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Accuracy of Handheld GPS compairing with Total Station in Land Use Survey: A Case Study in RUET Campus

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ABSTRACT: Global Positioning System (GPS) has become as an important tool in land use study. Using GPS, it is possible to conduct survey with less manpower and less time. In this study, land use analysis was carried out using handheld GPS and Total Station. Campus of Rajshahi University of Engineering & Technology (RUET) was selected as the study area for this study. Garmin GPS was used to locate ground position and track logs of different objects within the study area. Handheld GPS could receive and track satellite signals between 0 to 3 meters of positional accuracy. The aim of the study was to compare the land use survey results conducted by both GPS and Total Station. Primary input for mapping the whole study area was GPS readings which were collected during the field survey. GPS readings were processed using some software i.e. Map source, Google Earth, Google Sketch up, Auto CAD, Photoshop and developed land use map. This paper is an attempt to evaluate the performance of handheld GPS in land use survey. Precision of handheld GPS is low. Accordingly, the results of the GPS survey indicates about 12% errors compared with the results of Total Station survey. However, handheld GPS is recommendable to conduct preliminary survey and where there is scarcity of manpower and time.

KEYWORDS: Land use Survey, Handheld GPS, Total Station, Google Earth, AutoCAD, RUET.

1 INTRODUCTION

The Global Positioning System (GPS) is an all-weather, space based navigation system. A GPS receiver can fix its latitude and longitude by calculating its distance from three or more Earth-orbiting satellites, whose positions in space and time are known. If four or more satellites are within the receiver's "horizon," the receiver can calculate its elevation, direction of travel and even its velocity. Errors inherent in the system dilute the repeatable horizontal accuracy of the computed position to a level of 20 to 100 meters. Actual position of an object is somewhere within a circle which has a radius measuring from 20 to 100 meters.

Conventional terrestrial survey method, such as Total Station, is used in land surveying with great efficiency, reduces field survey and permits to accelerate data acquisition with highest accuracy. Total Station (TS) combine an Electronic Distance Measurement (EDM), an electronic digital theodolite, and a computer in one unit. The device automatically measure horizontal and vertical angles, as well as distances, and transmit the results in real time to a built-in computer. The horizontal and vertical angles and slope distance can be displayed, and then upon keyboard commands, horizontal and vertical distance components can be instantaneously computed from these data and displayed. If the instrument is oriented in direction and the coordinates of the occupied station are input to the system, the coordinates of any point sighted can be immediately obtained. This data can also be stored within the instrument, thereby eliminating manual recording.

The aim of this study is to compare the results of handheld GPS survey with that of a survey conducted with TS. The paper will address the performance and accuracy comparisons between handheld GPS and total station on land use data. The campus of Rajshahi University of Engineering & Technology (RUET) was selected as the study area to test the performances and accuracy of handheld GPS and TS on land use data.

2 METHODOLOGY

For the implementation of any work, planning is essential and a step by step procedure of work should be followed from beginning to end of the work. In this case study we have planned to proceed in a systematic way.

At the beginning of the study, the whole campus area of RUET was surveyed using TS. A detail master plan was developed from the TS data and total land area, water body, greenery, open space and infrastructures are analyzed and mapped. Though the TS survey is more time consuming and laborious, the land use analysis and necessary survey results from this TS survey are considered as error free. This land use map is utilized to compare with GPS survey results. Afterwards, the same field parameters within the study area were surveyed using handheld GPS. Two models of GARMIN handheld GPS were used during the field survey. GPS used to identify the geographical location and positions of different building structures, water bodies, open spaces etc. Later, GPS data were processed to prepare the master plan of RUET. Finally the results of the GPS survey were compared with TS survey result to assess the performance and accuracy of handheld GPS.

Although GPS survey has so many advantages compared to conventional terrestrial survey methods, GPS has some limitations. For examples, in cases of failing to track sufficient GPS satellites due to the overhead obstructions, GPS can't work properly. In these events, inaccessible places are marked using some way points.

3 RECONNAISSANCE SURVEY

Proper field reconnaissance is a prerequisite for land use survey. The previous master plan of RUET, done by Total Station method, was used to select the control points of the GPS survey. This map provides required information like: location of boundary walls, roads, water bodies, buildings, agricultural lands and other open spaces. General information about topography of area helped to design the realistic observation schedule. The reconnaissance survey also helped to figure out about the inaccessible points within the RUET campus such as infrastructures, road network, low lands, ditches and agricultural lands. Moreover, densely accumulated tall trees in RUET campus were the main obstructions to direct open sky contact. Due to inadequate direct sky contact signal error occurs and the GPS device cannot work properly. In this unavoidable situation we have to proceed by trial and error method. So the inaccessible places were avoided by choosing way point method. In that case the way points were fixed up in the accessible points. Further we re-adjusted the position in Google earth to reduce the error level.

