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Facility Mapping of Street Lighting in Rivers State University Main Campus, Port Harcourt: Nigeria

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Abstract
The use of location-based technology provides a solution to complex, real-world problems for mapping the spatial location of features, planning, and management. The lack of adequate geospatial information on existing lighting facilities impedes works and physical planning departments of Rivers State University to accurately locate and respond to faulty lighting facilities. This prompted the study which is aimed to map the lighting facilities at Rivers State University main campus with the objectives of providing spatial and attribute information of lightening facilities, creation of a functional database of these facilities and identify their operational status. Secondary data such as projected coordinates of identified controls in Northings (m), Easting (m), and Ellipsoidal Heights (m) and shape file of Rivers State University were obtained from the data management unit of the Department of Surveying and Geomatics, Rivers State University. Global Positioning System data collection technique was utilized during field surveys to obtain primary data such as spatial and attributes data of the facilities with the aid of a Unistrong G970iipro RTKDifferential GPS and accessories with 2mm least count. The research noted numbers of functional and non-functional lightening facilities such as solar lights, transformers, electric street lights, among others. The result also showed that the roadways in the study area are well illuminated and have a high level of perceived safety and security at night. However, immediate repair and maintenance of the non-functional electric and solar lights cum providing lightning facilities in noted areas is necessary to ensure adequate lightening of the University main campus premises.

Key Words: Facility, Mapping, Location-Based, Lightening

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1. Introduction
Artificial lighting is strongly linked to urbanisation and is expanding in terms of scope, brightness, and spectral range. Changes in urban lighting have both positive and negative effects on city performance, but little is known about how the nature and magnitude of these changes vary across the urban landscape (Hale et al., 2013).

Mapping involves the action of a proposed plan for positioning or setting the positions of a designed feature. The purpose of mapping is to graphically represent a terrain feature or features which is projected onto a plan as part or whole of the earth surface. In this study, Streetlights are modelled as geo-spatial points on a separate map layer associated with attribute information. A handful of attributes reside in the database file to provide for record linking and to support canned map rendering functions, but most of the attributes reside in the database (Eze and Godwill 2022; Eze,et al, 2023).

Street light facilities are among a city's most important assets, providing safe roads and enhancing security. In order to bring efficiency, accountability and transparency in the entire process, a comprehensive GIS-based Street Light Information System is necessary to ensure that street lights facilities are in good condition at all times.

Facilities are designed and built to serve a specific purpose in an efficient manner. However, facility mapping is the process of identifying the spatial locations of these facilities in relation to one another and viewing their interactions at a glance. The procedure would aid in improving space planning and overall operational management. The primary goal of FM application development is to provide decision makers with a decision support system that will make utilities more efficient and effective (Makinde et al., 2017).

The lack of information on existing lighting facilities makes it difficult for the works department to locate and respond to faulty lighting facilities. The lack of an updated map of lighting facilities on the River State University main campus impedes accountability and quality service delivery. Because no records of these facilities are kept, some areas may be vulnerable to insecurity due to the lack of a lighting facility.

Officials of the institution face stiff challenges in obtaining information on historical maintenance records, ongoing and completed street light maintenance activities, for example - present conditions of the street lights - to make decisions.

As a result, a lighting facility map is required to guide the operations of the works and physical planning departments for proper decision-making in areas with limited or no lighting facilities. Also, to develop a comprehensive GIS database of all the lighting facilities on the campus field survey and mapping and implement a comprehensive Street Light Information System to introduce efficiencies into the system (Beyer and Ker, 2009).

The significance of this study is such that it will provide information on the position and working status of lighting facilities in the study area as field survey and up-to-date database of lightning facilities will be carried out. The study will also provide a mechanism for updating lighting facility maintenance details and tracking service history to the university's estate and works department

The Study Area

The Rivers State University main campus within Port Harcourt metropolis is located at Nkpolu – Oroworukwo in Port Harcourt Local Government Area of Rivers State, Nigeria. It is located between the following geographical coordinates: latitude 4˚ 47'54"N to 4˚ 48' 55"N and longitude 6˚ 59'23"E to 6˚ 58' 57"E. Rivers State University is surrounded by the Mile 3 market in the North, Agip Company in the West, Mile 2 Diobu in the East, and Eagle Island in the South. It has an approximate area of 177.098 hectares (Eze, Hart and Eke, 2022).

