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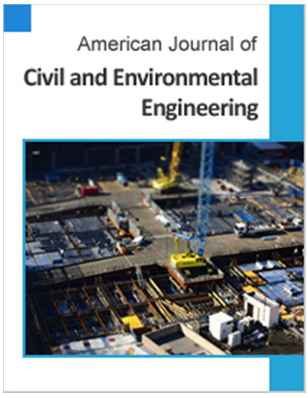

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Evaluation of the Potentials of High Resolution Satellite Imagery in the Determination of Encroachment on Right-of-Way for FUTA Road in Akure, Nigeria

Nzelibe Ifechukwu Ugochukwu*, Tata Habert

Department of Surveying and Geoinformatics, Federal University of Technology, Akure, Nigeria

Email address
iunzelibe@futa.edu.ng (N. I. Ugochukwu)
*Corresponding author

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Abstract
The issue of encroachment on Right Of Way (ROW) in Nigeria is one which has led to several devastations. Therefore, there is a need for right of way surveys to be carried out more frequently and adequately. Due to the fact that the conventional means of carrying out right of way surveys, though provides a more appropriate solution, has been found to be expensive, time consuming and laborious, there is the need to seek alternative means for carrying out right of way surveys. To achieve this aim, the potentials of high resolution satellite image-QuickBird was evaluated by selecting a 1.4km road corridor upon which feature within the 30m ROW were extracted and coordinated by method of conventional ground survey, using Total station instrument. Both datasets were plotted in same environment using the ArcGIS10.3.1 software and spatial analyses were carried out, which include: Buffering, Overlays, Queries and Computations of areas of encroachment. Based on the results and analysis obtained from both data sources, the mean and standard deviation computed for their absolute differences in area of encroachment were 1.656177 m^2 and 0.587613 m^2 respectively. The satellite product had plotting accuracy of about 1.51635m against 0.08m from conventional surveys and the project had estimated cost of US $500 against about US $3253 for conventional survey. Evidently, the satellite product provided a quicker, cheaper and less laborious solution in carrying out ROW surveys within a satisfactory level of accuracy.

1. Introduction

In past two decades space borne technology based data have been successfully utilized for identification, mapping and monitoring encroachment as well as other public utility/facilities information of any urban area in detail. When trying to detect or identify spatial features in an urban environment, it is more important to have high spatial resolution [3]. A multitude of methods for extracting road regions have been proposed. Most of those methods assume that road appearances can be modelled in terms of certain spectral, spatial, and geometric characteristics that differentiate road regions from other regions in images [1]. The capability to accurately recognise diverse categories of features from aerial imagery, such as roads and buildings, is of importance in understanding the world from above, with many useful applications ranging from mapping, urban planning to environment monitoring [5]. Even with many remote sensing data and methods available for road extraction, transportation procedure requires more than the centrelines. Obtaining information that is spatially coherent at the operational level for the entire road system is challenging and needs multiple data sources to be integrated [11]. Gopalan (2009) has discussed that fine spatial resolution satellite data permits small objects to be seen and mapped, special choice of spectral bands improves the discriminating ability between the land covers. Shaker et al. (2011) noted in their article on building extraction from high resolution space images in high density residential areas in the great Cairo region that high resolution satellite images such as IKONOS, QuickBird, and GeoEye provide the needed high temporal resolution lacking in aerial image acquisition missions. In this work, buildings extracted from IKONOS imagery were compared with those obtained using black and white aerial photographs. The work of Thomas et al. (2001) concluded that high-resolution imagery is a valuable tool for mapping urban areas and extracting land cover information. Sohn and Dowman (2003) proposed an automatic method of extracting buildings in densely urban areas from IKONOS imagery, they detected detached buildings, however, accuracy was lacking.

For the purpose of this study, a popular road in Akure known as FUTA Road was selected for the evaluation. In a bid to achieve the set objectives, details contained within the defined 30m ROW were coordinated using method of conventional surveying with total station equipment, which acted as a reference data. On the same study area, similar data were also extracted from a high resolution satellite image (QuickBird) based on same coordinate reference system. The results obtained from both datasets were analysed by overlay operation and computing the areas of encroachment of adjacent structures with emphasis on evaluating the potential of the high resolution satellite image in determination of encroachment into the ROW and as well determine the positional accuracy obtainable based on the spatial resolution of the input satellite image used for this study.

2. Study Area

For the purpose of evaluating the potential of high resolution satellite image, in carrying out ROW surveys, the study area chosen was FUTA road which connects one of the major road in Akure (Oba Adesida road) to Federal University Of Technology Akure, FUTA. The road is approximately 1.4 km in length and the geographic coordinates of the starting and ending point of the road are respectively 5° 8' 59"E, 7°17' 35"N and 5° 9' 40"E, 7°17' 18"N. Figure 1 shows a highlighted area on the satellite image which shows the study area.

