82
	Total	380.689	380.689	100	100

The red area represent built-up areas, green area were the Vegetation, yellow was for farmland, blue indicate water bodies and white stood for open space. The result of the Classification as presented in table 1.0 shows a higher level of agreement between the two images in respect of waterbodies and open space but wide disparities exist in respect of other land cover types. Landsat-7 ETM+ performed better in farmland discrimination while NigeriaSat-1 performed better in the discrimination of Built-up area and vegetation.

The classified images were tested for accuracy. To assess the accuracy of the classification, the classified images were compared to their sample set (reference map) and their results were presented in from of an error matrix sometimes referred to as confusion matrix.

Table 2.0: Error Matrix table for 2006 Landsat-7 ETM + (Supervised Classification)

Classified map	Landuse	Reference map							
		Water	Open	Vegetation	Built	Farmland	Total	Error of commission	User Accuracy
	Water	9846	53	0	332	0	10231	3.76	96.24
	Open	0	9489	30	1125	30	10674	11.10	88.90
	Vegetation	1707	0	23861	0	128	25696	7.14	92.86
	Built	97	97	0	29305	97	29596	0.98	99.02
	Farmland	0	549	2470	12105	40955	56079	26.97	73.03
	Total	13650	10188	25229	43867	39342	132276		
	Error of Omission	27.87	16.68	13.35	33.20	0.65			
	Producer Accuracy	72.13	83.32	86.65	66.80	99.35			

$$\text{Overall accuracy} = \frac{113456}{132276} \times 100 = 85.77\%$$

Table 3.0: Error matrix table for 2006 NigeriaSat-1 (Supervised Classification)

Classified map	Landuse	Reference map							
		Water	Open	Vegetation	Built	Farmland	Total	Error of commission	User Accuracy
	Water	8518	0	0	997	0	9515	10.48	89.52
	Open	0	4979	0	6928	62	11969	58.40	41.60
	Vegetation	0	0	37088	0	0	37088	0.00	100
	Built	90	181	0	39980	23	40274	0.73	99.27
	Farmland	0	1666	0	7376	24388	33430	27.05	72.95
	Total	8608	6826	37088	55281	24473	132276		
	Error of Omission	1.05	27.06	0.00	27.68	0.35			
	Producer Accuracy	98.95	72.94	100	72.32	99.65			

$$\text{Overall Accuracy} = \frac{114953}{132276} \times 100 = 86.90\%$$

Inspection of the matrix shows how the classification represents actual areas on the landscape. Examination of the error matrix reveals for each category, error of omission and error of commission. Error of omission refers to those sample points that were omitted during classification. For example, the assignment of errors of Open Space on the ground to built up area category on map (in other words, an area of "real" open space on the ground has been omitted from the map). Using the same example, an error of commission would be to assign an area of Built-up on the ground to the Open space category on the map. The user accuracy for farmland is 24388/33430 or 72.95%. This tells the user of the map that of the area labeled farmland, 72.95%

actually correspond to farmland on the ground. The producer's accuracy for farmland is 24388/24473 or 99.65%. This informs the analyst who prepared the classification that of the actual farmland, 99.65% was correctly classified. The overall accuracy for the classified maps of Landsat-7 and NigeriaSat-1 image was 85.77% and 86.90% respectively. Okpala-Okaka (2008) emphasized that the overall accuracy (%) is a function of the scale of the map and imagery employed in the classification. He stated that for scale 1:50000 -1:250000, an overall accuracy of 50-70% is acceptable.

The Kappa coefficient or (KHAT) is a measure of the difference between the observed agreement between two maps (as reported by the diagonal entries in the error matrix) and the agreement that might be attained solely by change matching of the two maps.

The KHAT statistics is computed as

$$\hat{K} = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (X_{i+} \cdot X_{+i})}{N^2 - \sum_{i=1}^{r} (X_{i+} \cdot X_{+i})} \qquad (1)$$

Where
r = number of rows in the error matrix
x_{ii} = number of observations in row i and column i (on the major diagonal)
x_{i+} = total of observations in row i (shown as marginal total to right of the matrix)
x_{+i}= total of observations in column i (shown as marginal total at bottom of the matrix)
N = total number of observations included in matrix

For LandSat-7 ETM+, the Kappa Coefficient is:

$$\sum_{i=1}^{r} x_{ii} = 9846+9489+23861+29305+40955=113456$$

$$\sum_{i=1}^{r} (X_i + X_{ii}) = (10231 \times 13650) + (10674 \times 10188) + (25696 \times 25229) + (29596 \times 43867) + (56079 \times 39342) = 4401231996$$

$$\hat{K} = \frac{(132276 \times 113456) - 4401231996}{(132276)^2 - 4401231996} = \frac{10606273860}{13095708180} = 0.8099 = 80.99\%$$

For NigeriaSat-1, the Kappa Coefficient is:

$$\sum_{i=1}^{r} x_{ii} = 8518 + 4979 + 37088 + 39980 + 24388 = 114953$$

$$\sum_{i=1}^{r} (x_{i+} . x_{+i}) = (9515 \times 8608) + (11969 \times 6826) + (37088 \times 37088) + (40274 \times 55281) + (33430 \times 24473) = 4583644642$$

$$\hat{K} = \frac{(132276 \times 114953) - 4583644642}{(132276)^2 - 4583644642} = \frac{10621878390}{12913295530} = 0.8226 = 82.26\%$$

Since the overall accuracy of the classification result from NigeriaSat-1 (86.90%) is greater than that of Landsat-7 ETM+ (85.77%), so is the K value, we assert that classification result obtained from NigeriaSat-1 is more efficient and effective than one derived from LandSat-7