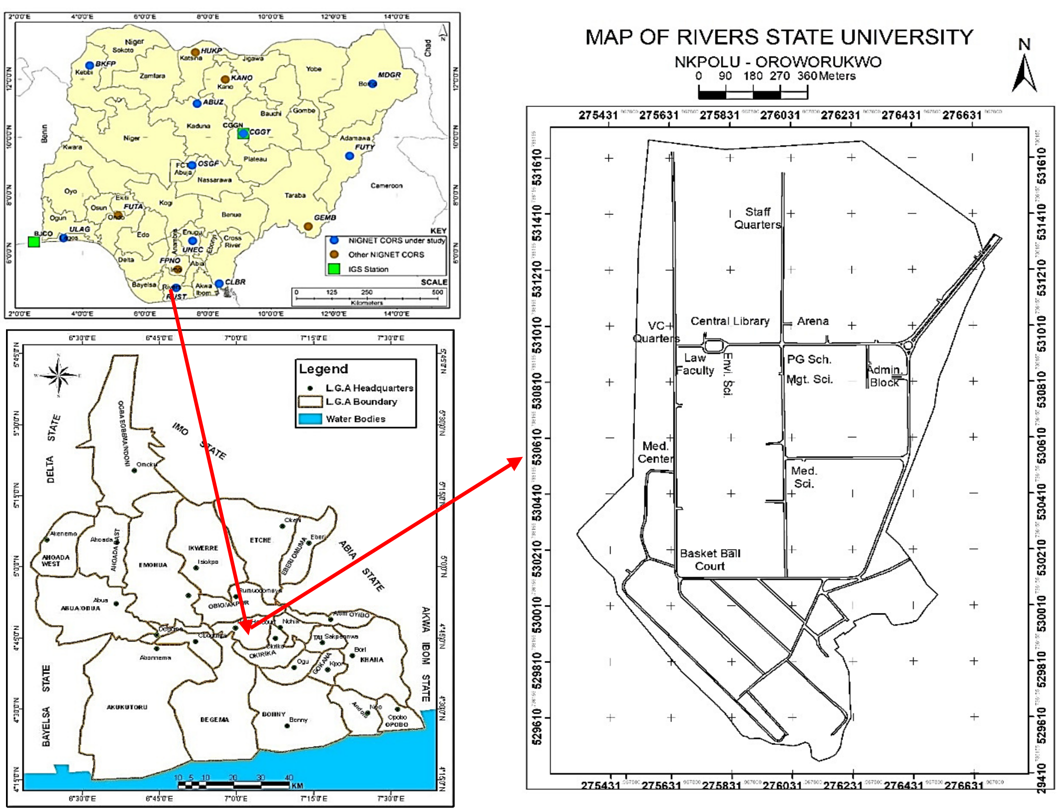

Figure 1.0: Map of study area (Author's concept, 2023)

2.0 Materials and Methods

2.1 Instrument / Equipment Used

The following equipment and instruments were deployed during the project.

1. Unistrong G970iipro RTKDGPS and accessories with 2mm least count
2. Radio / Telephone (Redmi Note 12, 6gig, 128 Ram)
3. Tripod stand

Hardware and Software Selection

i. DEL Latitude E6540 laptop installed with intel CORE i7, 8gig, 64-bits, Windows 10 operating system operating system.
ii. Printer
iii. Field books

Software Requirement

i. ArcGIS 10.3
ii. Integrated Land and Water Information System(ILWIS)
iii. AutoCAD (computer aided design).2007 version

The choice of ArcGIS 10.3 software is its capacity to perform vector based operations.

