

Topographic Map Update of Esan Central LGA, Edo State, Nigeria, Using SPOT-5 and ASTER LiDAR Data

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Abstract

This study examines the effectiveness and accuracy of SPOT-5 and ASTER LiDAR data satellite images, Global Positioning System (GPS), Digital Terrain Model (DTM) and Geographic Information System (GIS) in carrying out a revision of Nigerian topographic maps at the scale of 1:50,000. The data for the study were collected by extraction of relevant spatial data from 1964 topographic map, delineation and interpretation of 2009 SPOT-5 data, and field surveys. The landscape changes extracted from SPOT-5 were used to update the topographic base map and to determine the nature and direction of changes that have taken place in the study area. The findings revealed that changes have occurred in both cultural and relief features over time. The coefficient of correlation and t-test calculated show that changes in point, linear and areal features are significant. Also significant were the planimetric and height accuracies of the revised map. The study shows that satellite data especially SPOT-5 is useful for the revision of topographic maps at scales of 1:50,000 and even larger. And, high resolution remote sensing at 5m and ASTER data (30m) with GPS ($\pm 1.9\text{m}$) can be used to create digital elevation model (DEM) on the map which is an essential datasets for complete revision.

Keywords: Topography, Map Update, Map Revision, SPOT-5, ASTER LiDAR

Cette étude examine l'efficacité et l'exactitude des images satellitaires SPOT-5 et ASTER LiDAR, du Système de Positionnement Global (GPS), le Modèle Numérique de Terrain (MNT) et le Système d'Information Géographique (SIG) dans l'exécution de la révision des cartes topographiques du Nigéria à l'échelle de 1:50,000. Les données ont été collectées à partir de la

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carte topographique de 1964, la délinéation et l'interprétation de la donnée SPOT-5 de 2009 et des travaux de terrain. Les changements du paysage extraits de SPOT - 5 ont été utilisés pour mettre à jour la carte de base topographique et déterminer la nature et la direction des changements qui ont eu lieu dans la zone d'étude. Les résultats ont révélé que des changements sont notés tant dans les éléments anthropiques que dans ceux du relief au fil du temps. Le coefficient de corrélation et le t-test calculés montrent que des changements dans les éléments ponctuels, linéaires et surfaciques sont significatifs. Aussi, significatifs étaient les exactitudes planimétrique et altitudinale de la carte révisée. L'étude montre que des données satellitaires comme SPOT-5 sont utiles pour la révision de cartes topographiques à l'échelle de 1:50,000 ou même à une échelle plus grande. La télédétection à une haute résolution de 5m et des données ASTER (30m) avec le GPS ($\pm 1,9\text{m}$) peut être utilisée pour créer le Modèle d'Élévation Numérique (MEN) sur la carte qui constitue une donnée essentielle pour la révision complète.

Mots clés: Topographie, Mise à jour de la carte, Révision de la carte, SPOT-5, ASTER LiDAR

Introduction

One major problem of developing countries is the inability to revise and update existing maps, which would reveal their development index. Production and regular revision of topographic maps is one of the major obstacles to development in Nigeria. The existing map series were produced using rather very expensive and time consuming overlapping aerial photographs and photogrammetric interpretation techniques. With the advent of commercial Earth Observation Satellites with high resolution such as SPOT, Quickbird, IKONOS, GeoEye and NigeriaSat 2, Geographic Information Systems (GIS) has been enhancing topographic map revision globally.

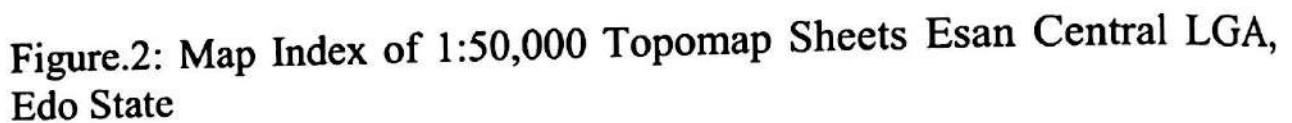
In spite of the significance of mapping in Nigeria, Ikhuoria & Ogedegbe, (1999) and Okpala-Okaka (2009) showed that most of the topographic maps are obsolete and with inaccurate information. For, example, the topographic maps at the scales of 1:500,000, 1:250,000, 1:100,000 and 1:50,000 which were produced and published between 1960 and 1965 have not received any significant revision. Consequently their functionality is constrained. The production of 1:50,000 topographic maps started in 1946, and was made official base map in 1962 (Balogun, 1997 and Ufuah 2003). Out of the 1,348 sheets covering

the entire country 1,122 (83.23%) were published. Up till 1989 about 90% of the country was covered at this scale (Atilola, 1992). In 2007, the Office of the Surveyor General of the Federation (OSGOF) embarked on the revision of the 1:50,000 topographic maps. According to Takheri (2009); the process of revising topographic maps at 1:50,000 commenced actively in 2007 in order to ensure that they are current and serve various stakeholders' needs. Up till today, the process is still ongoing, although they were to be completed in two years (2007-2009).

