DEVELOPMENT OF GEODATABASE FOR JNEC CAMPUS

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Abstract—Development of geodatabase is crucial for Jigme Namgyel Engineering College (JNEC) enabling data storage capabilities in terms of spatial and non-spatial information. As a result, the study was aimed to develop a GIS-based geodatabase of JNEC to store both spatial and non-spatial information about the college infrastructure for efficient future retrieval through online WebGIS. Traditional surveying techniques were adopted to collect the geospatial data through field surveying, while the survey questionnaires were deployed to collect the non-spatial data from the residents of JNEC campus to integrate with the geospatial information's collected through field surveying. The updated geodatabase of JNEC campus includes the information of buildings (i.e., residential, hostels, recreational, academic, and administrative), electric poles, lamp posts and transformer details. This study enables us on easy retrieval of the past and update the future upcoming infrastructures for the references and for development of any authentic reports.

Keywords— GIS, Geodatabase, WebGIS, geospatial

I. INTRODUCTION

Geographic Information System is a computer-based technology that has risen in popularity and used over the previous decade [1]. The Environmental System Research Institute – ESRI (1990) defines a Geographic Information System (GIS) as "a well-organized system of computer hardware, software, geographic data, and employees for capturing, storing, updating, manipulating, analyzing, and displaying all types of geographically referenced data" [2]. GIS implies that the location of features is known, that the data in a GIS is organized to yield useful knowledge, and that a GIS is made up of several interconnected and linked components that perform different functions such as data capture, input, manipulation, transformation, visualization, combinations, query, analysis, modeling, and output [3]. As a result, geodatabases can be generated using GIS.

The purpose of this project was to develop a Geographic Information System database for Jigme Namgyel Engineering College using the Geographic Information System program. The creation of a database necessitates the capture and storage of both spatial and attribute data on a computer. This geo-database provides data such as building coordinates, electrical loads, plinth area, number of residents, furniture, equipment, year built, type of building, last major maintenance, and other data with a single mouse click. The Geographic Information System is a database rather than a map or photograph [4]. Database systems make it possible to store and update a wide range of geographic data without having to rewrite the programs every time when new datasets are added [5].

Due to the lack of a GIS database in Jigme Namgyel Engineering College campus, access to information about the JNEC environment is extremely slow and inefficient. The majority of the infrastructure and utilities are built and maintained entirely on the basis of 'on-the-spot' assessments by university field technicians and artisans. As a result, survey tools are employed to collect data in order to remedy this issue (there will be two types of data; spatial data and attributes data). Traditional field survey methods are utilized to collect spatial data, and attribute data is obtained by conducting survey questionnaires with residents of the JNEC campus. The non-geospatial information is then integrated with the geospatial data.

The geodatabase is integrated into the web map in order to acquire information about each feature with a single mouse click. It gives users with a customizable way to obtain information about the college. It is also beneficial in the future because updating this geo-database is simple with GIS software. This geo information could also be used as an interactive map for the university's students, visitors, and suppliers.