Research Methods

The methodology employed is based on the quantitative paradigm of data collections. Spatial and attribute data were collection through field surveys. The positions of lightening facilities were determine with the use of DGPS by observation of projected coordinates (Eastings and Northings) of the lighting facilities. The coordinates were obtained using a differential GPS in Real Time Kinematic (RTK) positioning mode.

The following mathods were useful in field data collection:

Planning

Adequate planning was embarked during the execution of the project, from selecting the appropriate method to use, the set of instruments that will provide the desired results with the accuracy stated, how to manage anticipated issues that may arise during the project execution, and other tasks. Prior to the project's implementation, all of the aforementioned tasks were carefully completed.

Reconnaissance Survey

Reconnaissance survey was carried out to take a general view of the study area and obtain first-hand information about the area. Controls points (monument) numerated with pillar numbers SVG-GPS 002, WGPS OO3 and WGPS 003 were identified, names of roads were lightning facilities are erected were also identified and noted in the field book.

Secondary Data Search

Secondary data such as projected coordinates of identified controls in Northings (m), Easting (m), and Heights (m) and shape file of Rivers State University were obtained from the Data Management Unit (DMU) of the Department of Surveying and Geomatics, Rivers State University as shown in table 2.1.

Table 2.1: Coordinates of Controls Points Identified in the Study Area

Station	Easting (m)	Northing (m)	Origin
SVG-GPS 002	275962.761	530903.200	UTM Zone 32N
WGPS 003	275992.841	530933.315	"
WGPS 004	275855.250	530938.002	"

Instrument Test / In-Situ Check

The Unistrong DGPS instrument was tested to ensure it performs at designed optimum level and ascertain its reliability to real time positioning. The identified controls were also checked for if they are in true position to each other, void of possible horizontal and vertical displacements and reliability to both linear and angular observations.

The DGPS (Base) was set up on SVG GPS 002, and with temporary adjustments made, the rover was then configured to the Base, and readings were taken on control points SVG-GPS 002, WGPS003, and WGPS 004, respectively, to confirm their status and reliabilities.

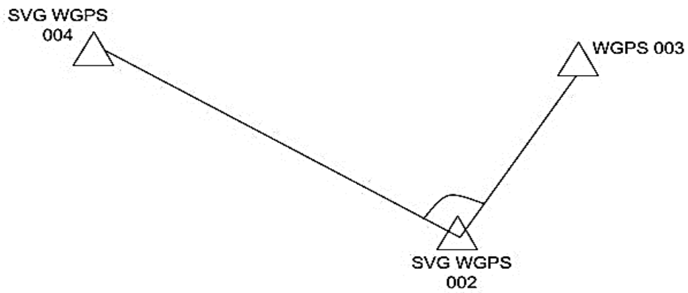

Figure 2.0: Schematic diagram of Controls Points

Thecoordinates were observed and the bearing, distance and angles were deduced. The observed and computed coordinates were compared and the resulting differences in bearings, distances and angles were negligible and confirm the in-situ of control pillars.

The bearing and distance of lines were computed from the following mathematical models;

Distance $= \sqrt{(\Delta E)^2 + (\Delta N)^2}$ **(1)** *Distance*

Bearing $= \tan^{-1}\left(\frac{\Delta E}{\Delta N}\right) + Q$ **(2)** *Equatio*

BB = FB $\pm$ 180°**(3)**

Note that; + 180° when FB < 180°

- 180° when FB >180°

α = FB – BB **(4)**

α^i= BB – FB **(5)**

Where;
α = External angle
α^i= Interior angle
FB = Forward Bearing
BB = Back Bearing
ΔE = Partial Easting
ΔN = Partial Northing

Table 2.2: Existing and observed coordinates of control points

Station	Easting (m)		Northing (m)		Difference (m)		Remark
	Existing	Observed	Existing	Observed	ΔE	ΔN	
WGPS 004	275855.250	275855.265	530938.002	530938.007	0.015	0.005	OK
SVG GPS 002	275962.761	275962.769	530903.200	530903.197	0.008	-0.003	OK
WGPS 003	275992.841	275992.863	530933.315	530933.326	0.022	0.011	OK