Having achieved a reliable classified image, the classified images were exported to ArcGIS 9.3 where they were vectorized into polygon. The vectorized classes of the images were integrated with contour derived from SRTM data and roads digitized from the satellite image to obtain the revised topographic map of Onitsha metropolis using the two image sets (See Figure 3.3 and 3.4)

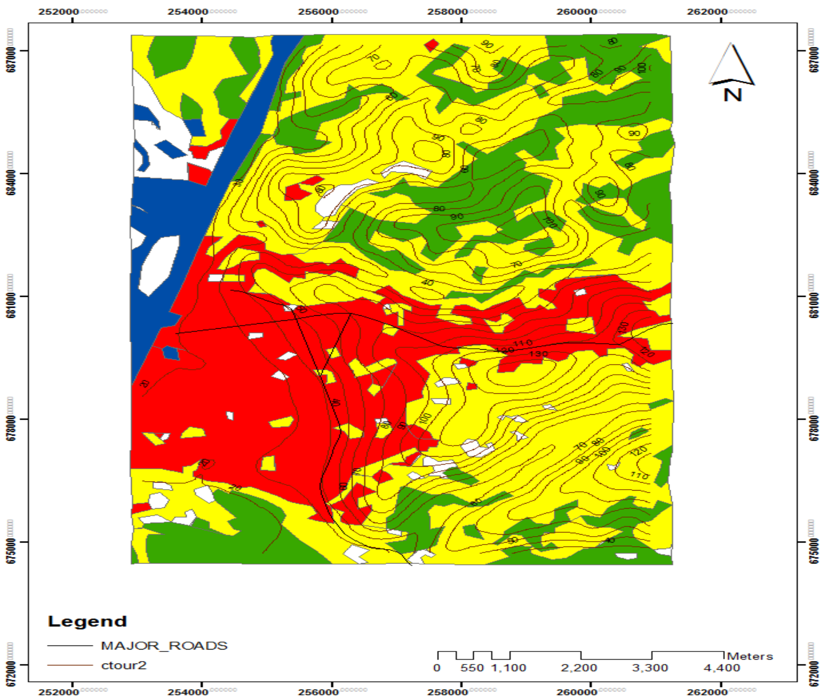

Figure 3.3: 2006 Revised Topographic Map of Onitsha Metropolis (Landsat-7 ETM +)

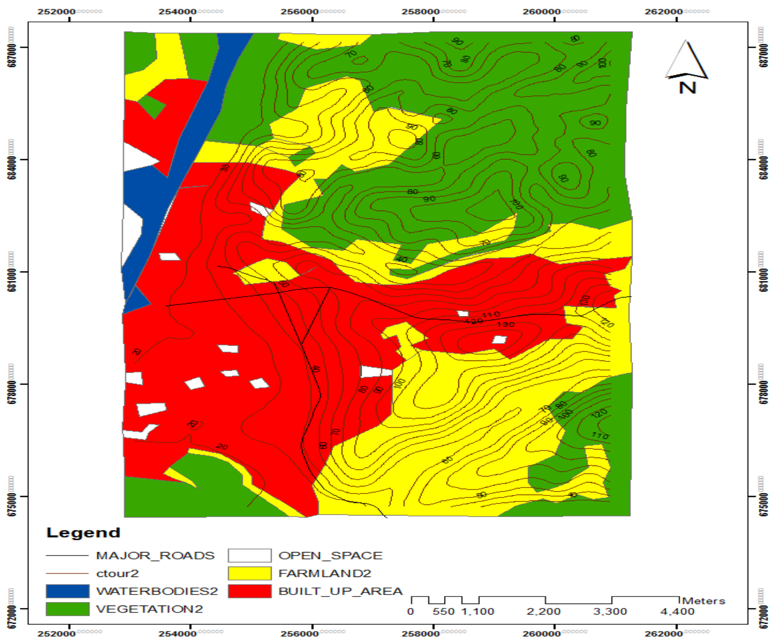

Figure 3.4: 2006 Revised Topographic Map of Onitsha Metropolis (NigeriaSat-1)

4. Conclusion

The use of remote sensing and GIS had been demonstrated in this study as an effective tool for revision of 1:50000 topographic map. 28.5m resolution Resampled Landsat-7 ETM+ and 32m resolution NigeriaSat-1 of date (2006) were used to revise (1964) 1:50000 topographic map of Onitsha metropolis. Comparative analysis of the two images showed that NigeriaSat-1 produced better result than Landsat-7ETM+ image based on their overall classification accuracy of 86.90% and 85.77% for NigeriaSat-1 and Landsat-7ETM+ respectively. Medium resolution satellite imageries perform better than high resolution satellite imageries in pixel-based image analysis. This could be the reason why NigeriaSat-1 performed better than Landsat-7ETM+ despite that

NigeriaSat-1 has higher spatial resolution than Landsat-7ETM+. The result could be different if the image analysis is object-based. The road networks were better identified in Landsat-7 ETM+ than in NigeriaSat-1. The result shows a high concentration of human activities close to the river Niger as regards to the Built up Area in the classification result. Farmland and vegetation occupied large portion of the Northern part of the classification maps. This area (3.3 towards Nkwelle Ezunaka town) is a relatively growing settlement in Onitsha. Field verification shows that these areas were characterized by relatively scattered buildings. A conclusion derivable from these is that there areas can be used for future development and planning.

Further analysis showed that a lot of changes had happened from 1964 to 2006. A major highway (Onitsha-Enugu Expressways) which appeared as a minor path in 1964 had grown to a major highway linking Onitsha and Enugu as identified from the landsat-7 image. NigeriaSat-1 performed better in terms of overall classification accuracy, because of homogeneous spectral characteristics of features. This is not the case with Landsat-7 ETM+, even though it has higher spatial resolution.

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