A. Study Area

The Jigme Namgyel Engineering College (JNEC), formerly known as the Royal Bhutan Polytechnic (RBP), is one of the constituent colleges of the Royal University of Bhutan. It was established in 1972 coinciding with the third five-year economic development of the country. It is situated at 800m above the mean sea level and is located in the west end of Dewathang town. The institute is 18 kilometers away from Samdrup Jongkhar town in Eastern Bhutan, second gateway to Bhutan from Assam in India. Although it started with the infrastructure development since 1972, it started offering Diploma level programs in engineering from 22nd Feb 1974. The latitude of 26.8603° or 26° 51' 37" north and longitude of 91.4641° or 91° 27' 51" east; Elevation: 858 metres (2,815 feet) [6].
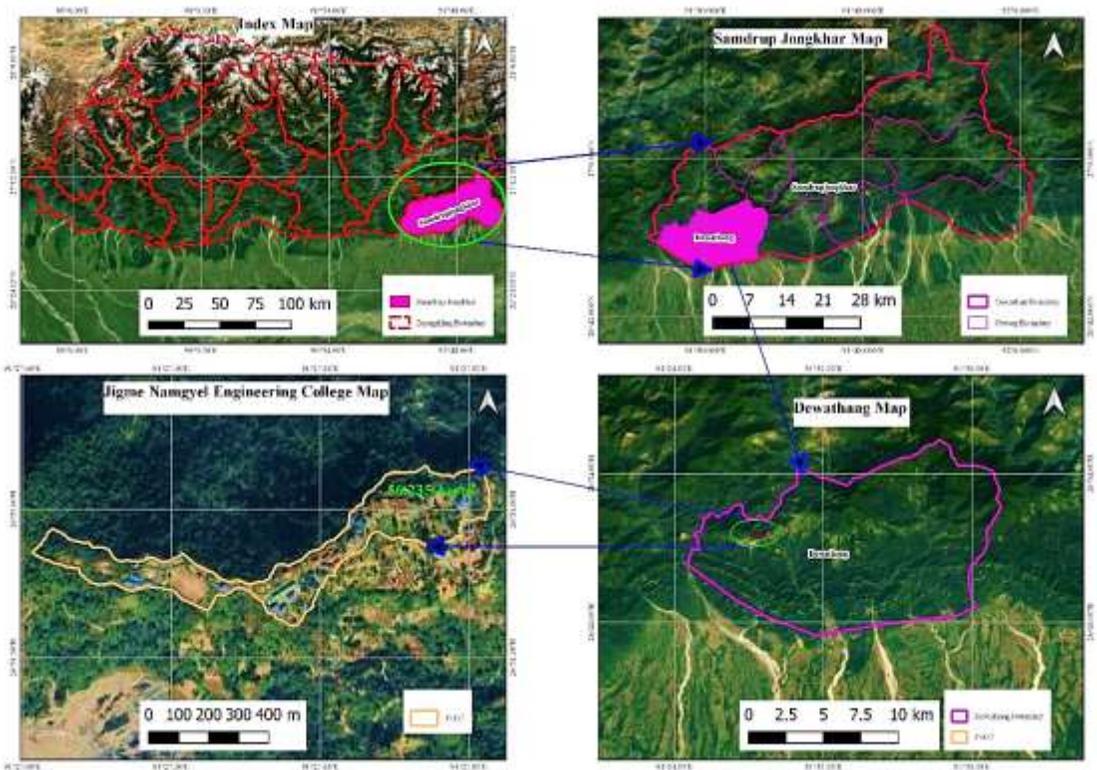

Fig. 1. Location map of the study area: Jigme Namgyel Engineering College in Dewathang

II. METHODOLOGY

The spatial information was acquired using ground survey methods, while the attribute data was gathered via a survey questionnaire administered to college faculty residents living on campus and from the state manager. The ground survey map was scanned into the computer and used as a framework for the creation of numerous spatial data layers. Buildings, electric poles, lamp posts, and transformers are all represented

by four layers. Five additional attribute tables for the building layer were linked to each other and attached to the layer, including residential, recreational, hostel, academic, and administrative layers. Three additional attribute tables for the lamp post layer have been attached, including street light, compound lighting, and solar street light.

A. *Data Collection*

This project primarily requires two types of data: geographical data and attribute data. The items or elements existing in the geographical space, such as building coordinates, roads, power lines, plinth area, and infrastructures, are referred to as spatial data. The attribute data comprises of each object's attributes or qualities that are important for campus administration.

B. *Spatial Data*

A survey was carried out to obtain spatial data of infrastructures and built-up areas. Prior to conducting the survey, a reconnaissance survey was conducted to assess the campus's surroundings. GPS (Global Positioning System) receivers are necessary to gather data of building coordinates and the locations of any other items. The information gathered in the field was processed in software to create a map.

C. *Attribute Data*

A survey questionnaire was used to acquire attribute data about buildings and other infrastructures, such as the year built and the number of residents. The information on college housing and academic blocks were obtained from the college administration team.

D. *Development of Survey Questionnaires*

- Who is the member of your family who works on campus?
- ✓ Name of the resident
- ✓ Citizenship Identity number
- ✓ Contact number
- When was the house built, and what style of structure is it?

E. *Reconnaissance Survey*

It is the preliminary survey or primary survey that has to be conducted before any survey work [7]. During this stage, the surveyors usually visit the site in order to obtain a general idea about how to begin a work. The primary purpose is to eliminate those routes or sites which are impractical or unfeasible and to identify the more promising routes or sites.

The reconnaissance survey of Jigme Namgyel Engineering College was carried on 21st March, 2022. Before the commencement of the actual field work, the inter-visibility of the Ground Control Points was checked

and cleared the area around Ground Control Points. The secondary Control Points for the inaccessible points were generated by using the GNSS instrument (Trimble R10 receivers).