Table 2.2: Deduced angle from observed coordinate of controls

Station	Sight	Bearing	ΔE (m)	ΔN (m)	Angular Deduction	Distance (m)
SVG GPS 002	WGPS 004	287^0 56' 31.38"	-107.504	34.810	117^0 01' 28.74"	112.999
	WGPS 003	44^0 58' 0.12"	30.094	30.129		42.584

Angle SVG GPS 002 = 360^0 - (Bearing of WGPS 004 - Bearing of WGPS 003)

= 360^0 - (287^0 56' 31.38" - 44^0 58' 0.12")

= 117^0 01' 28.74"

Table 2.4: Deduced angle from existing coordinate of controls

Station	Sight	Bearing	ΔE (m)	ΔN (m)	Angular Deduction	Distance (m)
SVG GPS 002	WGPS 004	287^0 56' 13.56"	-107.511	34.802	117^0 01' 46.51"	113.004
	WGPS 003	44^0 58' 0.07"	30.080	30.115		42.564

The results of the check show that the control pillars are in place.

Table 2.4: Summary analysis of control check result

	Angle	Distance (m)	Distance (m)
Computed	$117^0$01' 46.51"	113.004	42.564
Observed	117^0 01' 28.74"	112.999	42.584
Discrepancy	-00^0 00' 17.76"	-0.005	0.020

The results of the analysis above demonstrate the dependability and continued maintenance of the controls in their initial positions. Therefore, the controls are suitable for the project use.

Field Data Acquisition

Differential GPS was employed in RTK mode for data acquisition. The master station was set up on SVG GPS 002, and the rover was also placed on the same station and recorded in a slant position to confirm the coordinates of the control for orientation.

Real-time kinematic GPS surveys make use of two or more GPS receivers. At least one receiver is set up over a known reference point and remains stationary, while another (rover) receiver is moved from point to point.

All baselines are measured from the reference receiver to the roving receiver. Kinematic GPS surveys can be either continuous or "stop and go." We employed stop-and-go station observation since the periods are of short duration, typically under two minutes. Real-time surveys are achieved with a radio or cellular data link between a reference receiver and the roving receiver. Measurement data from the reference receiver is transmitted to the roving receiver, enabling the rover to compute its position in real time. It was observed that the distance on the project site between the reference station and the rover is below 2 kilometres.

Being conscious of the various sources of errors in all GPS observations, the study ensured that during the observation, 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 errors from multipath, obstructions were avoided.

Figure 2.2: UnistrongG970iipro DGPS Used for Field Data Acquisition

Source: Indiamart.com

Operation Procedures of the UnistrongDGPS
The DGPS used is the Unistrong model. The following processes were used in operating the DGPS:

Setting the Base Station
1. Switch on the instrument and *Create Project*
2. Set coordinate system,
3. Next *Device*
4. Goto *Communication*
5. Select serial number of receiver (Base)
6. Click on the serial number of the receiver (Base)
7. Click *Base*
8. Set up mode
9. Click input coordinate to type in the coordinate of the base station
10. Press *OK*
11. Press *Stop*
12. Click *Save and apply.*

Setting the Rover
In setting the rover to connect with the base station, the following settings were made:

1. Goto*Communication*
2. Press *Stop*
3. Put on the second receiver (rover)
4. Click on the serial number of the receiver (rover)
5. Goto*Rover*
6. Press Ok
7. Click *Save and apply*

Point Observation
In carrying out the survey, the following were done:

1. Goto*Survey*
2. Click *Point Survey* to start observing points
3. Exit

Database Creation
A database was created using Arc-Catalog in ArcGIS 10.5 to create a geodatabase file for the study where the feature dataset and feature classes were created. Point features were used to represent lighting facilities, and line features were used to represent roads and perimeter of the study area.

2.1.1 Exporting Point
To download the survey data acquired from the field, it was exported as a *".csv"* file extension via Bluetooth.

