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COMPARATIVES ASSESSMENTS OF POSITIONAL ACCURACY BETWEEN DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) AND TOTAL STATION SURVEY INSTRUMENTS FOR CADASTRAL SURVEYING IN URBAN AND REGIONAL PLANNING

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Abstract

Improvements in technology have facilitated the capturing of geometrical precise positions of features on the earth's surface by using Differential Global Positioning System (DGPS) and Total Station surveying instruments for cadastral purpose in urban and regional planning. The study assesses comparatively the positional accuracy between the use of Global Positioning System (DGPS) and Total Station for cadastral surveying. A Sokkia Differential Global Positioning System and Sokkia Total Station were used respectively for the observation of control points, parcel delineation and setting out of plots on the ground and re-observation of established points.

Keywords: Accuracy assessment, Total Stations, DGPS, Cadastral Surveying, Urban and Regional Planning

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Results showed differences in coordinates with a standard deviation of 0.013 m in Easting and 0.004 m in Northing respectively. The results of perimeter compared for DGPS as 596000.820 m^2 and 596000.700 m^2 for Total Stations. Also, correlation coefficient analysis was carried out and the result obtained shows R^2 = 0.999999988 in the Northing coordinates and Easting as R^2 = 0.999999998 respectively. This shows that the coordinate for both instruments were correlated. It is worthy to conclude that using either of the instruments still the preferable method for cadastral surveying.

INTRODUCTION

In the earlier days, surveying was labour intensive and time consuming to achieve the desire accuracy. The development of Global Positioning System (GPS) technologies have made the acquisition of highly accurate and reliable data possible with reduced physical efforts, these technology has reduced about one-half of the project cost and save about two third of the project time when compared with conventional methods (Kumar et al...,2012).Technology developments have made Differential Global Positioning System (DGPS) and Total Stations instruments are been used to determine positions and setting out of plots for cadastral surveying in urban and regional developments (Yagol et al., 2015). Cadastral mapping using DGPS and Total Stations are progressively well known in many developing countries of the world, replacing the conventional surveying method where tapes, theodolites or compass are used (Yagol et al., 2015). The accuracy of the cadastral data obtained by DGPS technology is comparable with those acquired by Total Station instrument for most cadastral purposes. The development of new satellite technologies has brought revolutionary changes in the area of Cadastral Mapping system and are suitable at large scales, with techniques of precise DGPS receivers and Total Station (Cay et al., 2004).A cadastral boundary is a discontinuity line on which the right of one party begins and the other ends (Zevenbergen,2009). Cadastral boundaries may be natural or artificial and can be represented either by visible features on the ground, or by lines on a map or by coordinates (FIG and World Bank, 1995). According to Dale, and McLaughlin (1999), linear features such asfences and hedges can serve as

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cadastral boundaries in rural areas, such visible boundaries are appropriate for many purposes in land management and land information system

Cadastral Surveying plays a crucial role in urban and regional planning, requiring accurate and reliable measurements. Two commonly used instruments for cadastral surveying are Differential Global Positioning System (DGPS) and Total Station. Cadastral Surveying practice policy is an organized and well-articulated document made by the surveyors in the state based on Surveyors' Council of Nigeria (SURCON) which has a set of guidelines, rules and regulations to control the practice of cadastral surveying within the states of Nigerian federation. These rules and regulations originated from CAP 194 of 1958 laws of the Federation of Nigeria and other survey laws. These laws have passed through series of amendments and repeals from then till date. The law establishing SURCON came to be in December 1989 as decree 44. This law was amended as CAP 425 of 1990 laws of the Federation. After the establishment of SURCON coupled with its empowerment with relevant provisions, a new set of rules and regulations were generally made at the national level with individual states and the Federal Capital Territory (FCT) to establish their own Cadastral Survey Policy (CSP) (Orisakwe, 2017).