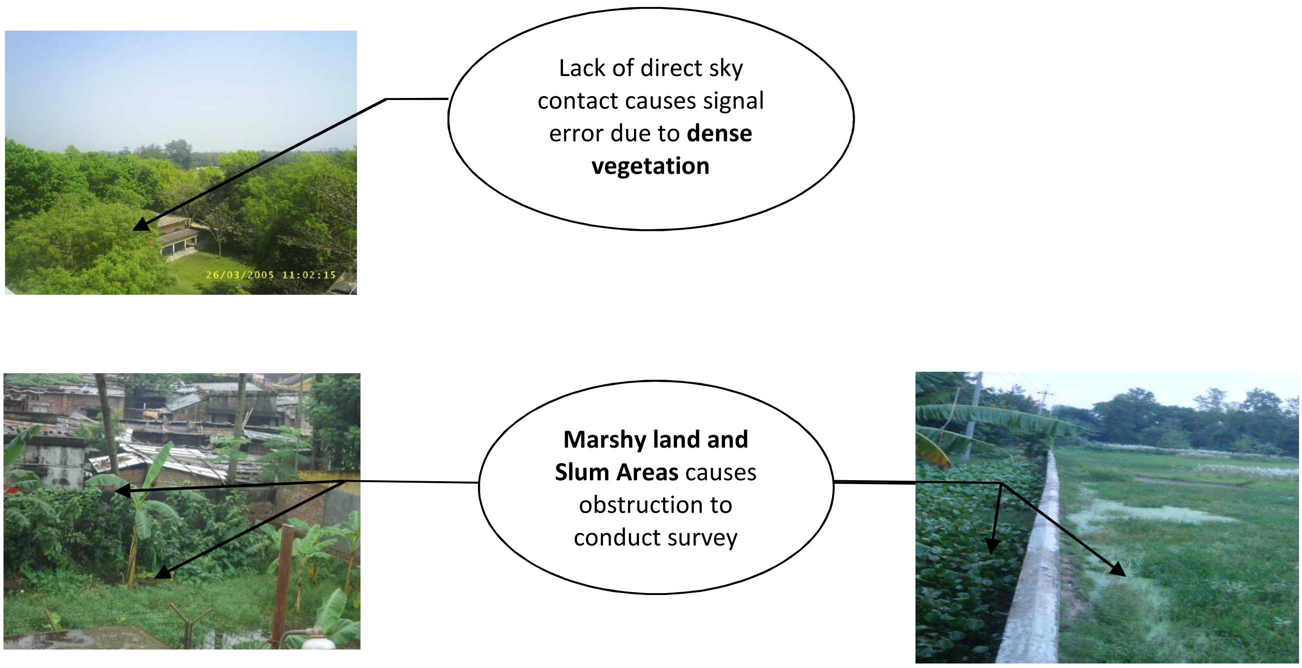
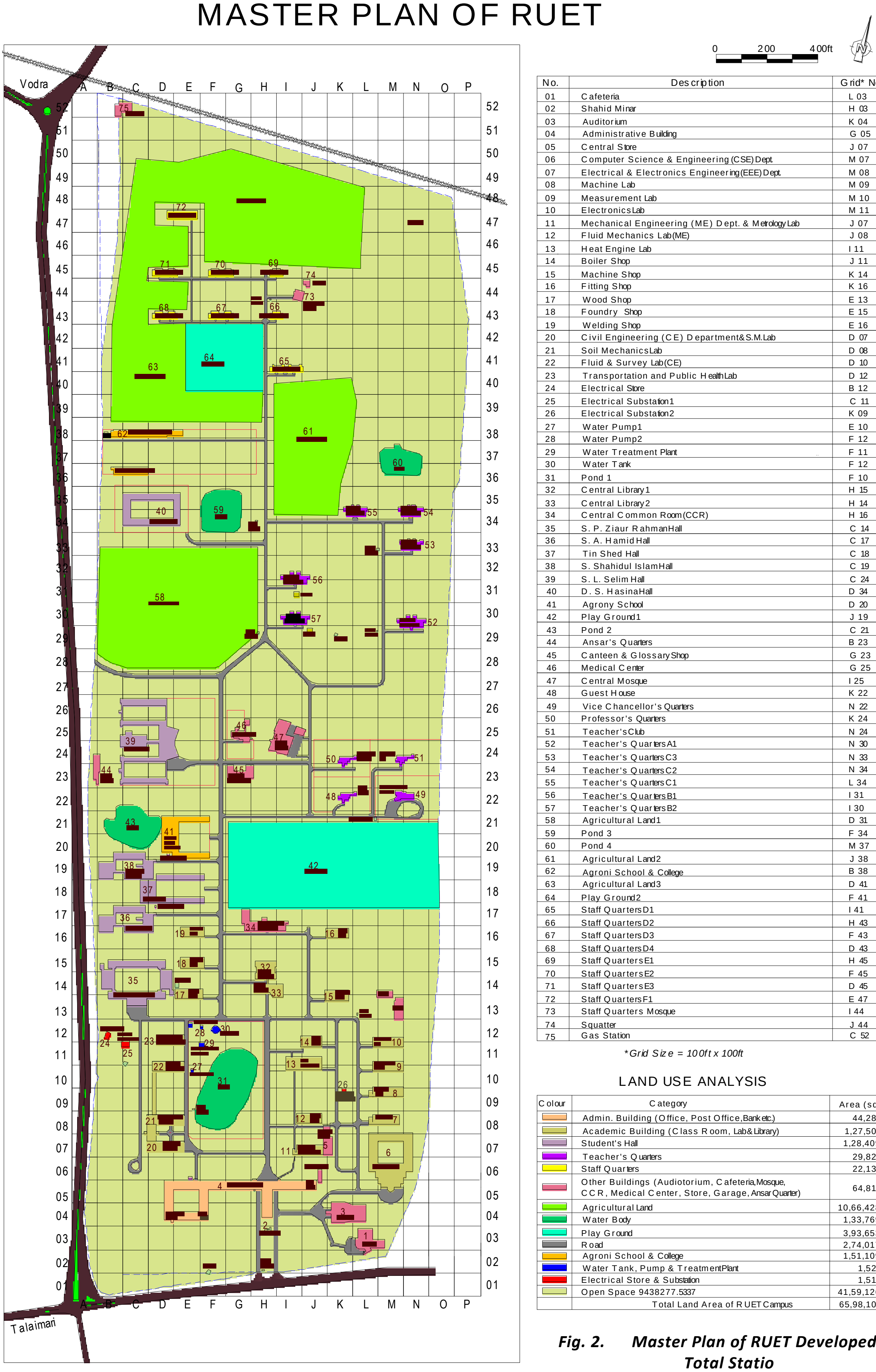