1. Goto*Project*
2. Scroll down to *Export file*
3. Click *Export* a pop up window will appear, click *OK*
4. Click *Share*
5. Select share medium
6 Click on Bluetooth
7 Connect to device and receive

3.0 RESULTS AND DISCUSSIONS

The spatial distribution map of functional and non-functionalelectric lights as shown in figure 3.1 satisfy parts of objective one of this study

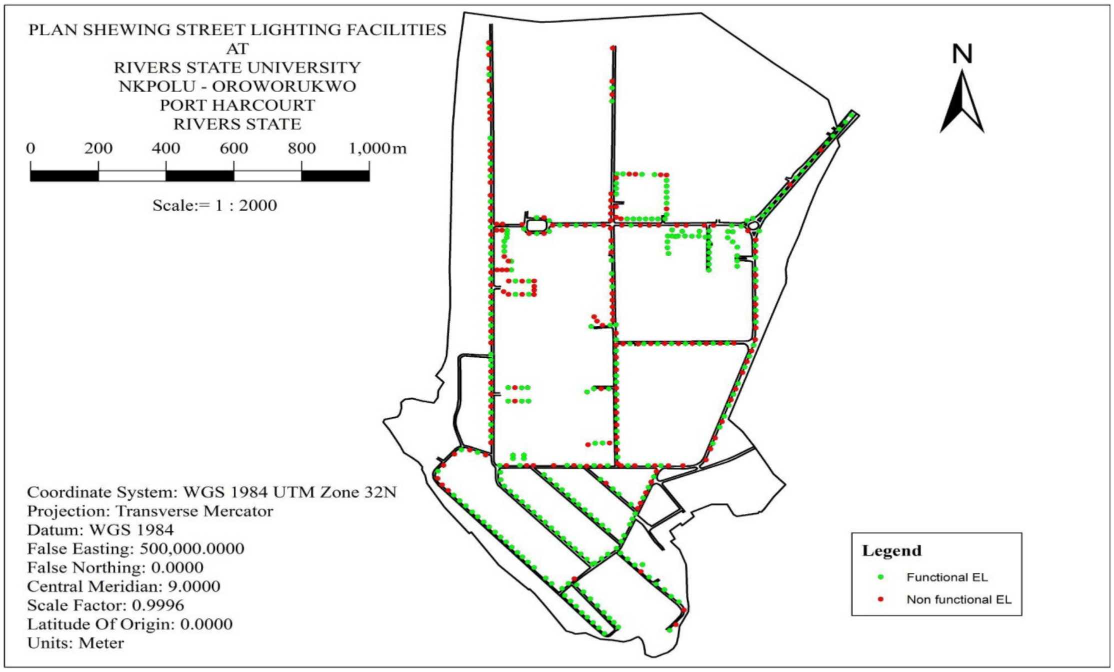

Figure 3.1: Functional and non-functional electric light in the study area

Table 3.1shows a specimen of database of the position of the functional and non-functional electric light also satisfy objective one of this study

Table 3.1: Location and Attribute Database of some Functional Electric Light

S/N	Easting (m)	Northing (m)	Point ID	Tag	Status
1	276000.237	531368.175	el7	EL	Functional
2	276000.650	531413.545	el9	EL	Functional
3	276012.190	531048.496	el12	T31	Functional
4	276012.153	531066.947	el13	T30	Functional
5	276012.296	531085.059	el14	T29	Functional
6	276014.474	531117.675	el16	T27	Functional
7	276032.672	531117.222	el17	T26	Functional
8	276088.699	531116.053	el20	T23	Functional
9	276125.392	531114.744	el21	T21	Functional
10	276161.131	531094.986	el24	T18	Functional

Table 3.2: Location and attribute database of some non-functional electric light

S/N	Easting (m)	Northing (m)	Point ID	Tag	Status
1	275975.204	530940.392	el1	EL	Non-functional
2	275996.576	530957.312	el2	T26	Non-functional
3	275996.739	530980.637	el3	T25	Non-functional
4	275997.044	531002.961	el4	EL	Non-functional
5	275997.136	531026.329	el5	T22	Non-functional
6	275997.587	531048.751	el6	EL	Non-functional
7	276000.498	531390.962	el8	EL	Non-functional
8	276000.813	531436.634	el10	EL	Non-functional
9	276001.887	531550.817	el11	EL	Non-functional
10	276012.156	531103.544	el15	T28	Non-functional