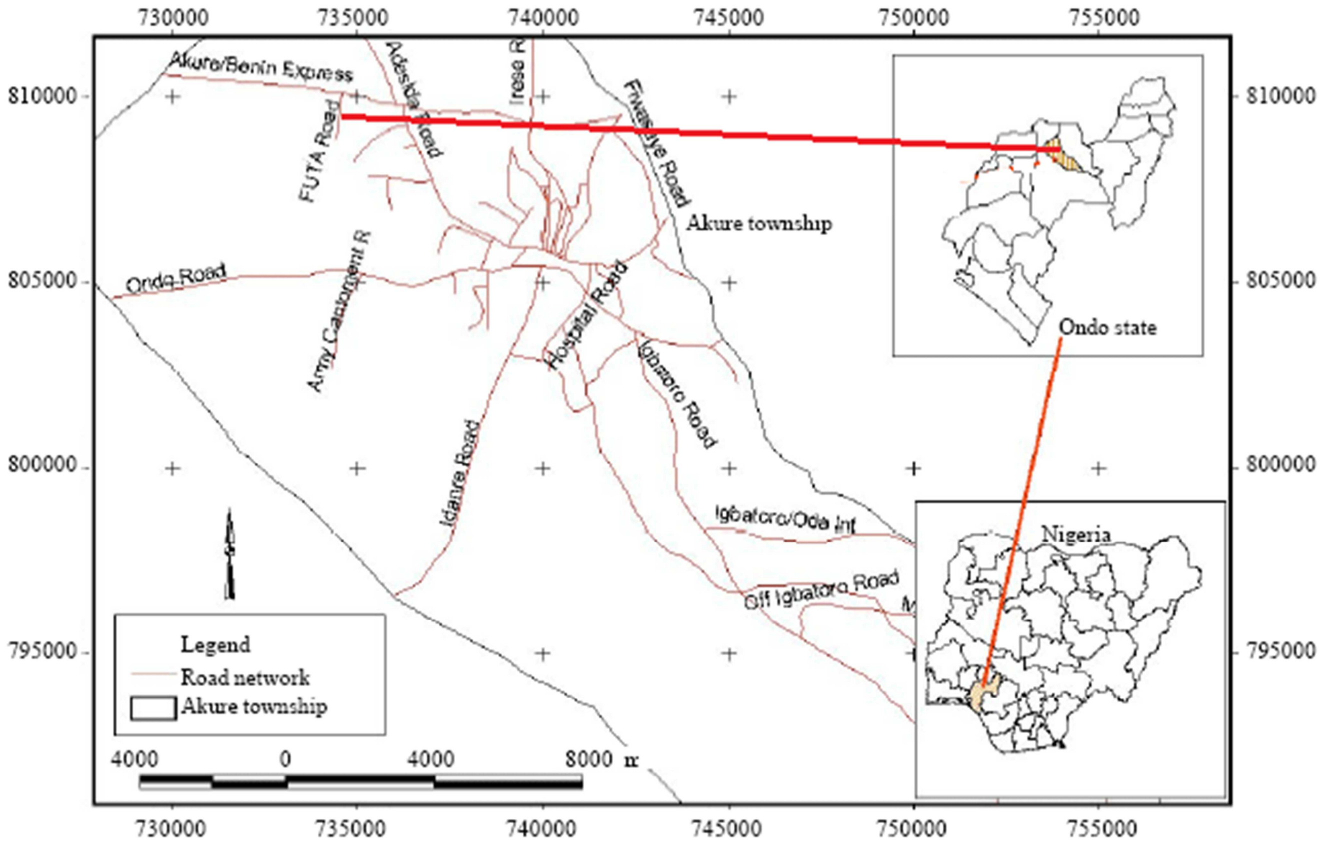

Figure 1. *Map of Nigeria showing Ondo state, Ondo state showing Akure and Akure showing FUTA Road.*

The 1.4km road, known as FUTA road is a road which gives access to the Federal University of Technology, Akure South gate, with usually high traffic volume which leads to congestion especially at peak periods (7:00am-10:00am and 3:00pm-6pm local time) on working days. One of the major reasons identified as part of the cause of the congestions is due to the width of the road being narrowed down by structures encroaching on the ROW being the major reasons which has led to the selection of FUTA road for this study.