Fig. 2. Reconnaissance Survey

F. *Traversing*

Traverse is a series of consecutive lines whose length and direction have been determined from field measurements [8]. The act of establishing traverse station and making the necessary measurement is called traversing. Traversing is a convenient, rapid method for establishing horizontal control points particularly when the line of sights is short due to heavy built-up areas where triangulation and trilateration are not applicable.

Traversing is carried for the following purposes;

- Property surveys to locate or establish boundaries.
- Supplementary horizontal control for topographic mapping surveys.
- Location and construction layout surveys for high ways, rail ways and other private and public works.
- Ground control surveys for topographic survey.

G. *Detail Survey*

A detail survey results in a site plan which shows all relevant site information, typically site levels, the location of features (point features, line features and polygon features), infrastructure, existing buildings, and structures. Detail survey is generally carried out using total station and prism.

In order to proceed with detail survey, control points were established in the campus and used the existing Ground Control Points (GCPs). To collect the building coordinates of JNEC campus we used the total station (Leica TS06) by performing traverse survey. GNSS instruments (Trimble R10 and R12) was employed for surveying electrical pole, buildings, transformers, and lamp posts

TABLE 1. CODE TABLE

CODE	DESCRIPTION	GROUP
BLDG	Building/House	PrivateBuildingA
EPOL	Electric Pole	UtilityP
EPYLN	Electric Power Pylon	UtilityP
SCP	Secondary Control Point	ControlPoint
PBDY	Plot Boundary	Parcel boundary

Fig. 3. Topographic survey around JNEC campus

H. Data Processing and Editing

Data processing is simply the conversion of raw data to meaningful information through a process with the use of some software like LISCAD, and QGIS.

From LISCAD we used some of the available modules like input and output, Least Square Adjustment, Coordinate Transformations, Computations, Digital Terrain Modeling (DTM), 3D Visualization and CAD. Before we started with processing in LISCAD, we have to transformed the field GIS file into raw file and then created the field file. It is important to edit the field file by using the field book in order to avoid confusions while processing. After reducing the Field file, we were able to see all the points that have been measured during the field work.

The data from total station was downloaded by utilizing drive after finishing our daily field job. The complete station's work was transferred to LISCAD. To make the data readable, we used the LISCAD software. The total station's raw data was downloaded to a computer via USB drive and processed using the LISCAD program. Daily field records in GIS format were entered into LISCAD, field files were produced, modified, and reduced to examine raw data, and field files were created, edited, and reduced. To obtain the map, LISCAD was used to do the necessary operations to construct, edit, and examine points, lines, and polygons.
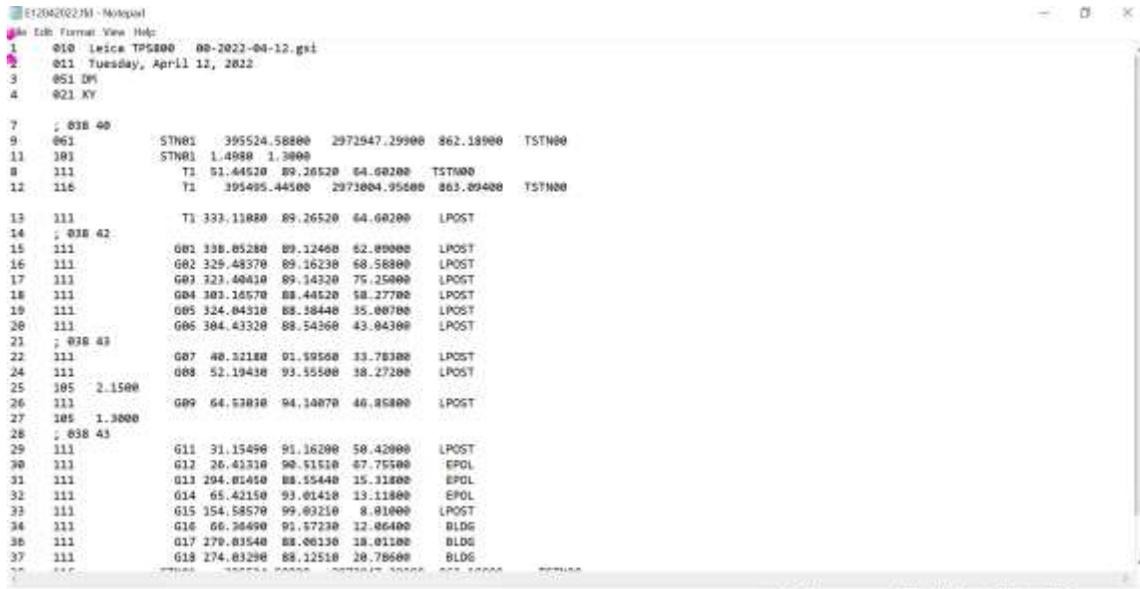