Figure 3.2 and Tables 3.3 and 3.4 shows the spatial distribution of functional and non-functional solar lights in the study area and satisfy objective two of this study

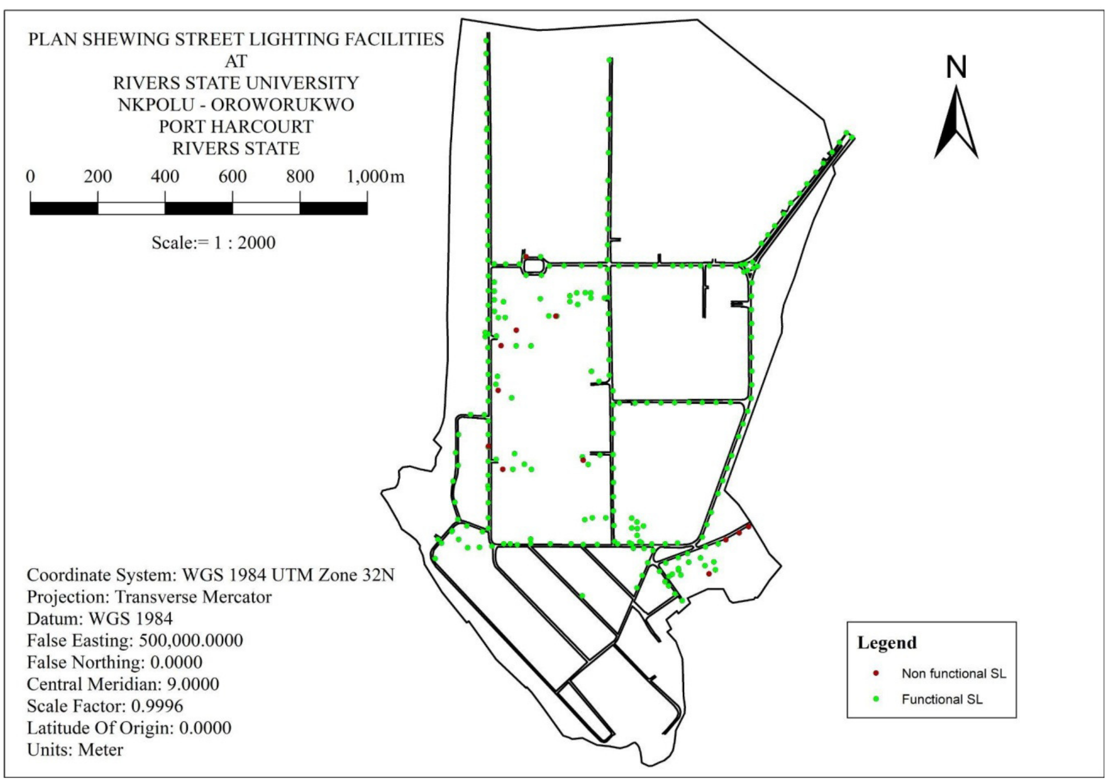

Figure 3.2: Functional and non-functional solar light.

The table below shows the specimen of database of the position of the functional and non-functional solar light.

Table 3.3: Location and attribute database of some functional solar light

S/N	Easting (m)	Northing (m)	Point ID	Tag	Status
1	275974.548	530940.323	sl1	SL	Functional
2	275996.550	530957.773	sl2	SL	Functional
3	275996.922	531002.283	sl3	SL	Functional
4	275997.585	531049.514	sl4	SL	Functional
5	275998.073	531093.738	sl5	SL	Functional
6	275998.288	531139.228	sl6	SL	Functional
7	275998.387	531193.860	sl7	SL	Functional
8	275999.766	531275.935	sl8	SL	Functional
9	276000.123	531345.616	sl9	SL	Functional
10	276000.636	531390.450	sl10	SL	Functional