Map revision is conceptualized in cartography as the process of bringing the information on a map up-to-date (Steiner, 1973). The aim of a revision is to produce a newer version of an existing map. Therefore, according to Usery and Welch (1989) map revision involves two distinct operations; change detection and map updating. Changes in topography are not constant in all regions. It is therefore necessary to formulate different revision policies such as cyclic revision, selective revision and continuous revision. Jamebozorg, Valadan & Sadeghian (2003) explained that cyclic revision is aimed at the revision of the whole series over a fixed period of years. Selective revision tries to achieve revision of individual sheets by an order of individual priority of demand and not by fixed periods. Continuous revision relies on a continuous inflow of information and field survey to maintain sheets in an up-to-date condition. Map revision could be done in frequencies of years depending on demand and the rate of changes in the development of the area concerned while the scope of revision could be quick, partial and complete (Smith 1983). The United Nations Organisation (UNO) recommended revision of 10 years for areas of high human activities and 15 years for remote areas (Atilola, 1992).

In Nigeria, the OSGOF formerly the Federal Surveys Department was established in 1897 as the national agency for surveying and mapping the country. Since its establishment, the longstanding goal of the agency has been to provide complete topographic map coverage of the national territory and update them regularly. However, the Office has not been able to update the basic topographical maps produced in the fifties and sixties nor complete the mapping of the country (Ayeni, 2003).

An analysis of the map revision studies carried out within the framework of *types of map revision* (quick, partial and complete) shows that most of them have been partial and experimental (Ufuah, 2002, Amamoo-Otchere, 1992, Obot, 2005 and Okpala-Okaka, 2009). Furthermore, none of the studies' approaches involved *relief and complete* map revision except Okpala-Okaka (2009). In light of these observations, this study examined the prospect of carrying out a *complete revision* of the Nigerian topographic map at the scale of 1:50,000 using



The data sets used for the study included the multispectral SPOT 5 (5m resolution) of October 2009 obtained from the Regional Centre for Training in Aerospace Surveys (RECTAS), Ile-Ife; ASTER LiDAR data (30m resolution) of 2003 downloaded from the National Aeronautics and Space Administration (NASA) website (www.nasa.org) and Magellian Mobile mapping GPS receiver unit. The ASTER LiDAR has a scene consisting of 4,100 x 4,200 lines, over a swath width of 60x60 kilometers while the GPS had a very low average Estimated Position Error (EPE) of 1.9m. The topographic map sheets revised were produced in 1964 by the Federal Surveys Department. The four map sheets were accessed in hard copy, on imperial system and based on the Universal Transverse Mercator Projection (Clarke 1880 Ellipsoid, Minna datum). The political map of Edo State produced in 1991 at the scale of 1:1000,000 served as additional revision data input. The sheets were scanned individually on an A-O Context Hawk-eye CX 36 colour scanner at 300 dots-per-inch resolution. The scanned sheets were geo-referenced and digitised on-screen using ArcGIS version 9.3. Six vector layers containing settlements, infrastructure, transportation, hydrographic, hypsometric and vegetation were extracted and edge-matched.

To facilitate identification of existing settlements and other important features on the SPOT 5 satellite image, the GPS point sets captured in the field were overlaid on the satellite image. The satellite image was processed and delineated into various polygonal classes (built-up areas, vegetation, and water bodies), linear features (roads, rivers, pipe line, power line, and rail line) and infrastructures (markets, court, schools, hospitals, hotels, industries, primary health centres and police stations). These features were then overlaid over the vector map layers derived from the topographic maps and the changes were detected. Two maps resulted from this operation. The first was a map (different layers) depicting the changes in the landscape. The second was a map that integrates the changes with the old map to produce an updated map of the landscape.