The common practice in Nigeria for cadastral surveying is based on the use of DGPS and Total Station instrument which is not time consuming and it is costly as when compared with the use of the analogue instruments, hence the need for this study to comparatively assess the accuracy between them.

Land Information System (LIS) consists of spatial and non-spatial data. Both these spatial data (such as parcel boundary, shape, and location) and non-spatial data (such as ownership, rights, and area) are stored, maintained, and accessed in the database environment (Ali, 2012). Spatial data is acquired through cadastral surveys which are concerned with geometrical data of each land parcel. The results of cadastral surveys are isolated plans of a parcel or a subdivision. Cadastral mapping goes a step further and produces complete maps, which are based on cadastral surveys (Steudler, 2010). The cadastral survey system gives preference to the survey records of parcel boundary positions over physical locations of beacons on the ground. These records provide information with the coordinates of the beacons and site plans within a particular national geodetic reference system in a country. In case of the lost or disputed boundary of a land parcel, it is

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this record or register that takes the precedence over marks on the ground (Ali, 2015).

Study Area

The study area is located close to the Ahmadu Bello University Zaria, in Kaduna State, North West Nigeria. The layout has a total of plots of 1000 as design according to the laws of Kaduna State Urban Planning Development Agency (KASUPDA) and 12 out of the plot were used for this study. The study area is located within Latitude 07°39'29"E and 07°40'15"E and Longitude 11°10'10"N and 11°09'12"N.