Fig. 4. Data editing in LISCAD

Field file is a standard format into which all raw field data must be converted before reduction or further processing in LISCAD. Before creating field file from the raw file, it is important to ensure the LISCAD is set to interpret the feature codes contained in the raw file correctly. The purpose of editing field file is to give accurate code to the features present in the field. It aids in the correction of codes, instrument heights, and reflector heights if they are entered incorrectly during field operations. The faces that are used for orientation are recognized during the reduction process, and modifications to all reductions are calculated on that face. The SEE file was used to create and alter survey data. Computation modules were used to edit and create points and lines. Only point feature remains once the field file has been reduced. It aids in the creation and movement of points. A line is drawn based on the shape of the features present. Grouping is required which is done according to the feature's group. By creating a shape file for the final map, all merged and aggregated files are exported into QGIS. We performed fundamental editions in QGIS, such as layer edition and coordinate conversion for certain features, then added a field to the characteristics table.

I. *DEVELOPMENT OF WEBSITE-BASED GEODATABASE AND ONLINE PLATFORM USING QGIS*

Implementation

The implementation procedure is classified into three categories: producing a file geodatabase, displaying the file geodatabase in QGIS, and building a web map using the QGIS plugin (qgis2web) that provides functionalities for the map such as zoom in, zoom out, geolocational tools, legend, measurement tool and search option.

Creating a file geodatabase

The maps created in QGIS Desktop are shapefiles. So, they need to be edited using QGIS. QGIS allows addition of data to shapefiles. We edited all of the feature parameters in QGIS, including symbology, projection, and coordinate system (DrukRef03), and others.

A file geodatabase is a collection of files in a folder on disk that can store, query, and manage both spatial and nonspatial data. File geodatabases offer structural, performance, and data management advantages over personal geodatabases and shapefiles [9].

- The file geodatabase uses an efficient data structure that is optimized for performance and storage. File geodatabases use about one-third of the feature geometry storage required by shapefiles and personal geodatabases for access. File geodatabases also allows you to compress vector data to a read-only format to reduce storage requirements even further.

- File geodatabases have no storage size limit. Individual datasets within a file geodatabase, such as a feature class or table, have a size limit of 1 TB.

- The file geodatabase offers improved performance. For example, it can easily support individual datasets containing over 300 million features and datasets that can scale beyond 500 GB per file, while maintaining very fast performance.

- The file geodatabase offers less restrictive editing locks. Locking can be done as per table instead of their entire database.

- The file geodatabase is supported by many platforms, including Windows and Unix (Solaris and Linux).

A feature dataset was created in the file geodatabase using polygons for buildings and points for electrical poles and lamp posts. A feature dataset is a collection of related feature classes that share a common coordinate system.

A feature class is a collection of geographic features that share the same geometry type (such as point, line, or polygon) and the same attribute fields for a common area. Residential buildings, academic buildings, recreational structures, electricity poles, and lamp posts have all been given their own feature class.

QGIS PLUGIN (QGIS2WEB)