Table 3.4: Location and attribute database of some non-functional solar light

S/N	Easting (m)	Northing (m)	Point ID	Tag	Status
1	275754.635	530967.053	sl89	SL	Non-functional
2	275680.629	530702.359	sl110	SL	Non-functional
3	275725.987	530748.491	sl113	SL	Non-functional
4	275843.078	530790.271	sl133	SL	Non-functional
5	275671.632	530569.960	sl137	SL	Non-functional
6	275643.262	530403.784	sl147	SL	Non-functional
7	275685.633	530334.758	sl155	SL	Non-functional
8	275924.268	530361.721	sl201	SL	Non-functional
9	276297.597	530023.932	sl251	SL	Non-functional
10	276347.734	530125.215	sl255	SL	Non-functional

Table 3.5: Location database of transformer

S/N	Easting (m)	Northing (m)	Point ID	Tag	Status
1	276389.000	530963.500	tr1	NIL	Functioning
2	276409.040	530797.666	tr2	NIL	Functioning
3	275798.000	530852.500	tr3	NIL	Functioning
4	275766.031	530760.683	tr4	NIL	Functioning
5	275668.860	530549.962	tr5	NIL	Functioning
6	275724.689	530548.014	tr6	NIL	Functioning
7	276029.886	530524.905	tr7	NIL	Functioning
8	276353.535	530566.806	tr8	NIL	Functioning
9	275638.479	530318.444	tr9	NIL	Functioning
10	276099.000	529975.384	tr10	NIL	Functioning

Discussions of Findings

The study revealed that a total of One Thousand and Twenty Seven (1,027) lighting facilities were recorded in the study area. These facilities ranges from electric lights, solar lights and electric poles. Figure 3.1 shows the up-to-date spatial distribution map of the functional and non-functional electric lights in the study area.

From the database of all the lighting facilities, extraction of the database for only the functional and non-functional electric light were queried in ArcGIS 10.5 software. From the select a report was generated to include the total number in each case.

Also, total of 320 electric poles were also recorded in the study area. Some of which have electric lights attached to them, especially those behind Hostel E close to the fence wall. 195 electric poles were recorded as high tension cable line, whereas 121 were low tension cable line while 4 were recorded as both high tension and low tension cable lines.

The findings also indicates as shown in table 3.5 that the study area is well serviced with transformers for the distribution of power supply. From the study, a total of 14 functional transformers were recorded and functioning properly.The result also showed that the roadways in the study area are well illuminated and have a high level of perceived safety and security at night. However, key maintenance should be carried out to fix the non-functional electric and solar lights. It was also noted that the horizontal distances between electric poles were not uniform as it varies from 26meters to 33meters and the none verticality of erected electric poles were also noted as some poles were tilted to different directions.

4. Conclusion

The efficacy of the Unistrong Differential Global Positioning System was demonstrated in this study. The ground surveying data acquisition techniques using the DGPS provided accurate and precise position information of lightening facilities in the study area. Field data were acquired in accordance to the specifications provided by the Surveyors Council of Nigeria (SURCON) with respect to facility mapping. The research findings justified the necessities of the study as the study aim and objectives were achieved and will greatly assist the Institution's Department of Works and Physical Planning in the planning, installations, maintenance and management of lightening facilities in the study area.

5. Recommendations

i. All non-functional lightning facilities should be fixed to prevent likely dark environment especially at nights
ii. Additional solar power lights should be installed in areas of necessities, such as Faculty of Environmental Sciences, Hostel A, B, D, F and G, The University Arena, and Roads A, B, and C, among others.
iii. The Research findings of this Study should be used as a working document to aid efficient planning, maintenances and management of lightening facilities in the study area

Acknowledgment

We sincerely acknowledge the Department of Surveying and Geomatics, Faculty of Environmental Sciences, Rivers State University for providing us the basic necessary secondary data (Projected Coordinates of ground controls in Northings (m), Easting (m) and Ellipsoidal Height (m) and shape file of Rivers State University Boundary. This assisted greatly in achieving the aim and objectives of this study.

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