3. Methodology

This paper attempts to evaluate the potentials of the High resolution satellite imagery as the primary data source for right of way survey. In order to achieve the goal of this study, there is a need to compare the results obtained from the High Resolution satellite Image against result from conventional surveying using, high precession digital surveying equipment (Total Station) with good surveying practice on same study area. This was achieved by different phases and modes of observations. For the purpose of this work the data collection phase was divided into two phases which include: Data Collection from Conventional Surveys and Satellite Imagery both on the same coordinate reference system, being the WGS 84 Datum, UTM zone 31N. Following these phases was the acquisition of attribute data and finally carrying out spatial analysis on the ROW plan from both data sources which include: Buffering, Overlay, Queries and Determination of areas of encroachment from both data sources.

3.1. Data Collection from Conventional Surveys

The data acquisition from Conventional Surveys forms the most important aspect of spatial data analysis in this study, since it was used as the standard evaluating the potential of the satellite product. At this stage, positional data were collected using Total station (South NTS-355) equipment, which has precision of 5" . This aspect involves several processes to collect data at desired level of accuracy using conventional surveying technique. The first process carried out was the reconnaissance survey which involved both field and office reconnaissance. The test of Total station instrument where also carried out to ensure the Instrument is in a good working condition, as well as the control check, to ensure the controls stations used for the survey were in-situ.

Due to the distance of the control stations from the study area, there was a need to extend the control point to the project site. The controls used for the survey were Government first order controls A72S, A73S and A74S in order to ensure accuracy of the survey. Sixteen temporary control stations were then setup for the purpose of the control extension, which were used to link the controls to the study area via a careful observation and good survey practice, using the traversing method of survey.

All features such as roads, structures (temporary and permanent), electric poles, street lights, sign post / bill boards, drainages/culverts, transformers, masts etc. were surveyed by coordinating their edges from a subsidiary traverse stations created within the project area. Identifiers were used to differentiate one feature from another. Coordinates of data captured include easting, nothings and elevations coordinate of details within the defined 30m ROW. The acquired total station survey data were downloaded from the instrument. The data was edited and categorised based on the various features observed on the point identifiers assigned to each feature, which included structures, roads, culverts electric poles, transformers and electric poles power lines.

3.2. Data Collection from High Resolution Satellite Imagery

The method of data collection from the high resolution satellite image was quite straight forward as the major phase involve is to locate the study area in its geographic coordinate system, and place an order on the purchase of the tile containing the study area from the satellite imaging corporation vendors [4]. The high resolution satellite imagery covering the study area, acquired and utilised for this work was the QuickBird satellite imagery. This satellite product was acquired based on UTM Zone 31N, with WGS84 Origin. The QuickBird Image product is collected from the QuickBird satellite sensor, using the state of the Art BGIS 2000 sensor. The sensor has a swath width of 16.8/18Km and a metric accuracy of 23m horizontal, a satellite revisit frequency of about 2.4days at 1m Ground Sampling Distance and a resolution of between 0.65m -2.62m [7]. This product is ordered for about US $14 per sq km. Other processes involved in the data collection from the high resolution satellite image include data model conversion from the raster to vector in order to extract the necessary information such as point coordinate, length of lines and area of polygon for features contained within the study area and for efficient spatial analysis. The process of vectorisation was carried out using ArcGIS 10.1.3 software. Figure 2 shows the Quick Bird Image imported into the ArcGIS environment as it is being processed. The attribute data of features extracted from the image were acquired by visiting the study area.