The seamless contour map layer derived from digitised topographic map was used to create a TIN-based Digital Elevation Model of the study area using the 3D Analyst of ArcGIS 9.3. In the same way the ASTER LiDAR data were converted into a TIN-based DEM in ArcMap environment. These two maps were displayed and visually compared to identify the changes in the relief over the period between 1964 and 2009. Graphic plots of transect were derived from the two data sets and were compared to also determine the changes in the relief.

A relational geospatial data base was created for each map layer in the ArcMap environment. Tables corresponding to each of the map layers were manipulated to compute the areas (polygonal layers), distances for linear layers, and numbers of point features represented on the 1964 and 2009 topographic maps at the scale of 1:50,000. The point, linear and areal features of 1964 and 2009 respectively were subjected to statistical analysis. The pearson product-moment coefficient of correlation r was used to determine the association or relationship between each of the two variables for 1964 and 2009. Also, the t - test was used to test for its significance. Heights in specific location in both old and revised topographic maps were recorded; both coefficient of correlation and t -test were used to determine the relationship and statistical test for significance. The profile heights for AsterDEM and topoDEM were also tested by the use of correlation coefficient and t -test.

Analysis of the changes in map Features

Database in tabular format representing the points, lengths of linear and area of areal features were extracted from ArcMap and discussed as follows:

Changes in point feature

Nine point features were captured from 1:50,000 topographic maps of 1964. These include: markets, churches, dispensaries, maternities, hospitals, pump stations, rest houses, schools and villages/hamlets/farmstead. The total number of point features was 96 in 1:50,000 topographic maps of 1964. Twenty-one point features were extracted from the satellite image of 2009 and GPS coordinates recorded in the field. These include; markets, churches, hospitals, dispensaries/maternities/primary healthcare, police stations, post offices, wireless mast, courts, rest houses/hostels, schools, headquarter, main towns, villages, dam, bore holes, mosque, royal palaces, power transmission station, industries, pump station and monastery. The point features amounted to a total numbers of 244. Therefore, the total number of point features increased from 96 in 1964 to 244 in 2009. This resulted to a total percentage change of 154.17% as shown in Table 1.

Changes in linear features

The linear features represented on the topographic map of the study area as at 1964 were main roads, secondary roads, minor roads, main paths, minor paths, and rivers. The total distance of the linear features in 1964 was 304.87km, while the total distance of the linear features in 2009 is 415.14 km. They include the main roads, secondary roads, minor roads, main paths, minor paths, power transmission line, pipelines and railway line. The distance of linear features increased from 304.87km to 415.14km as shown in Table 2. Some linear features like minor paths, rivers, and power transmission line were intermittently visible on the image. This is as a result of the location of the study area in the Tropical Rain Forest zone. The dense vegetation cover overshadowed the rivers and the minor paths, and as a result they were identified by the use of GPS in a field survey, and also the linear strip of vegetation helps to identify river channels.

Changes in area features

Vegetation (heavy forest, light forest, savanna and scrub) and built-up-area are the major areal features shown on the 1964 topographic map of the study area. All the other areal features such as scattered cultivation, farmland and bare surfaces were shown in different area- symbols all over the map. Thus it was not possible to ascertain their individual boundaries. There were sixteen built-up areas indicated with polygons occupying 498 hectares and nineteen hamlets/camps indicated by their names and several coalescing dots. In 2009, there were 18 settlements (built-up area) expanded from 498 hectares in 1964 to 1532 hectares in 2009 as shown in Table 3. The change during the 45-year period is therefore 1034 hectares, which represents a general percentage change of 207.63%.

Changes in relief between 1964 and 2009

The contour lines extracted from 1964 1:50,000 topographic maps as shown in Figure 3 were used to create Topographic Digital Elevation Model (TOPODEM), shown in Figure.5. The Advanced Space Borne Thermal Emission and Reflection Radiometer Digital Elevation Points in Figure.4 were used to create Advanced Space borne Thermal Emission and Reflection Radiometer Digital Elevation Model (ASTERDEM) created from Aster data of 2003. The ASTERDEM is shown in Fig. 6. These described better the topography of the area as at 1964 and 2009.

Visual interpretation of the two DEMs (TOPODEM and ASTERDEM) shows that the areas above 350m are broader in the Aster-DEM than the Topo-DEM. The Topo-DEM has higher knolls which are interspaced by the height between 250m- 300m. These isolated hills in TopoDEM are shown as plateau with a broader surface on Aster-DEM. Both DEMS show the Ishan plateau. It also shows that the plateau slopes down from above 350m to below 150m at the foot of the plateau especially at the River Niger valley.