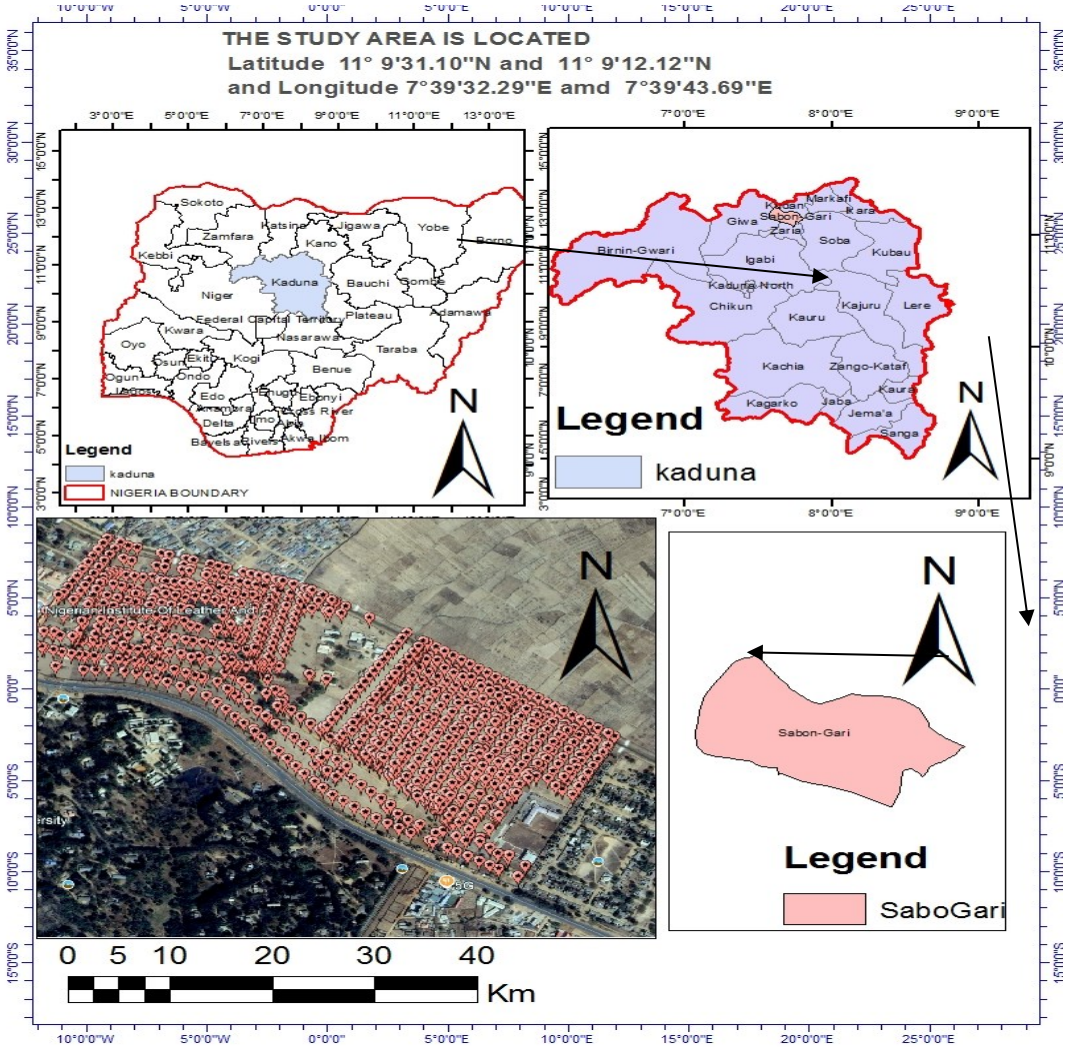

Figure 1: Satellite image and map of the study area.

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Materials and Method

The methodology flowchart adopted in this research is shown in (figure 2). A field survey was carried out using Differential Global Positioning System (DGPS) and Total Station respectively to acquire coordinates of perimeter boundary of the entire study area, each fixed parcel boundary point and Ground Control Points (GCPs) for Geo-referencing the acquired satellite image. After Geo-referencing, the cadastral boundaries for each of the plot were extracted from the layout design on image. Ground Survey method, using the instruments was adopted for observations and setting out of the points for each parcel of land extracted from the satellite image.

Data acquisition

The data used in this study are mainly primary data (coordinate x, y) acquired using DGPS and Total Station instruments. The instruments were used to measure the position of points on the ground and also provided ground control points (GCPs) required for Geo-referencing the satellite image and geometric correction during the pre-processing. In order to locate its position, the receiver gets signals from at least five satellites which were maintained in this study for the better quality of data streaming. It involved direct field observation and measurement of hedges to obtain geometric data using a Sokkia GRX2 Differential Global Positioning System (DGPS) instrument. The acquired data were processed using Sokkia GRX2 utility software leading to the production of a cadastral survey plan.