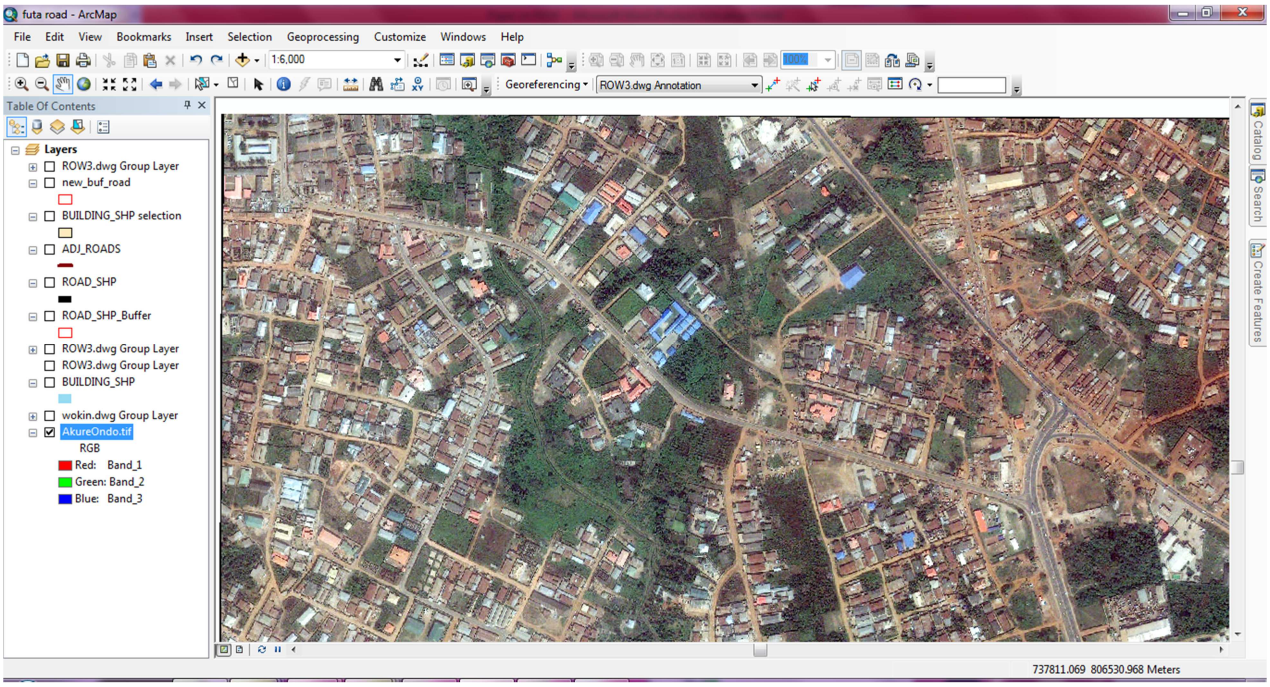

Figure 2. QuickBird satellite image product in ArcGIS 10.3.1 Environment.

3.3. Data Processing

3.3.1. Buffering

By means of a buffer tool, a distance of 15m was buffered (offset) both to the right and left of FUTA road so as to mark its right of way limits. Structures that fell within 30m ROW strip of right of way limits were attributed as not_observing_ROW, while structures that were outside the 30m ROW the right of way of way limits were attributed as observing_ROW.

3.3.2. Overlay Operation

Features from the conventional survey were imported into the ArcGIS environment and were overlaid on the resulting features from the High resolution satellite imagery. After the overlay was performed it was observed that features from both data sources, falls in place with little or no significant difference by visual inspection as shown on Figure 3. Consequently further analysis had to be carried out, in order to bring out the discrepancies that existed between the two data sources, which led to computation of area of the structures derived from both data sources as explained in section 3.3.3.

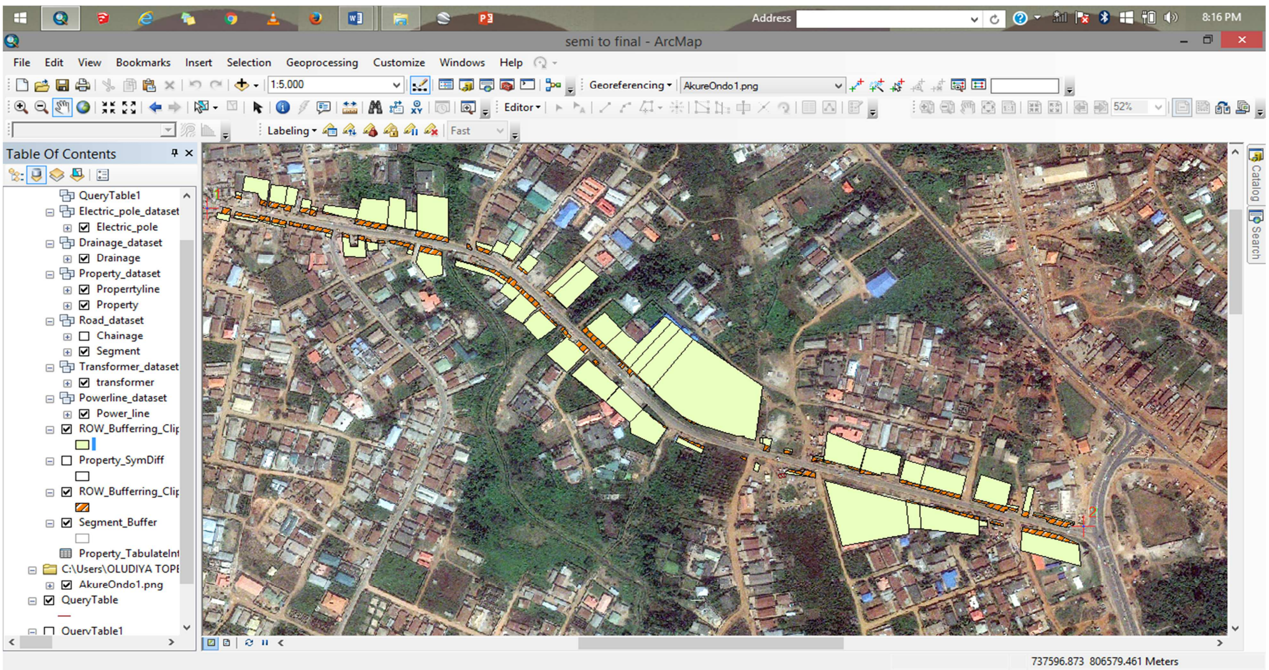

Figure 3. Overlaying of the field work with georeferenced satellite image.