Fig.1. Problematic places during field survey

Fig.1 shows the inaccessible places of RUET campus.

MASTER PLAN OF RUET



No.	Description	Grid* No.
01	Cafeteria	L 03
02	Shahid Minar	H 03
03	Auditorium	K 04
04	Administrative Building	G 05
05	Central Store	J 07
06	Computer Science & Engineering (CSE) Dept.	M 07
07	Electrical & Electronics Engineering (EEE) Dept.	M 08
08	Machine Lab	M 09
09	Measurement Lab	M 10
10	Electronics Lab	M 11
11	Mechanical Engineering (ME) Dept. & Metrology Lab	J 07
12	Fluid Mechanics Lab (ME)	J 08
13	Heat Engine Lab	I 11
14	Boiler Shop	J 11
15	Machine Shop	K 14
16	Fitting Shop	K 16
17	Wood Shop	E 13
18	Foundry Shop	E 15
19	Welding Shop	E 16
20	Civil Engineering (CE) Department & S.M.Lab	D 07
21	Soil Mechanics Lab	D 08
22	Fluid & Survey Lab (CE)	D 10
23	Transportation and Public Health Lab	D 12
24	Electrical Store	B 12
25	Electrical Substation 1	C 11
26	Electrical Substation 2	K 09
27	Water Pump 1	E 10
28	Water Pump 2	F 12
29	Water Treatment Plant	F 11
30	Water Tank	F 12
31	Pond 1	F 10
32	Central Library 1	H 15
33	Central Library 2	H 14
34	Central Common Room (CCR)	H 16
35	S. P. Ziaur Rahman Hall	C 14
36	S. A. Hamid Hall	C 17
37	Tin Shed Hall	C 18
38	S. Shahidul Islam Hall	C 19
39	S. L. Selim Hall	C 24
40	D. S. Hasina Hall	D 34
41	Agrony School	D 20
42	Play Ground 1	J 19
43	Pond 2	C 21
44	Ansar's Quarters	B 23
45	Canteen & Glossary Shop	G 23
46	Medical Center	G 25
47	Central Mosque	I 25
48	Guest House	K 22
49	Vice Chancellor's Quarters	N 22
50	Professor's Quarters	K 24
51	Teacher's Club	N 24
52	Teacher's Quarters A1	N 30
53	Teacher's Quarters C3	N 33
54	Teacher's Quarters C2	N 34
55	Teacher's Quarters C1	L 34
56	Teacher's Quarters B1	I 31
57	Teacher's Quarters B2	I 30
58	Agricultural Land 1	D 31
59	Pond 3	F 34
60	Pond 4	M 37
61	Agricultural Land 2	J 38
62	Agroni School & College	B 38
63	Agricultural Land 3	D 41
64	Play Ground 2	F 41
65	Staff Quarters D1	I 41
66	Staff Quarters D2	H 43
67	Staff Quarters D3	F 43
68	Staff Quarters D4	D 43
69	Staff Quarters E1	H 45
70	Staff Quarters E2	F 45
71	Staff Quarters E3	D 45
72	Staff Quarters F1	E 47
73	Staff Quarters Mosque	I 44
74	Squatter	J 44
75	Gas Station	C 52