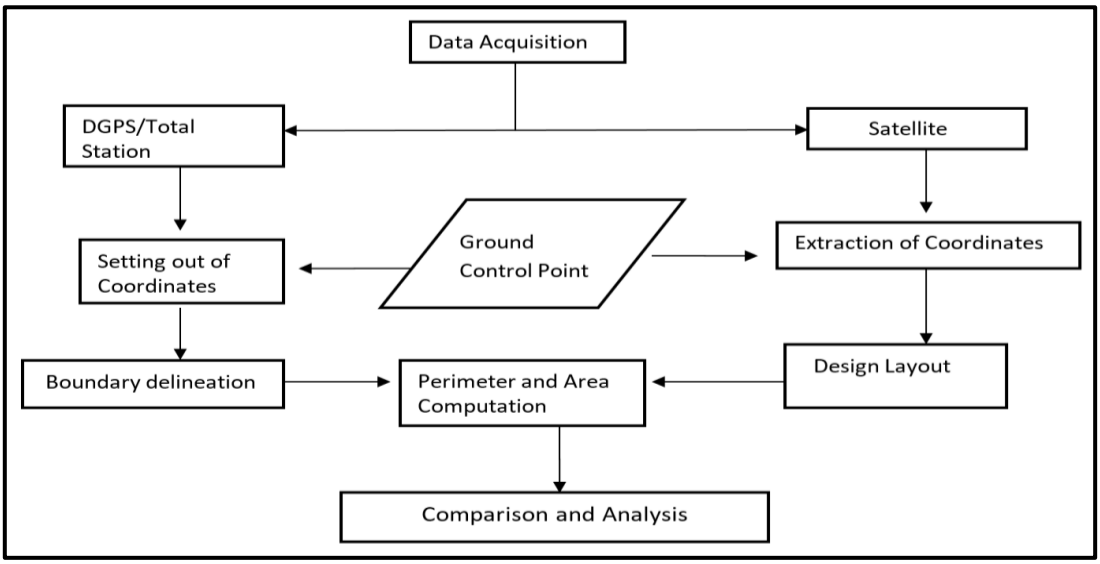

Figure 2. Methodology flowchart for the study. Ground Survey

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Data quality

Control check

Control checks are necessary where a surveying work is to be tied to reference points. This is to ascertain whether the control pillars are in-situ or not. From the check carried out it shows that the control pillars are *in-situ*.

Table 1 shows the level of satisfaction to which the work had been carried out. Though a lot of factors stand to impede the quality of the data this work had been carried out to ensure very high quality by using precise control point in for the fieldwork.

Table 1: Control check data table

Name	Existing E(m)	Observed E(m)	Diff. (m)	Existing N(m)	Observed N(m)	Diff. (m)	Remark
FGN 45	1233265.864	1233265.862	0.002	354074.937	354074.935	0.002	OK
FGN 46	1233340.359	1233340.356	0.003	353896.421	353896.420	0.001	OK
GN 47	1233135.736	1233135.734	0.002	354076.330	354076.333	0.003	OK

DGPS/ Total Station Observations

Being aware of the various sources of errors in all GPS and Total Station observations, the study ensured that during the observation with DGPS, canopy covering was avoided as much as possible for a better reception from satellites bearing in mind the Geometric Dilution of Precision (GDOP). The GDOP was monitored throughout the observation period to make sure that it was ≤ 2. To avoid error from multipath, obstructions were avoided.

RESULTS AND DISCUSSION

Analysis using the plot Area comparison

The total study area acquired using Global Positioning System was 596000.823m^2 while that of the Total Station was 596000. 700m^{2}respectively. The differences could have been as the result of error during observations. Figure 3 is the bar chart showing the comparison of the two instruments adopted in the study.