3.3.3. Determination of Area of Encroachment

This is one of the most sensitive parts of this work as reasonable inferences were drawn from the areas computed from both data sources. In order to compute the area of encroachment for both data sources, a query was performed on the structures polygon which determines the portions of the structures contained within the defined 30m ROW being the area of encroachment into the right of way as shown on Figure 4. Based on the query, polygon feature classes were created for the area of encroachment, for features from both data sources. The areas of encroachment were thus computed for the both feature classes using the 'calculate geometry' tool of the ArcGIS. Results of the computed area from both data sources were tabulated and the difference computed as shown on Table 2.

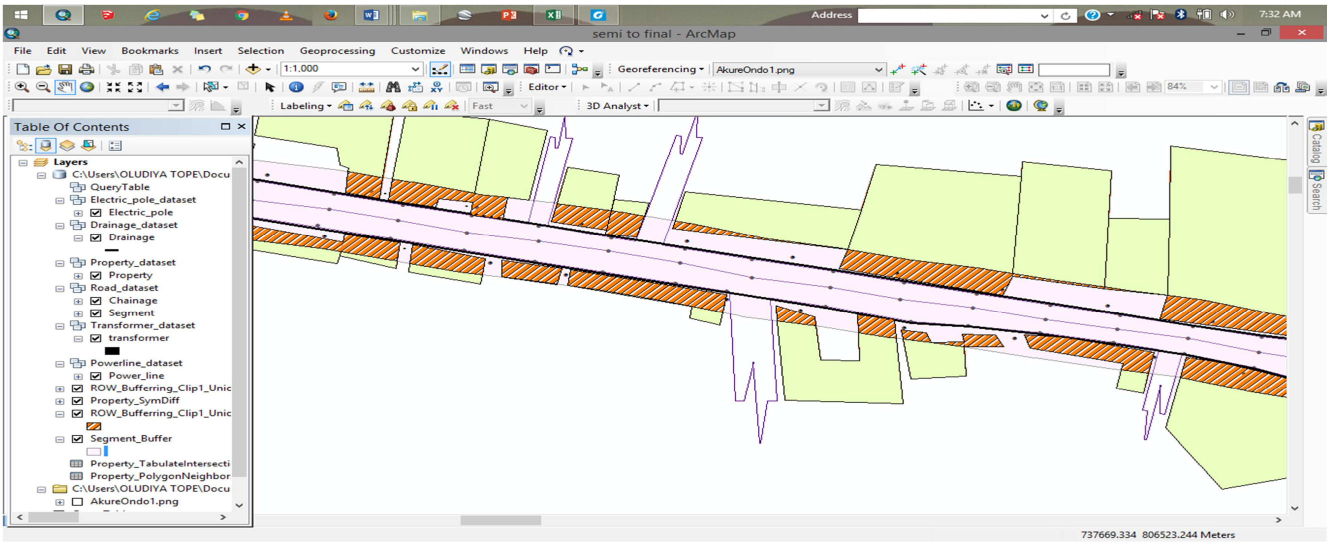

Figure 4. *Screenshot of encroached area on the ROW using ArcGIS.*

4. Results and Discussions

4.1. Results on Number of Entities Identifiable

Table 1 shows the number of spatial entities obtainable from Conventional Surveys and High Resolution Satellite Image.

Table 1. *Summary of number of entities obtainable from Conventional surveys and High Resolution Satellite Image.*

S/N	SYMBOL	FEATURES	No from Conventional Surveying	No from Satellite Image
1.	S	Total adjacent Structures along FUTA road	93	93
2	SN	Structures Not observing ROW	52	52
3.	R	Adjoining Street roads	12	12
4.	TR	Transformers	3	2
5.	F	Major Fences	2	2
6.	M	Mast	1	0
7.	B	Uncompleted buildings	1	1
8.	SL	Street Lights on ROW	2	0
9.	EP	Electric Poles	76	0
10.	SP	Sign Posts on ROW	35	2

4.2. Result on Computed Areas of Encroachment

Based on the process adopted in section 3.3.3; results from the computed area of encroachment from conventional surveys and high resolution satellite image, the differences in the areas and some useful attribute data (use and nature) of the structures on the ROW are shown on Table 2.