Table 1: Changes in Point Features between 1964 and 2009

S/N	Point Features	No. in 1964	No. in 2009	Changes	Change (%)
1	Market	6	16	10	166.67
2	Churches	4	84	80	2000
3	Disp./Mat./Phc.	9	14	5	55.56
4	Police station	0	5	5	100
5	P. Office/Agency	0	5	5	100

6	Wireless Mast	0	10	10	100
7	Court	0	3	3	100
8	Rest house/hotel	2	5	3	150
9	Schools	38	40	2	5.26
10	Headquarter	0	1	1	100
11	Main Town	0	2	2	100
12	Villages	35	31	-4	-11.43
13	Dam	0	1	1	100
14	Boreholes	0	10	10	100
15	Industries	0	3	3	100
16	Royal Palace	0	4	4	100
17	Mosque	0	3	3	100
18	Pump Station	1	1	0	0
19	Hospital	1	4	3	300
20	Power Station	0	1	1	100
21	Monastery	0	1	1	100
	Total	96	244	148	154.17

Source: Computed from Topographic map, SPOT 5 image and field survey.

Table 2: Changes in Linear Features between 1964 and 2009

S/ N	Linear Features	Lengths in 1964 (km)	Length in 2009 (km)	Changes	Percentage Change %
1	Main Roads	30.95	32.6	1.65	5.33
2	Secondary Roads	6.52	72.8	66.28	1016.56
3	Minor Roads	89.52	98.55	9.03	10.09
4	Main Path	19.33	20.6	1.27	6.57
5	Minor Path	146	116.9	-29.1	-19.93
6	Power Trans. Line	0	10.9	10.9	100
7	Rivers	12.55	10.85	-1.7	-13.55
8	Pipeline	0	48.4	48.4	100
9	Railway	0	3.5	3.5	100
	TOTAL	304.87	415.14	110.27	36.17

Source: Computed from Topographic map, SPOT 5 image and Field survey.

Further analysis of the ASTERDEM and TOPODEM surfaces involved a comparison of heights profiles on the two surfaces. A transect running from SW to NE was created on the two DEMs. The heights along transects for both DEMs shown in Table 1 were imported and a terrain profile along transect was plotted on a graph as shown in Figure 7.

Statistical Analysis of the Changes in map Features

The computation shows that the correlation coefficients for point, linear and areal features are 0.487, 0.817 and 0.736 respectively. The correlation coefficient shows high positive correlation between the variables in linear and areal features, while point features show low positive correlation. The t-test calculated for point, linear and areal features are -1.893, -1.132 and -2.620 respectively. From the analyses, the null hypotheses were rejected in point, linear and areal features. Therefore, we accept the alternative hypothesis which states that; changes in point, linear and areal features are significant.

Quantitative or statistical interpretation of the TopoDEM and ASTERDEM was carried out using data in Table 4. The correlation coefficient computed for the two data is .995. This result indicates a strong positive correlation between the two data sets. The computation of t-test shows that the planimetric and height accuracy of revised 2009 1:50000 topographic map is significantly difference from the 1964 1:50000 old topographic maps of the study area. This concludes that there is a difference in the relief between 1964 and 2009. This difference is caused by human actions which include construction of roads, buildings, open field mining and weathering erosion. According to Ramirez (2005), all these changes although local in nature alter the relief and the representation of the features on the surface of the earth.

Figure 7 also shows changes in relief over the period of 45 years. Also the correlation coefficient calculated is .995; the mean value of the TopoDEM heights is 249.8, while the mean value of the ASTERDEM heights is 266.4. Therefore, it can be concluded that the 30m resolution ASTER elevation data can be used as a substitute for existing contour elevation information in the 1:50,000 topographic maps.

Comparing GPS, Aster and Topographic Elevation Data Sets

The names and coordinates (lat/long) of some selected features and their elevations using GPS, ASTER and topographic contours are shown in Table 5. For example, Silo Complex at Irrua with a coordinate of Latitude 6° 43' 58.16" and Longitude 6° 10' 52.75" has GPS elevation

point of 369m, ASTER data of 380m and contour height of 300m. The mean, standard deviation and standard error of each of the variables and the multiple correlations were calculated. The GPS has a mean of 348.93, standard deviation of 74.89 and standard error of 14.33. ASTER Data has a mean of 317.41, standard deviation of 99.75 and standard error of 19.20; while topographic data (contour) has a mean of 330.08, standard deviation of 68.06 and standard error of 13.45. From the analysis and the method of production, topographic data is most accurate; this is closely followed by GPS data, since the standard error, mean and standard deviation of the GPS data are closer to that of topographic data. The three variables are closely related. Also the multiple correlations calculated is .684, which shows slightly high positive correlation between the variables.