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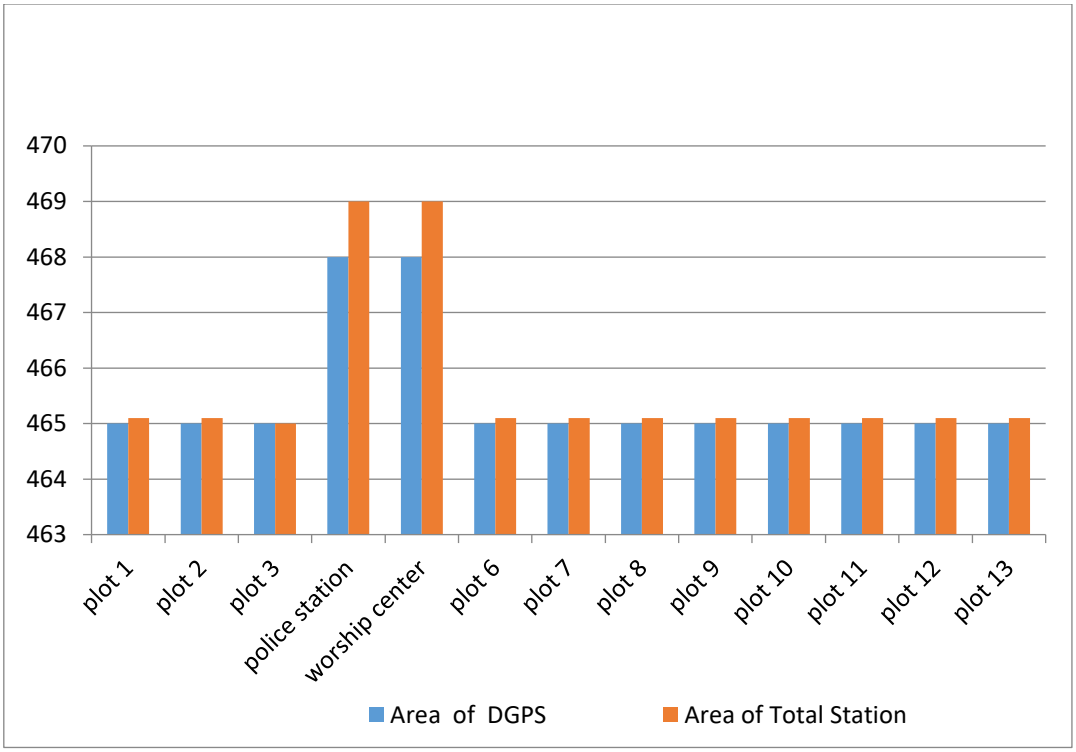
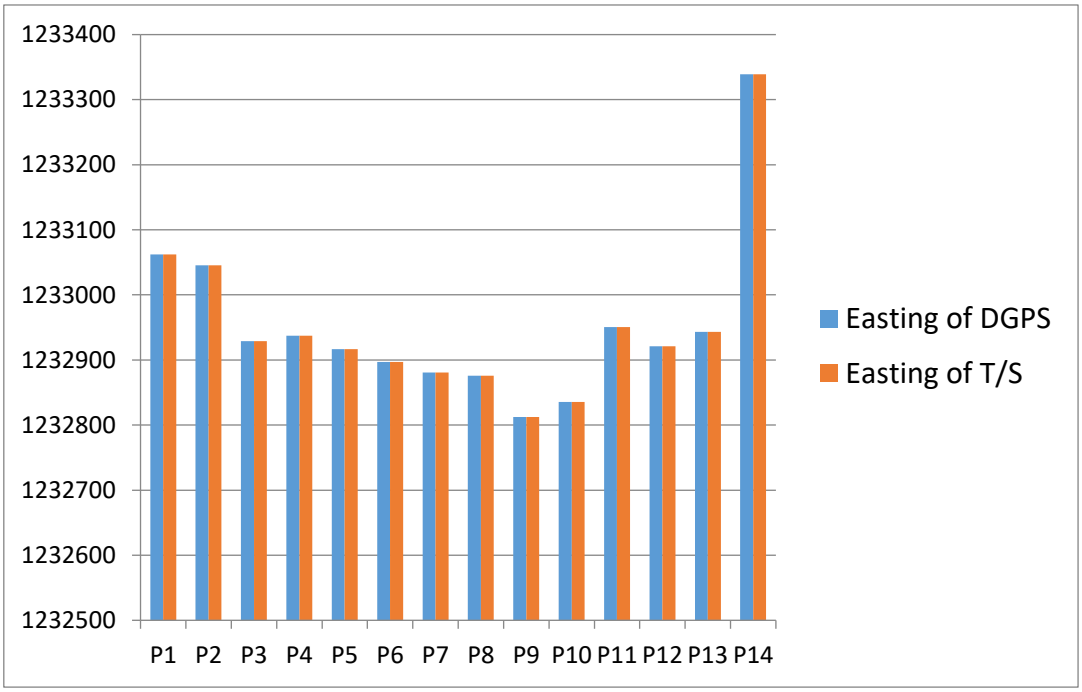


Figure 3: Bar chart comparison area for DGPS and Total Station

(a)



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(b)