Table 2. *Results for Area of Encroachment.*

S/N	Conventional (m^2)	Satellite Image (m^2)	Difference	Use	Nature of Structure
1	27.147	26.338	-0.809	Commercial	Temporal
2	41.595	43.151	1.556	Residential	Temporal
3	43.689	42.769	-0.920	Commercial	Permanent
4	44.4	45.278	0.878	Commercial	Temporal

S/N	Conventional (m^2)	Satellite Image (m^2)	Difference	Use	Nature of Structure
5	37.917	39.874	1.957	Residential	Temporal
6	2.611	1.575	-1.036	Commercial	Temporal
7	68.073	69.308	1.235	Commercial	Permanent
8	52.535	51.456	-1.079	Commercial	Temporal
9	37.492	39.073	1.581	Commercial	Temporal
10	54.975	55.820	0.845	Residential	Temporal
11	73.884	72.005	-1.879	Commercial	Temporal
12	59.633	61.925	2.292	Commercial	Temporal
13	99.676	101.547	1.871	Commercial	Temporal
14	76.79	74.729	-2.061	Commercial	Temporal
15	19.715	21.579	1.864	Commercial	Temporal
16	76.591	78.541	1.950	Commercial	Temporal
17	107.304	109.329	2.025	Commercial	Temporal
18	73.54	74.695	1.155	Commercial	Temporal
19	99.099	100.421	1.322	Residential	Temporal
20	116.805	118.129	1.324	Commercial	Permanent
21	75.187	76.826	1.639	Commercial	Temporal
22	140.344	141.901	1.557	Commercial	Temporal
23	34.153	35.760	1.607	Commercial	Temporal
24	223.214	220.240	-2.974	Residential	Temporal
25	114.693	115.793	1.100	Commercial	Temporal
26	104.639	106.602	1.963	Commercial	Temporal
27	12.769	14.716	1.947	Commercial	Temporal
28	169.322	170.979	1.657	Commercial	Temporal
29	264.153	265.404	1.251	Commercial	Temporal
30	111.201	112.053	0.852	Commercial	Permanent
31	229.386	227.667	-1.719	Residential	Permanent
32	70.796	72.957	2.161	Commercial	Temporal
33	133.607	137.035	3.428	Residential	Temporal
34	6.035	7.679	1.644	Commercial	Temporal
35	73.916	75.438	1.522	Commercial	Temporal
36	76.132	74.465	-1.667	Commercial	Permanent
37	35.666	37.180	1.514	Commercial	Permanent
38	193.9	192.212	-1.688	Commercial	Temporal
39	51.605	52.914	1.309	Commercial	Temporal
40	36.107	34.056	-2.051	Residential	Temporal
41	140.546	142.305	1.759	Commercial	Permanent
42	220.12	223.426	3.306	Commercial	Permanent
43	61.799	62.140	0.341	Commercial	Temporal
44	120.043	121.787	1.744	Residential	Temporal
45	75.877	74.691	-1.186	Residential	Permanent
46	123.976	125.771	1.795	Commercial	Temporal
47	18.285	20.056	1.771	Commercial	Temporal
48	71.701	73.594	1.893	Commercial	Permanent
49	101.47	103.406	1.936	Commercial	Temporal
50	228.569	226.262	-2.307	Residential	Temporal
51	10.875	8.579	-2.296	Commercial	Temporal
52	25.958	26.856	0.898	Commercial	Permanent

4.3. Spatial Query

In order to further emphasise the potential of the High resolution imagery the database created based on data collected as specified in section 3.2 were queried. Queries are designed for the purpose of retrieving information from the database. The queries performed in this work gave answers to certain generic questions asked from the database. This was made possible as a result of the implicit link of both the spatial and attributes data. The queries were based on the products from the analysis carried out on the database. Single criteria are carried out where one condition is used to design query. This condition is used to retrieve the information from the database. Figure 5 and 6 shows a single criteria query carried out on the spatial database, the syntax and the result respectively.