*Grid Size = 100ft x 100ft

LAND USE ANALYSIS

Colour	Category	Area (sq.ft)
	Admin. Building (Office, Post Office, Bank etc.)	44,286
	Academic Building (Class Room, Lab & Library)	1,27,501
	Student's Hall	1,28,409
	Teacher's Quarters	29,823
	Staff Quarters	22,130
	Other Buildings (Audiotorium, Cafeteria, Mosque, CCR, Medical Center, Store, Garage, Ansar Quarter)	64,814
	Agricultural Land	10,66,428
	Water Body	1,33,769
	Play Ground	3,93,653
	Road	2,74,017
	Agroni School & College	1,51,109
	Water Tank, Pump & Treatment Plant	1,529
	Electrical Store & Substation	1,514
	Open Space 9438277.5337	41,59,126
	Total Land Area of RUET Campus	65,98,101

Fig. 2. Master Plan of RUET Developed by Total Statio

Fig.2 shows the master plan of RUET developed from TS survey.

4 GPS SURVEY

4.1 CALIBRATION OF HANDHELD GPS

Before conducting the field survey, the GPS machine is calibrated. Conventional chain, tapes and GPS were used to verify differences in linear measurements. As well, area measurements were also done both manually and GPS. Then the two measurements were compared and error calculated.

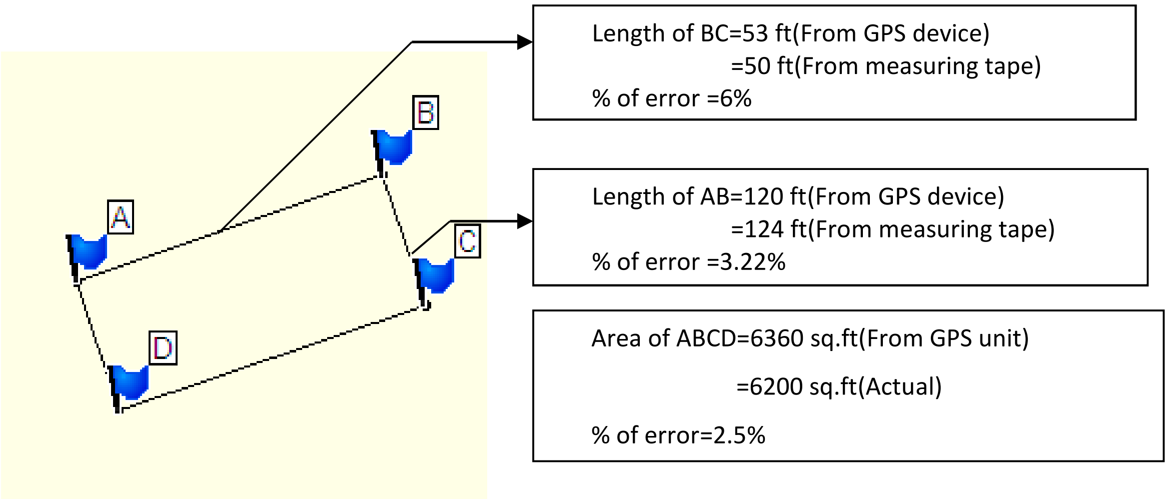


Fig.3. Calibration of GPS device

Fig.3 shows calibration of GPS device.

Error levels of handheld GPS are then computed and presented in Table 1.