Web Mapping is a service through which the consumers will choose what they want to show on the map [10]. It facilitates the availability of one's geographical information system data to their web and make it accessible to the consumers. GIS users typically aren't web programmers and it presents a challenge when one needs to create a web map that is of the same quality as a map created in a GIS. QGIS2Web is a tool that turns QGIS layers into HTML, JavaScript, and Cascading Style Sheets (CSS) files. QGIS2Web can create an interactive web map that pops up a variety of properties and widgets to make them more appealing to audience. It not only replicates the symbology and cartographic aspects of current QGIS Desktop, but it has the option to export a web map to either Open Layers, Leaflet, or Map box GL JS. The overall methodology is summarized in the flowchart given in the Fig. 5.
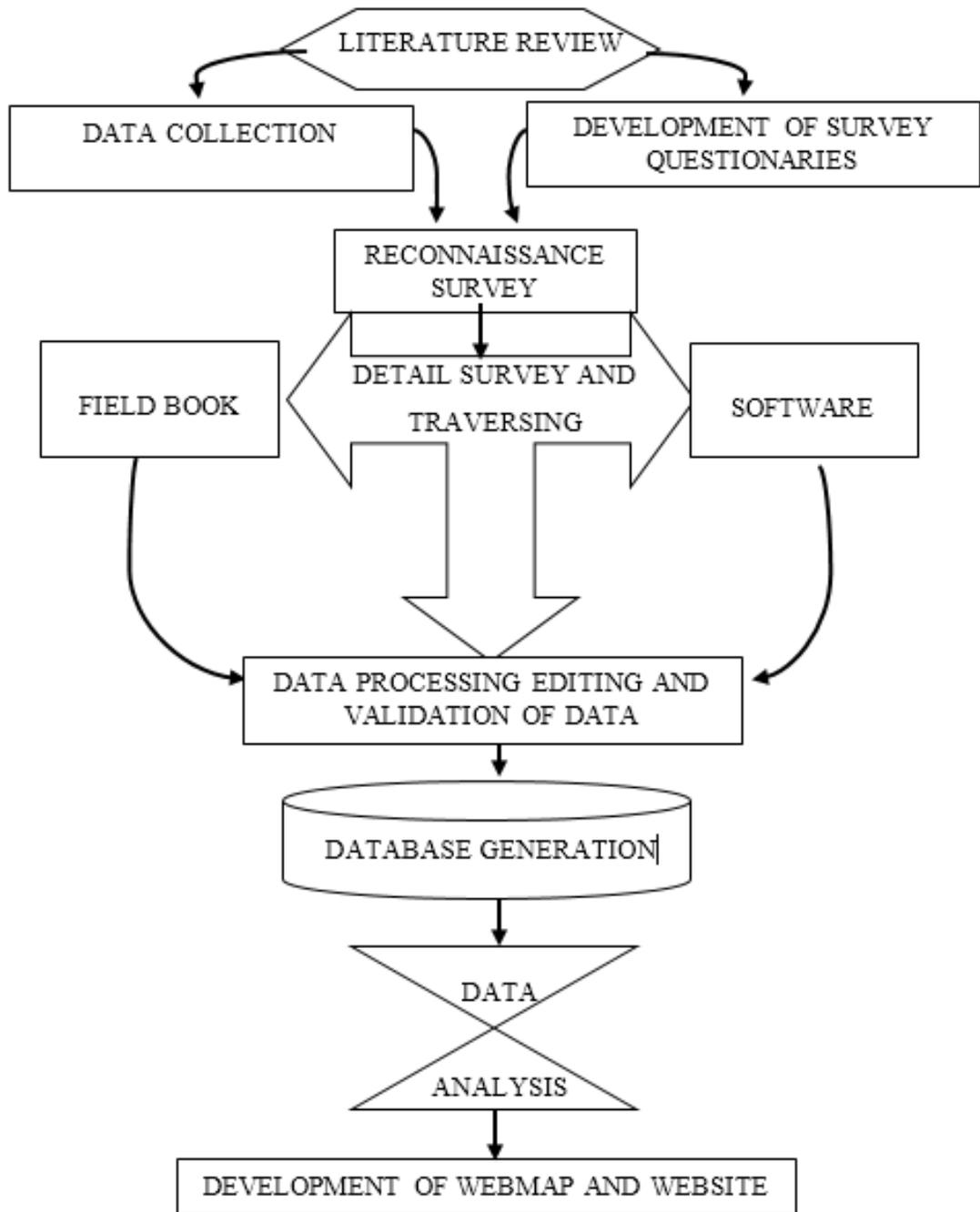
Fig. 5. Work flow diagram

III. RESULT AND DISCUSSIONS

It's difficult to predict potential problems with the database since it hasn't been officially integrated at the university. Preliminary testing, on the other hand, had been quite successful. It improves data retrieval speed and provides a level of flexibility previously unattainable. It creates a geo-database for the JNEC campus that includes all spatial information, including point and polygon features. In addition to all relevant attribute data, the master plan of JNEC's campus will serve as a useful tool for architects and planners.