Table 3: Changes in Areal Features between 1964 and 2009

S/N	Areal Features	Area in 1964 (hec)	Area in 2009 (hec)	Changes	Change (%)
1	Irrua	78	372	294	376.92
2	Opoji	71	103	32	45.07
3	Ewu	81	368	287	354.32
4	Ugbegun	7	113	106	1514.29
5	Eidenu	6	47	41	683.33
6	Udowo	11			
7	Ugbokhare	12	71	48	208.70
8	Ibore	26	61	35	134.62
9	Atuagbo	21	53	32	152.38
10	Ugbalo	9	15	6	66.67
11	Ujabhole	38	60	22	57.89
12	Afuda	9	25	16	177.78
13	Usugbenu	37	108	71	191.89
14	Unogbo	27	43	16	59.26
15	Ugbegun-Ebudi	58	--	-58	-100
16	Idumoza	7	--	-7	-100
17	Ibhiolulu/Idumoghodor	0	45	45	100
18	Oghodogbo	0	2	2	100
19	Udomi	0	28	28	100
20	Uhe	0	18	18	100
	Total	498	1532	1034	207.63

Source: Computed from Topographic map, SPOT 5 image and Field.

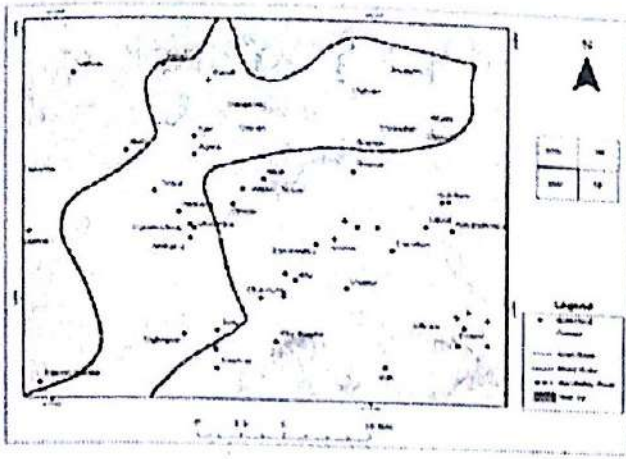


Figure 3: 1:50,000 Topographical Map Showing Contour Lines of the Study Area.

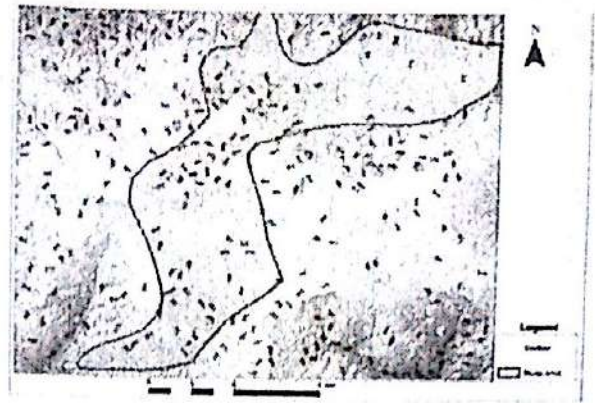


Figure 4: ASTER Digital Elevation Points of the Study Area.

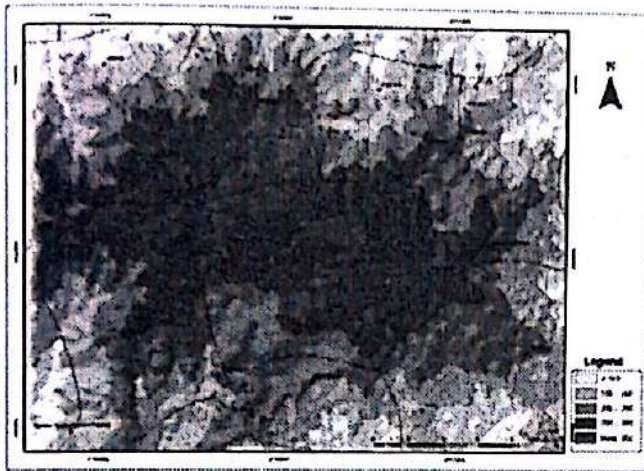


Figure 5: Grid-based DEM derived from 1:50,000 Topo Map of the Study Area



Figure 6: Grid-based DEMs derived from ASTER Data of the Study Area

Table 4: Profile Heights in metres for Aster DEM and Topo DEM

S/N	Interval (m)	Profile on Aster DEM (m)	Profile on Topo DEM (m)
1	0.03	90	120
2	0.06	225	220
3	0.09	270	290
4	0.12	330	340
5	0.15	345	350
6	0.18	405	400
7	0.21	363	380
8	0.24	315	320
9	0.27	195	220
10	0.3	165	190
11	0.33	45	100