Table 1: Estimation of Error in Handheld GPS Measurement

Linear Measurement (ft)				Area Measurement (sq. ft)		
No.	**GPS Length**	**Actual Length**	**Error (%)**	**GPS Area**	**Actual Area**	**Error (%)**
01	55	57.00	3.63%	2553	2346.00	8.10%
02	85	79.59	6.36%	2648	2514.24	5.05%
03	90	87.00	3.33%	3286	3213.40	2.20%
04	100	98.00	2.00%	4567	4375.40	4.19%
05	100	105.00	5.00%	5225	5229.00	0.07%
06	100	94.16	5.84%	6289	6174.20	1.82%
07	125	121.47	2.82%	6543	6296.20	3.77%
08	200	194.74	2.63%	7359	7337.72	0.29%
09	220	216.66	1.52%	8225	7741.18	5.88%
10	250	246.84	1.26%	10215	10199.70	0.15%
Average Error			**3.24%**	**Average Error**		**3.15%**

From the above data, it is found that the GPS device traces less measurement for large distance and large measurement for small distance. From the calibration result the error level for linear measurement lies between 1% to 6.5% and for area measurement the error level lies between 0.15% to 8.1%. Finally we have reached to a decision that the error level of GPS device lies between o.50 % to 8 % and the average error is about 4%.

4.2 Field Survey With GPS

After calibration of GPS devices, field surveying was conducted using two GPS devices. One GPS device was particularly kept for fixing permanent objects by choosing way points and another GPS was used for counting area by track logs. Waypoints are sets of coordinates that identify a point in physical space. For terrestrial navigation these coordinates can include longitude and latitude. The GPS track log is an electronic breadcrumb trial that shows the path that the travelers have traveled. The GPS track log points are often captured in latitude and longitude using WGS 84 datum. Some portion of boundary wall, all physical structures and infrastructures are fixed by waypoints. Ponds, open space, road network, play grounds and low lands are surveyed by track logs.

4.3 Development of Maps and Land use Analysis

Basically the land use pattern consists of varied shapes of polygons. It is better to define the concepts of parent-polygon and children-polygon. For example, a polygon Y is divided into two polygons Y1 and Y2. Then, relative to Y1 and Y2, polygon Y is called the parent-polygon of Y1 and Y2 polygons and, Y1 and Y2 are called the children-polygons of polygon Y. Accordingly the land use pattern can be classified into two groups: (1) one parent-polygon is divided into several children-polygons, and there is no border merging relationship between parent-polygon and children-polygons; (2) one parent-polygon is divided into several children-polygons, and there is border merging relationship between parent-polygon and children-polygons (Lin, 2003).

The fundamental principles upon which the surveying is being carried out are working from whole to part. So the location and position of boundary wall of RUET were fixed first. Then the whole campus was sub-divided into several smaller zones. Each smaller zone was then surveyed maintaining the survey schedule. Subsequently GPS data were posted to the GARMIN software known as 'Map Source'. Using Map Source and Google Earth, each and every position was traced separately. In some events, GPS survey was repeated where there were some errors.

- GPS data was the input for Map Source. With the help of Map Source software, track logs draw the ground coverage of different objects in the study area. From the track logs, the total land area of RUET and area of all other physical structures, agricultural lands, play grounds and open space were mapped and computed.
- Map Source data were then transferred in Google Earth and the positions of different objects were compared with the Google Earth's aerial image. To reduce the variation of field data comparing with Google Earth image, field survey was repeated for some cases. The revised data was modified in Google earth and the position (North-East) of different objects were readjusted.
- The whole aerial image of RUET was divided into several parts and enlarged to redraw the survey elements in AutoCAD.
- Enlarged satellite image of whole RUET campus were knitted together in Adobe Photoshop and kept in CAD to draw the map of whole RUET campus.
- Finally, Google Sketch-Up was used to develop the 3D image of the built up area of RUET with some animation. Figure 7 provides 3D image of RUET campus.
- From AutoCAD, all necessary land use calculation was performed. The results from this calculation were the basis of comparison with TS survey. Table 2 presents the summary of this comparison and error level.

Table 2: Summary of Land Area by GPS Survey & Estimation of Error

Category	**Description**	**Land Area (in Acre) by GPS**	**Land Area (in Acre) by Total Station**	**Error (%)**
Administrative Buildings	Office, Bank & Post Office	1.09	1.02	7.06
Academic Building	Class Rooms & Labs	3.49	3.31	5.58
Residential Buildings	Students Halls	2.73	2.78	1.65
	Teacher's Quarters	0.79	0.65	22.76
	Staff Quarters	0.53	0.51	5.29
Related Facilities	Cafeteria, Canteen & Auditorium	0.57	0.56	1.78
Tin Shed Buildings	Tin Shed Hall & Garage	0.68	0.66	9.65
Water Supply Facilities	Water Tank, Pump House & Treatment Plant	0.04	0.04	15.66
Others Buildings	CCR, Mosque, Medical Centre, Guardrooms & Electric Sub-Stations	1.32	1.03	28.44
Water Body	Ponds & Ditches	2.49	3.02	17.27
Agricultural Land	All Agricultural Lands	41.06	38.08	12.2
Playground	Cricket, Football, Basketball & Tennis Field	6.87	6.65	10.67
Open Space	All Open Fields	84.09	105.90	20
Road	All Roads	6.20	6.27	1.11
Total Land Area of RUET (in Acre)		152.00	151.77	11.37