A topographic survey was carried out for the campus including buildings, electric poles, lamp posts and transformers. Buildings are represented by polygons, and electric poles, lamp posts and transformers are represented by points. By providing visible colors and shape sizes, the features are given appropriate iconography. Different symbols represent them, which are listed in the legend at the upper right corner. To determine the distances on the map, an appropriate scaling is provided.
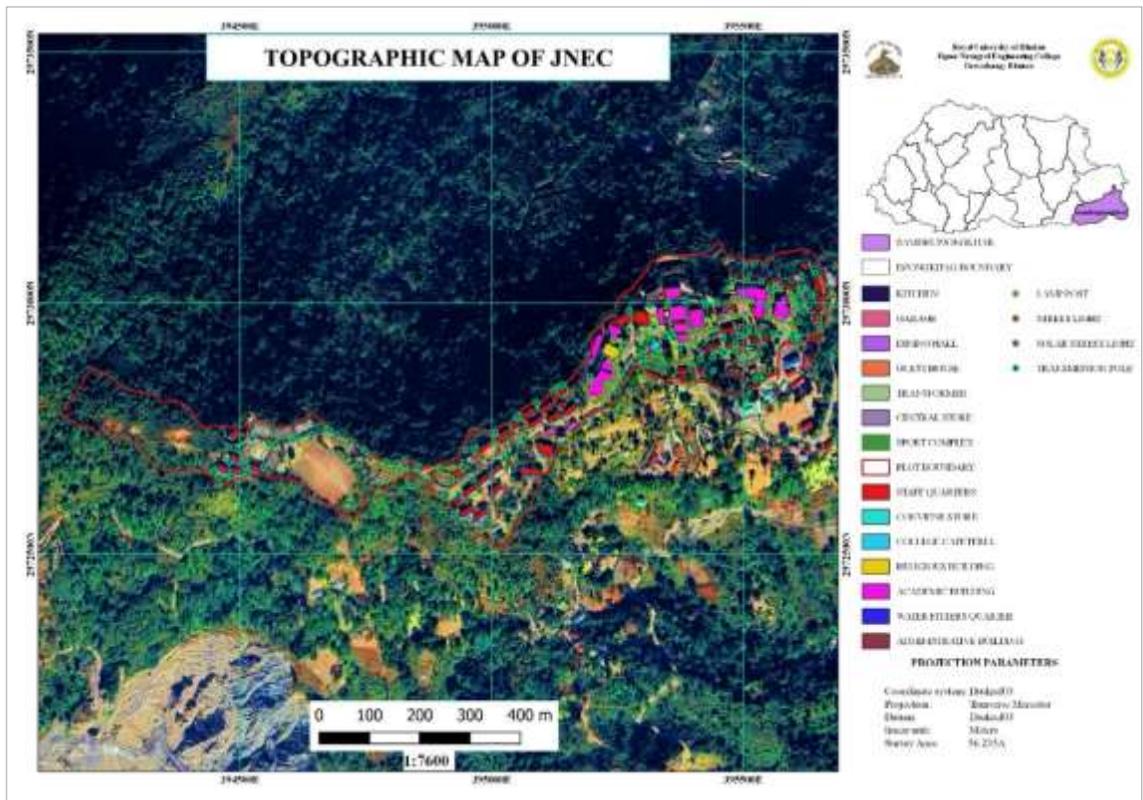

Fig. 6. Topographic Map of JNEC

A survey questionnaire was used to collect information about the building's residents and its attributes. The type of electric poles and lamp posts, as well as the voltages they carry, are also provided by the survey. When a new theme is established, the attribute table for that theme is automatically produced and remains in edit mode. The table was divided down into multiple fields before any records were added to it. Each field's name accurately defines the type of data contained within it. Each time spatial data is created, a new entry is automatically added to the theme's attribute table. The records were then changed to reflect this. This resulted in the creation of four theme tables. A theme table is a table that is related to the spatial data of the topic. Typically, a unique identifier is created to link each spatial data record to its corresponding record in the attribute data. The four theme tables were categorized: buildings, transmission poles, transformers, and lamp posts. Five additional tables were created for the buildings theme. The residential building table, hostel table, academic building table, administrative building table, and recreational building table.