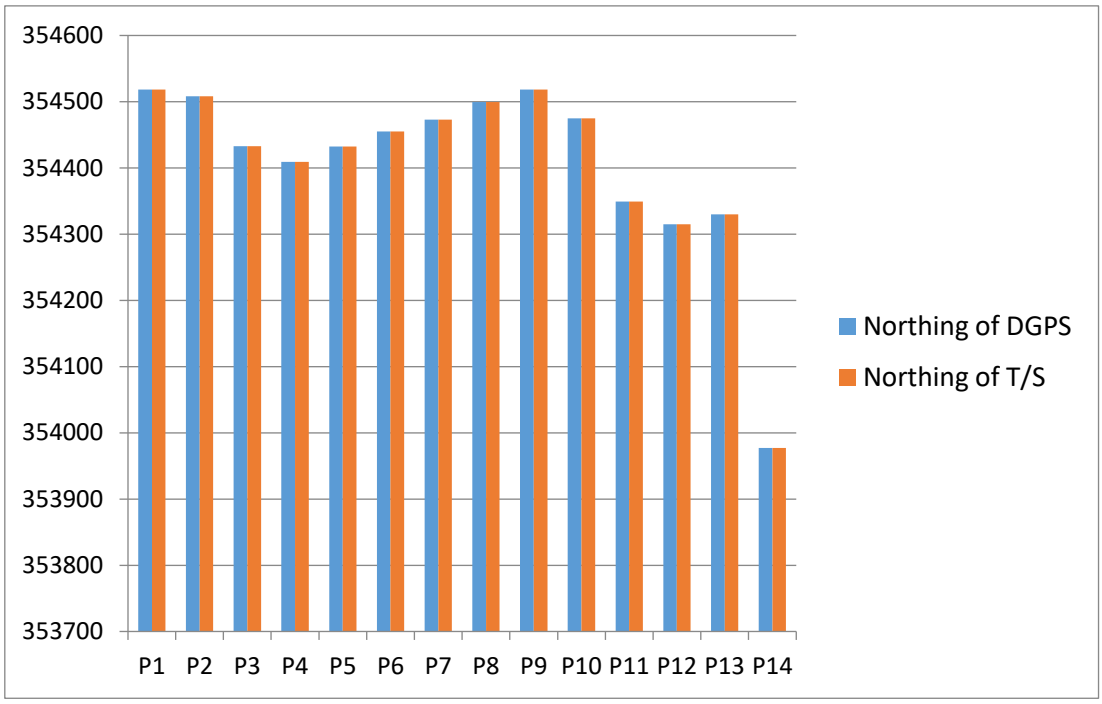

Figure 4: Comparison between DGPS and Total Stations in the (a) Easting, (b) Northings

Analysis using Coordinates comparison

The results in (figure 4a, b) show that the two sets of coordinates are close and their differences are within the acceptable international value of 1m according to (Toringe, 2013). The analysis of the result shows a standard deviation value of 0.013m in the Easting coordinate and 0.005m in the Northing coordinate respectively. This indicates that the Northing coordinate is more precise than the Easting coordinate

Analysis using correlation coefficient

In correlation analysis, the values of correlation coefficient (r) lie between negative one (-1) and positive one (+1), when the value of r = – 1, it indicate a perfect linear relationship with a negative slope. It also implies that there is a decrease in the Y axis and an increase in the X direction. When the values of r = +1 it indicate a perfect linear relationship with a positive slope. This also means that there is an increase in both the Y and X axis.

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The data used in the study were examined using correlation extension in micro soft excel. The observed Eastings and Northings using DGPS and Total Station were correlated. The result in (Table 2) gave a correlation coefficient value of R^2 = 0.999999988 in the Northing coordinates while that of the Easting gave a value of R^2 = 0.999999998 respectively. The result shows that the values of R^2 are close to 1 which is an indication that the coordinates are well (highly) correlated in the eastings and northings (X and Y axis) directions. The errors in Table 2 emanated from GPS observation due to cycle slip and probably GDOP during data streaming and in using the Total S