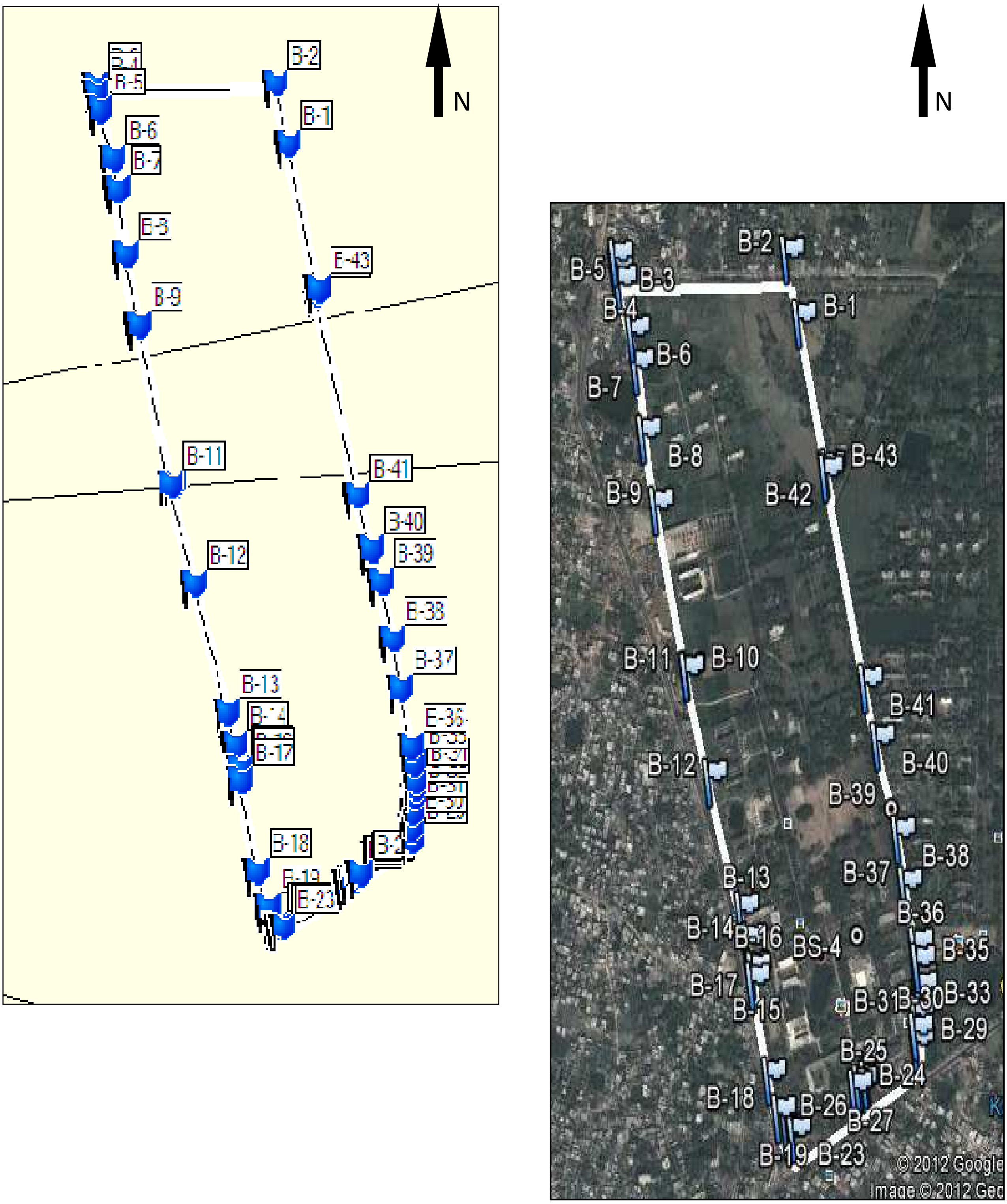


Fig.4. Waypoints of boundary of RUET campus in Map-Source and Google-Earth

Fig.4 shows boundary position of RUET campus

Fig.5. Waypoints of buildings of RUET

Fig.5 shows the spatial position of buildings of RUET in Google-Earth

5 LAND USE MAPPING

The final map of RUET Campus is prepared in Auto CAD which is plotted on grid. The grids are numbered according to latitude and longitude. From the grid zone, the position of different object can easily find out.