Therefore the changes in relief over time are minimal. This is also reflected in the line graph showing elevation points of GPS, ASTER and topographic data (Figure 8). From the above analysis, it could be inferred that GPS, ASTER and contours data are accurate and effective in topographic update especially in determining changes in relief.

The second hypothesis states that; the planimetric and height accuracy of revised topographic map is not highly significant. In testing this hypothesis, two sets of variables were utilized; twenty five locations with their heights derived from both 1964 and 2009 1:50,000 topographic maps of the study area represented as Topo data and ASTER data as shown in Table 5. The second sets of the variables were derived from the profile heights for the AsterDEM and TopoDEM as shown in Table 4. The computation shows that the correlation coefficient r for 1964 data and 2009 data is 0.995. This shows a high positive correlation between the variables. The t -test calculated is -3.141 and the table or critical value is .010. We reject the null hypothesis and concluded that; the height accuracy of revised topographic map is highly significant. Also using data in Table 1, the computed r is .875. This as well shows high correlation between the variables. Thus, since t -.955 is outside the interval -.349 and .349, we reject the null hypothesis and concluded that the planimetric accuracy of revised topographic map is highly significant. Since the null hypothesis is rejected at the two levels, we therefore accept the alternative hypothesis which states that; the planimetric and height accuracy of the revised topographic map is highly significant. This means that the planimetric and height accuracy of the 2009 revised topographic map is significantly different from the old map of 1964.

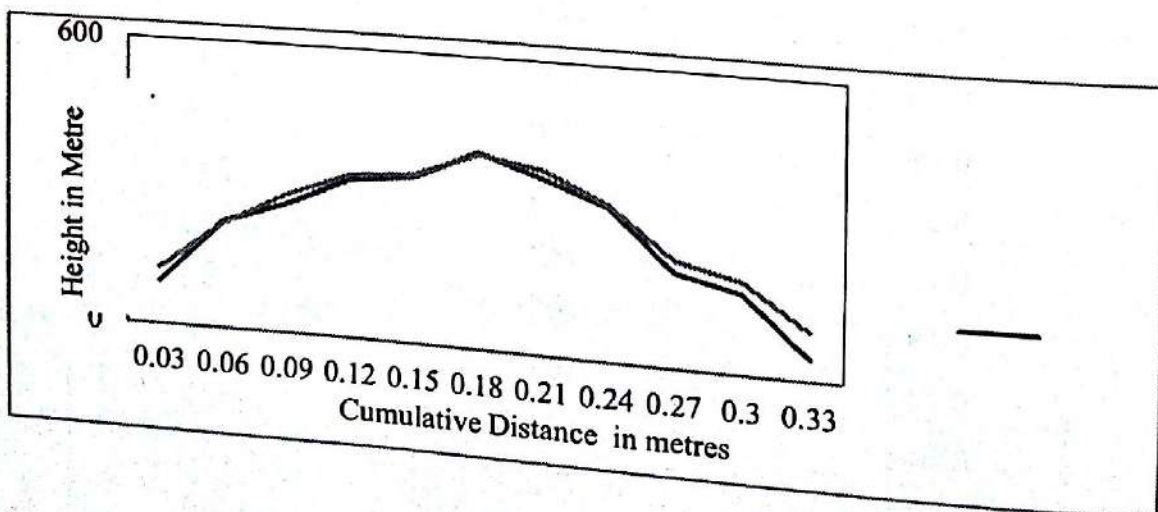


Figure 7: Terrain Profile Along Transect.