Table 2. Coordinate Differences

	Easting (m)		Diff (m)	Northing (m)		Diff (m)	Position Diff (m)
POINTS	**DGPS**	**TOTAL STATON**		**DGPS**	**TOTAL STATION**		
P1	1233062.326	1233062.327	-0.001	354518.165	354518.162	0.003	0.000
P2	1233045.526	1233045.530	-0.004	354508.181	354508.185	-0.004	0.000
P3	1232929.018	1232929.017	0.001	354432.773	354432.775	-0.002	0.000
P4	1232937.482	1232937.435	0.047	354409.085	354409.079	0.006	0.002
P5	1232916.79	1232916.77	0.020	354432.339	354432.329	0.010	0.000
P6	1232896.96	1232896.98	-0.020	354454.968	354454.967	0.001	0.000
P7	1232880.942	1232880.943	-0.001	354472.991	354472.981	0.010	0.000
P8	1232875.844	1232875.839	0.005	354499.408	354499.409	-0.001	0.000
P9	1232812.648	1232812.639	0.009	354518.237	354518.228	0.009	0.000
P10	1232835.411	1232835.413	-0.002	354474.664	354474.667	0.003	0.000
P11	1232950.644	1232950.646	-0.002	354349.107	354349.105	-0.002	0.000
P12	1232921.044	1232921.043	0.001	354314.847	354314.846	0.001	0.000
P13	1232943.199	1232943.189	0.01	354329.649	354329.639	0.010	0.000
P14	1233339.094	1233339.091	0.003	353977.135	353977.131	-0.004	0.000
P15	1233328.665	1233328.667	0.002	353967.837	353967.839	-0.002	0.000
P16	1233298.232	1233298.232	0.000	353940.575	353940.575	0.000	0.000
P17	1233259.295	1233259.293	0.002	353912.525	353912.527	-0.002	0.000
P18	1233276.598	1233276.595	0.003	353889.979	353889.976	-0.003	0.000
P19	1233297.648	1233297.644	0.004	353869.891	353869.895	-0.004	0.000
P20	1233320.013	1233320.011	0.002	353848.791	353848.595	0.001	0.000
Mean	1233056.369	1233056.365	0.00395	354256.057	354256.055	0.0015	
Std	194.56606	194.56767	0.01251	264.10785	264.10644	0.0496	
Var	37855.9548	37856.577	1.57-E04	69752.958	69752.211	2.46-E5	
R^2	**0.999999998**			**0.999999988**			

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Analysis using time comparison

Using the time of completion as a comparison factor, the survey work when using Global Positioning System took five (3) days for its completion while that of the Total Station took three (5) days for the fieldwork, which was less economical and consumed more time. This implies that producing a cadastral map using Differential Global Positioning System is faster compared to Total Station in the ground survey method.

CONCLUSION AND RECOMMENDATIONS

The study has shown good potentials on the use Total Station and DGPS for cadastral surveying. This study integrates the probability of adopting DGPS for a direct method of cadastral surveying to achieve high precision with low cost and within an appropriate time. The accuracy assessments of DGPS and Total Station for cadastral surveying have been discussed. A comparison between parcel boundaries acquired from the two techniques was carried out and proved to be effective and useful for cadastral surveying. Some parcel area with value for DGPS as 750 m^2 and 744m^2 for Total Station respectively, the entire perimeter of the area with a value for DGPS as 596000.823m^2 and 596000. 700m^2 for Total Station respectively and period for both methodologies adopted were compared alongside human resources involved.

Correlation coefficient analysis was carried out on the coordinate for the two techniques and the result shows highly correlated. The observed Eastings and Northings using DGPS and Total Station were correlated. The correlation coefficient value of R^2 =0.999999988 in the Northing coordinates while that of the Easting gave a value of R^2 = 0.999999998 respectively. The result shows that the values of R^2 are close to1 which is an indication that the coordinates are well (highly) correlated. The comparisons show that parcel boundaries can be determined with acceptable precision and accuracy meeting the requirement for cadastral surveying. It was also discovered that the use of DGPS is more suitably, economically and easy in setting out of plots in cadastral survey in urban and regional planning.

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