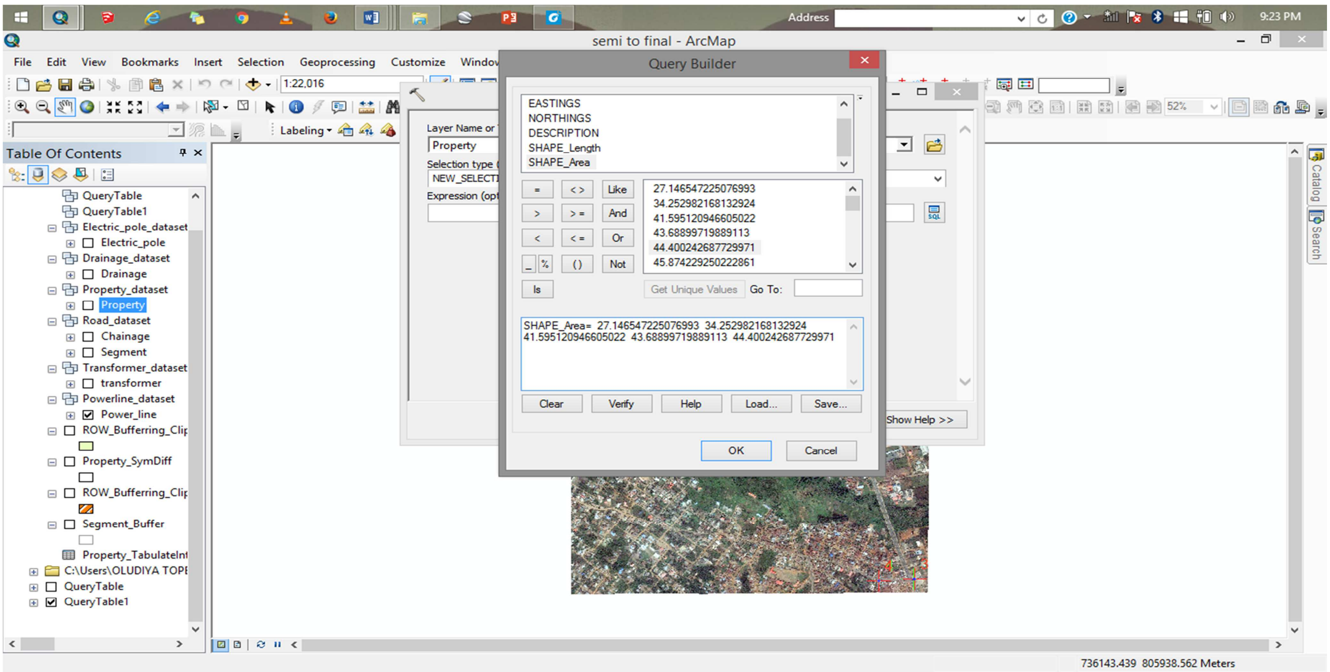

Figure 5. Query for a building in the right of way.

SYNTAX: (([SHAPE_Area]) = "ATOLAGBE SHOPING COMPLEX").

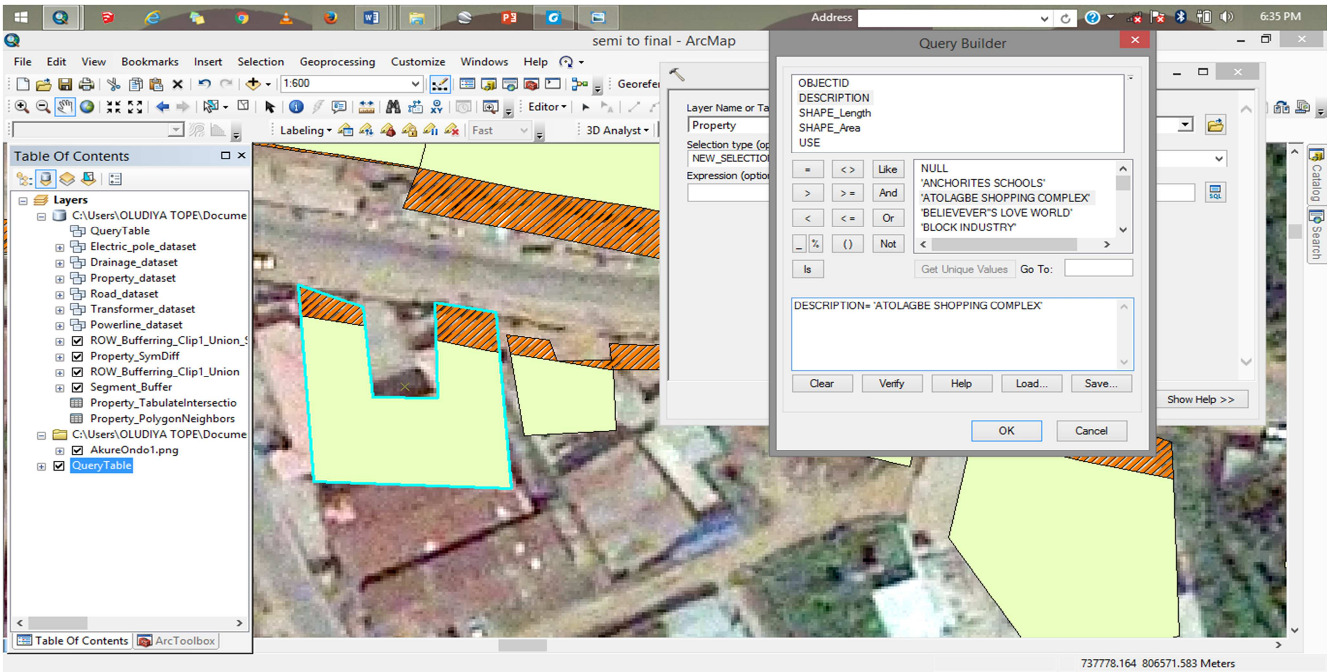

Figure 6. Result of query for structures in the study area.