The results of the study show that; the use of high resolution (5m) SPOT 5 remotely sensed data to revise topographic maps was successful and effective in the study area. The results of the features extracted showed that there were no difficulties to detect and identify areal, point and linear features on the image. Therefore, SPOT-5 imagery has very high image interpretability for all classes of land use features. All features are identifiable on the image with the exemption of individual buildings. The interpretation was supplemented with ground truthing with a GPS receiver. Thus, remote sensing and GIS techniques are found to be adequate for topographic map revision at the scale of 1:50,000 and even larger. Also, high resolution satellite images especially SPOT-5 (5m), ASTER data (30m) and GPS ($\pm 1.9\text{m}$) can be used to create a digital elevation model (DEM) which constitutes essential datasets for complete topographic map revision at the scale of 1:50,000.

Both ASTER elevation data and topographic elevation data were positively correlated with the GPS height data. The 30m resolution ASTERDEM manifests artefacts and a prior processing of the data is recommended to achieve cartographic good quality for 1:50,000 topographic map revisions. Also, the findings indicate that 30m resolution ASTER elevation data can be used as a substitute for existing contour elevation information in the 1:50,000 topographic maps.

The study area covers 253km^2 with 33 settlements (villages and towns). Two settlements Ekor and Eko-Akhaluavbalu went into extinction. The built-up areas had a total area of 498 hectares in 1964, which increased to 1532 hectares in 2009. Outside the built-up areas, the remaining parts are made up of mosaic farm land, forest areas, disturbed farmland/ cultivated land, water body (lake), and grass/shrub land.

Table 5 Comparing Elevation data sets (GPS, ASTER, and TOPOGRAPHIC DATA)

S/N	Name/Location	Latitude	Longitude	GPS Data	ASTER Data	Topo Data
1	Silo Complex	6° 43' 58.16"	6° 10' 52.75"	369	380	300
2	PHCN Trans Station	6° 44' 5.21"	6° 11' 49.753"	405	450	350
3	Irrua Girls Sec School	6° 44' 17.88"	6° 12' 31.14"	422	460	410
4	Zumma Mem. Hosp.	6° 44' 17.96"	6° 13' 18.02"	420	380	350
5	Eguare Prim Sch Irrua	6° 44' 2.64"	6° 13' 6.42"	415	380	360
6	Palm Plantation	6° 43' 50.40"	6° 12' 55.84"	400	350	370
7	LG. Secretariat	6° 44' 21.22"	6° 13' 48.26"	393	350	360

8	Palace Irrua	6°44'45.77"	6°13'46.29"	429	380	365
9	Ewu Flour mill	6°44'23.37"	6°10'16.06"	436	450	30
10	Nig. Adv Sch. Theology	6°46'36.81"	6°14'8.14"	424	380	390
11	Idunwele Prim Sch	6°46'55.94"	6°14'0.63"	412	400	380
12	Prim Health Centre	6°47'16.83"	6°14'18.39"	346	300	320
13	Ukhun-Idoa Pipeline	6°47'39.33"	6°14'26.47"	333	280	200
14	Uzoghola Prim Sch	6°48'8.22"	6°14'28.38"	382	300	365
15	Eguare Prim Sch Opoji	6°48'14.40"	6°11'29.61"	378	380	392
16	Ugbegun Palace	6°47'20.44"	6°15'2.70"	309	300	290
17	Abolele Prim Sch	6°41'43.76"	6°11'53.58"	312	300	290
18	Uromi-Ubiaja Rail	6°38'44.99"	6°14'4.46"	342	300	320
19	Ugbokhare Prim	6°38'43.45"	6°14'32.93"	354	400	390
20	Ibore Mkt	6°40'16.02"	6°21'40.76"	319	300	320
21	Atuagbo Prim	6°46'37.64"	6°16'47.64"	284	200	340
22	Ekilor Prim Sch	6°46'47.70"	6°17'35.88"	189	100	180
23	Ujabhole G/S Uwessan	6°48'21.86"	6°20'6.10"	360	300	340
24	Afuda Mkt	6°48'3.76"	6°21'47.25"	212	200	200
25	Uwessan P/S Ibhiolulu	6°46'25.61"	6°21'26.32"	321	300	340
26	NNPC Pipeline	6°47'13.67"	6°20'45.81"	268	200	240
27	Ugbalo Water	6°48'43.60"	6°18'54.13"	160	50	180

Ground truthing is an important component of map revision with satellite data. Detailed field verification and completion carried out during the field survey in the study area enhanced topographic map revision processes. Revision of a topographic map requires a revision policy. There are three categories of map revision policy: cyclic, continuous and selective. In Nigeria, the initial policy of topographic map revision was cyclic revision. Revision was supposed to have been carried out in every decade. Unfortunately, for over 40 years (1964 – 2007) there was no major revision of the Nigerian topographic maps. Therefore, it can be said that presently, Nigeria has not executed her revision policy. Ufuah, (2003) stated that inadequate funding, lack of qualified personnel, lack of modern equipment, problems of data and data acquisition, and lack of government interest are some of the reasons why map revision/revision policy has not been given proper attention in Nigeria.