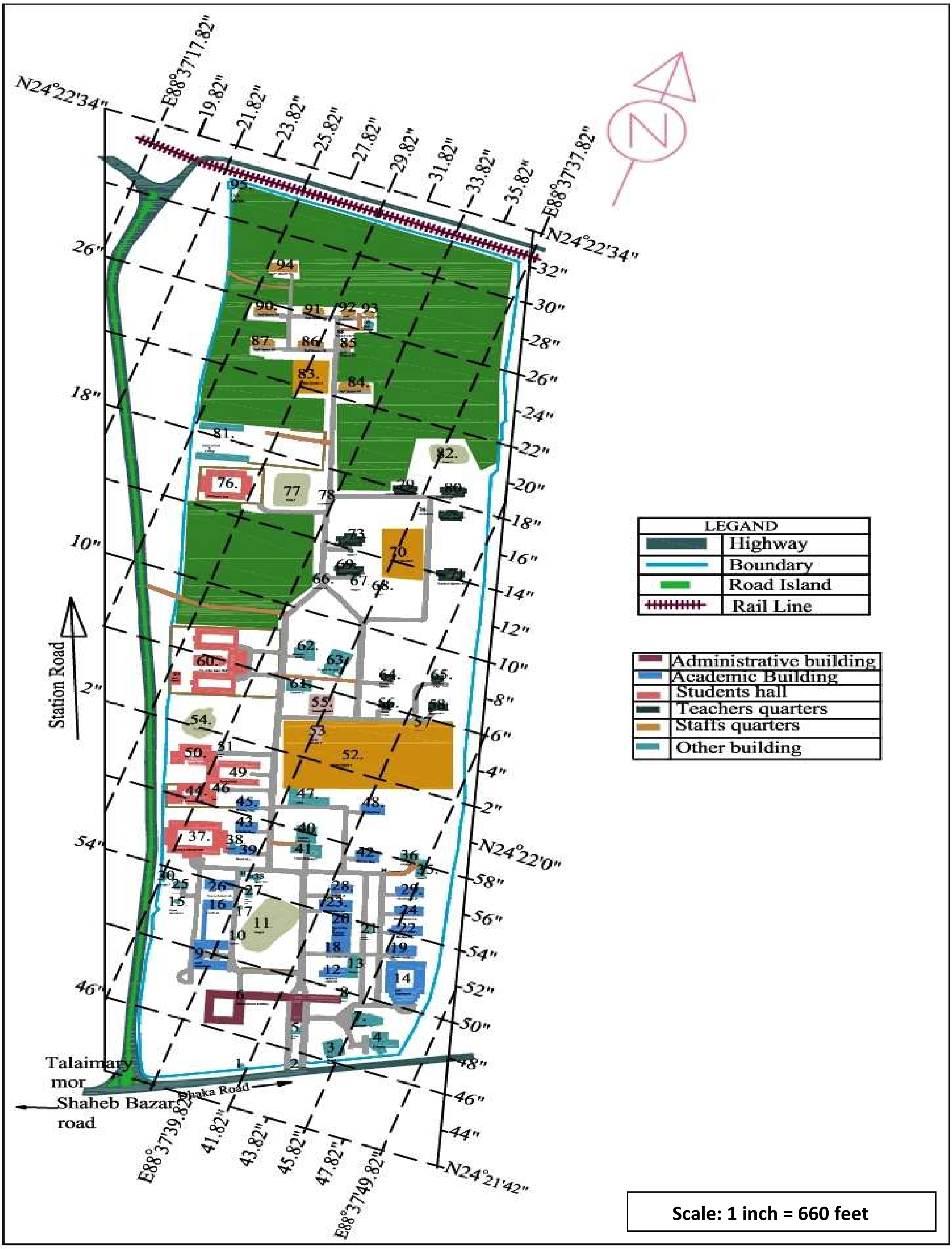


Fig.6. Land use Map of RUET

Fig.6 shows the Geographical position & location of RUET campus

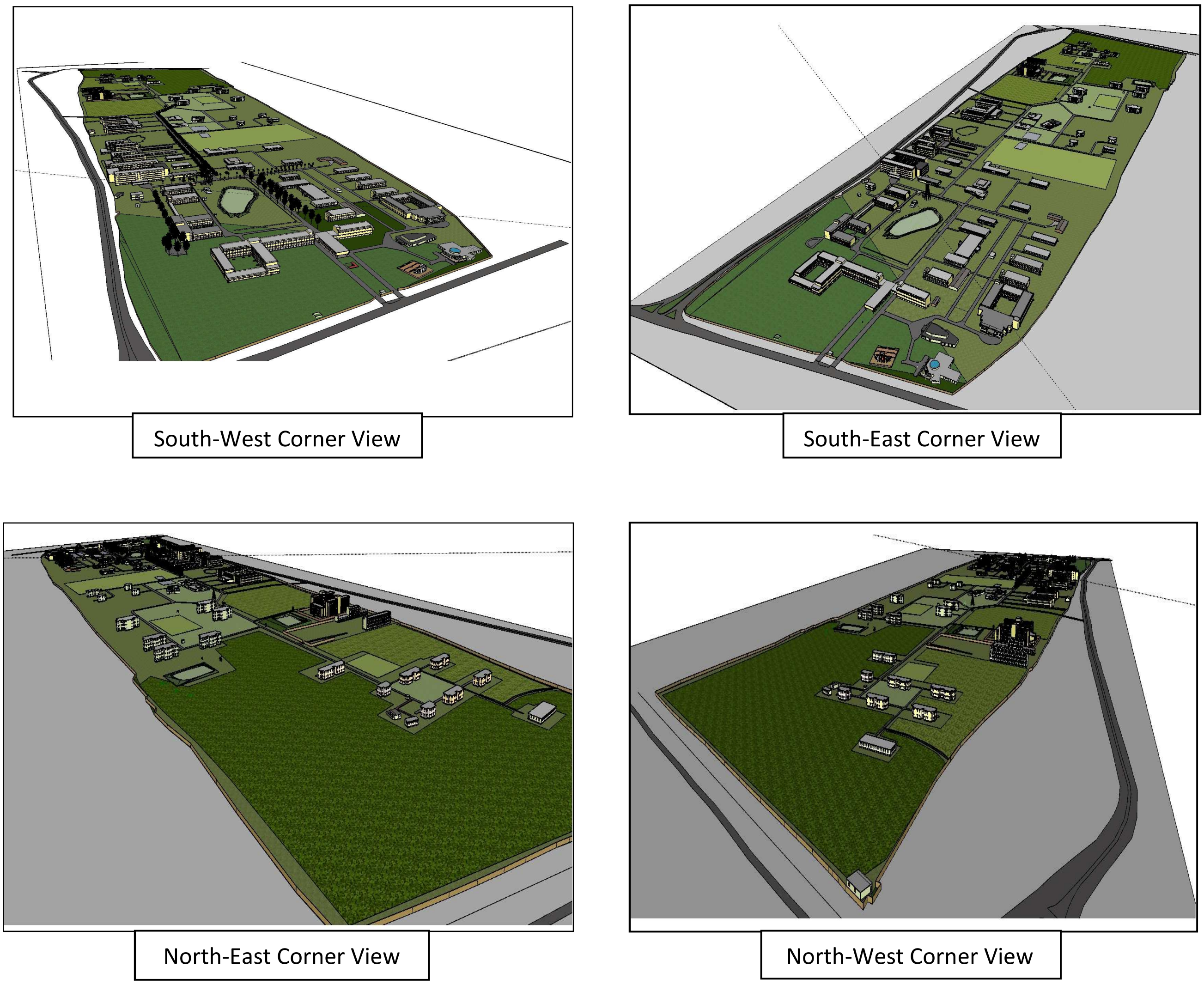


Fig.7. 3D View of RUET Campus using Google Sketch-Up

Fig.7 shows the 3D view developed in Google Sketch-Up

6 CONCLUSION

In the early era, the surveying was conducted by various conventional methods which require more manpower, more time and with less accuracy. GPS replaced conventional surveying method that often employ theodolite, level or total station because this technology that has been extended in various fields that measure geographical coordinates, velocity and time with astonishing speed and accuracy. Its effects in research field become also important.

The accuracy of handheld GPS is not high. So it is not recommendable to use handheld GPS in any precise survey, rather it can be used in preliminary survey. Specially, if there are scarcity of manpower and time, handheld GPS can sketch out the study site quickly. Comparing the survey results conducted in RUET campus it was found that the there are ample difference between TS and hand GPS. The average error level is about 11.37%. Due to the low accuracy of handheld GPS and due to signal blockages, hand GPS produces erroneous results.

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