4.4. Discussions on Findings

In order to properly evaluate the potentials of high resolution satellite imagery in carrying out ROW surveys, a conventional surveying was carried out using a Total station which served as a standard for determination the potentials of the Satellite imagery. Based on the result on Table 1, the number of adjacent structures along the road, Structures on the ROW, major fence and adjoining street, from both data sources were found to be the same for both data sources. While it was not the case for some other features such as Transformers, masts, culverts, street light, sign posts and Electric pole. This could be attributed to the fact that some of these features were not easily identifiable on the high resolution satellite image or they seem to appear smaller than the resolution of the satellite product.

Result on Table 2, is the area of encroachment of structures along the ROW, this result on was obtained after performing overlay and queries on the ROW plans obtained from both data sources. Based on this result the sum of the area of encroachment computed from the conventional surveying is 4543.557m^2 while from High resolution satellite Image is 4581.436m^2. The algebraic difference in the area of encroachment between the two data sources is 37.879 m^2. The mean and standard deviation computed for the individual absolute differences in area of encroachment between both data sources were 1.656177 m^2 and 0.587613 m^2 respectively.

In an attempt to further evaluate the potentials of the high resolution satellite imagery in carrying out ROW surveys a comparison was made based on the plotting accuracies determined from both data sources. Based on this comparison, the field data after processing was found to be plotted with an accuracy of about 0.08m for conventional survey and 1.51635m for high resolution satellite imagery (0.65m resolution QuickBird Image).

Finally considering the project duration, the conventional survey took about 10 days from the reconnaissance survey to the end of the processing, while the project duration using High resolution satellite image covered just 3 days from start to finish

5. Estimated Project Cost Analysis

To evaluate the potential of the high resolution Satellite imagery in ROW surveys in term of cost of executing the project, cost analysis was carried out. This was done by making use of the scale of fees approved by the Nigeria Institution of surveyors (NIS) and Federal government of Nigeria in 2008 [6]. For the conventional surveys, the costing of the project was done by using direct cost approach for executing each component of the project as estimated from the NIS scale of fees [6]. The total cost required for executing the ROW project, using conventional surveying for the selected study was determined to be about US $3253 (₦1,180,971.65). On the other hand, to determine the cost of executing the project using high resolution satellite product, the cost had to be broken down into the cost of acquiring the image product and processing charges. The 0.65m resolution QuickBird image product cost about $14 per sq. km having a minimum order area for archive imagery, for all sensors, to be 25 sq. km with a 2km minimum order width [4]. Hence the QuickBird image product required for the project is approximately US $350 based on the minimum order area, which covers the study area. Image processing charges, required for extracting features within the selected ROW strip, according to the NIS scale of fees was determined to be about US $100. Hence the total estimate for executing the ROW project using QuickBird high resolution satellite image was about US $500 for the 1.4km ROW strip. Comparing the estimated costs for determination of encroachment on ROW from both data sources, it becomes evident that the high resolution satellite image provides a cheaper in the determination of encroachment on a ROW.

6. Conclusion and Recommendations

This study has revealed that the high resolution satellite image, which was evaluated using the QuickBird Image product, has exhibited a positive potential in evaluating encroachment on ROW, since we were able to obtain coherent data from both sources on the following parameters: 93 structures were identified adjacent to the road with 52 encroached into the ROW forming about 60% of the adjacent structures encroaching on the ROW. Out of this 52 structures that encroached the ROW, 41 are commercial (mostly shops) and 11 residential and 40 are temporary structures mostly containers and wooden structures while 12 are permanent structures.

Based on this study, which aims at evaluating the potentials of the high resolution satellite imagery in carrying out ROW surveys, it is evident that the High resolution image has shown good potentials, having accuracies described in section 4.4 above which is acceptable in determination of encroachment on ROW. Furthermore, the High resolution image has shown an easier, quicker and cheaper approach to determination of encroachment on right of ways. Consequently, it is recommended that a High resolution satellite image could be employed determination of encroachment on ROW, for a more frequent and adequate evaluation of encroachment on right-of-way especially in Urban areas using Geospatial information systems Processing Technique.

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