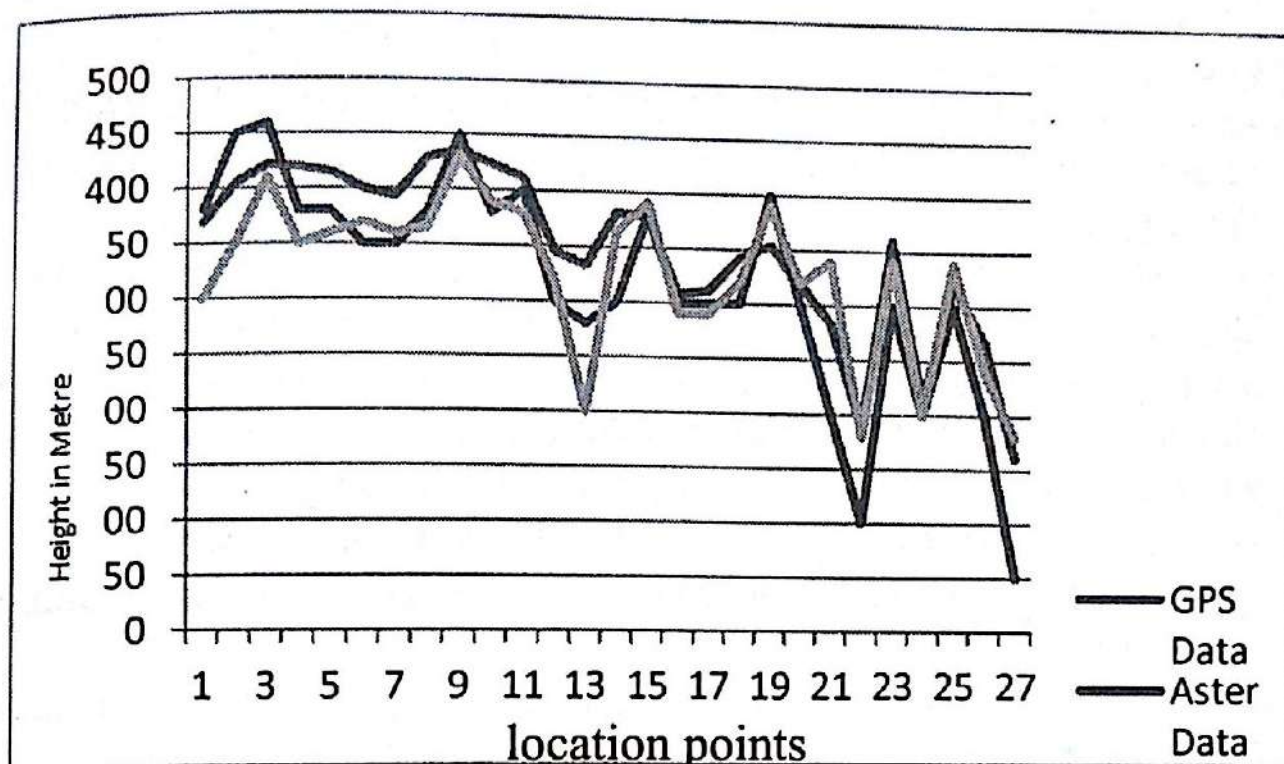


Fig 8: Line Graph Showing Elevation Points.

Conclusion

Nigeria has established her topographic map series in the past with the assistance of foreign mapping authorities. However, the maintenance and revision of these maps which are supposed to be a continuous task have become a major concern and problem to the nation. The results of the study shows that satellite data especially SPOT-5 is useful for the revision of topographic maps at scales of 1:50,000 and even larger. Although, the information content of the data is not sufficient to map all required map features, however, with the use of additional data (GPS) and ground truthing, the application of SPOT-5 image in the practical revision of the topographic changes with respect to Esan Central Local Government Area was successful.

The greatest challenge affecting mapping and map revision in Nigeria is perhaps the attitude of government towards the surveying and mapping sector. Government apathy towards mapping is manifested from inadequate funding of the sector. Adequate funding by the Federal Government will encourage mapping and regular map revision especially topographic maps which will enhance proper planning as well as effective environmental management and sustainable development in Nigeria.

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