College shapefiles have been developed, as well as a geodatabase for each feature. The colleges were then displayed on a map. Plugins (QGIS2Web) have been used to display the map from QGIS in the browser (web). As a result, a web map was developed. The existing coordinates within the JNEC campus done by TS06 are legitimate because the deviation of coordinates with regard to Real Time Kinematic (RTK) is within the range of centimetres (<10cm) which shows that Total Station (TOS) is more accurate than RTK. The map includes a title, legends in which the features are represented by different symbols, additional features such as zoom in and zoom out, geolocation tool, and measurement tools such as distance and area measurements. The attribute data for various features is viewable with a single mouse click as shown in the figures below.
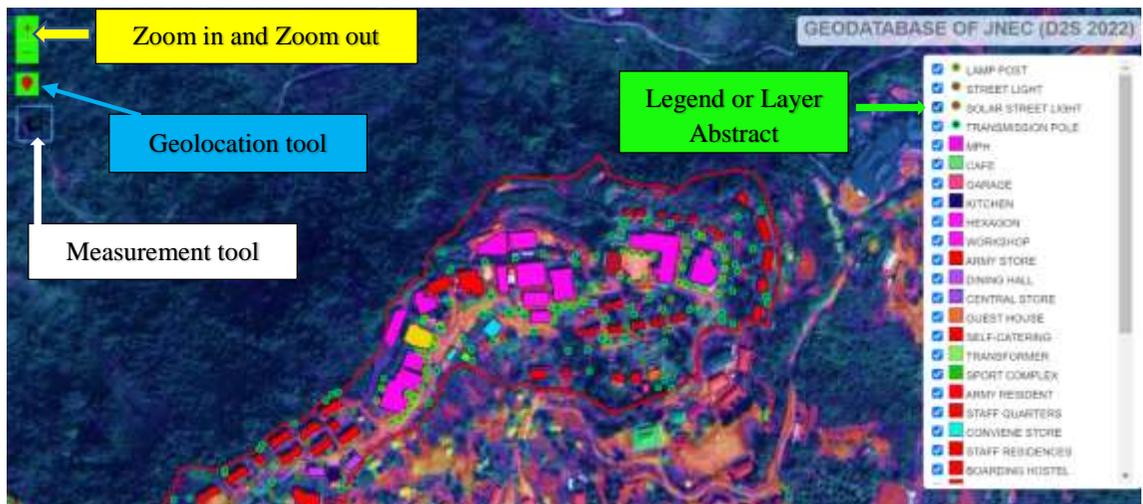

Fig. 7. Features available in Web Map

The attribute information for residential building which is represented by B-type building with the respective Building ID for the users to identify it is given in figure 8(a). The information of residents residing are also provided with their respective personal details. Figure 8(b) shows the attribute data for academic building, for instance; Department of Civil Engineering and Surveying (DCES), the number of floors and capacity is provided which is beneficial during examinations. The year of construction and the building type is also specified with the HOD's details provided. Figure 8(c) shows an attribute data for administration building with its building ID, number of floors, locations of the important units is provided. Its structure type and year of construction is also given. Figure 8(d) is an attribute data of recreational building i.e., Student Service Center. The building ID and the details of the occupant is given to contact the respective person. The number of units and floor is also provided to know about the capacity it can hold for planning purposes. The type of structure and year built is also provided.

The figures 8(e) shows the attribute data for electric pole. It provides information such as: types of poles, its height, voltages it can carry, type of insulator used and conductor used. It is colored blue. The figure 8(f) gives the attribute data for lamp post (compound lighting). The information such as type of lamp used, type of pole, its height, wattage it can carry, reflector type, voltage, current it provides, type of conductor and insulator used is known. Through this it provides flexibility for technicians during destructions, new constructions and helps for educational purposes for the trainees. The figure 8(g) is an attribute data of transformers in which it contains its voltage, phases, rating, type of cooling, frequency and year of manufacture. Transformers are used to regulate voltages, mitigate power loss and increase energy efficiency.

(b)

DESCRIPTION: DEPARTMENT OF CIVIL ENGINEERING AND SURVEYING
BUILDING ID: DCES
NO OF FLOOR: 2
NO OF CLASS: 8
CAPACITY: 300
NO OF TABLE: 175
NO OF CHAIR: 350
YEAR OF CONSTRUCTION: 01-JAN-1992
TYPE OF BUILDING: CONCRETE
NO OF LAB: 5
HOD: DAWA TSHERING
CONTACT NO: 17415393

(c)

DESCRIPTION: ADMINISTRATION BLOCK
BUILDING ID: ADMIN
NO OF FLOOR: 2
LOCATION OF PRESIDENT OFFICE: FIRST FLOOR
LOCATION OF EXAM CELL: FIRST FLOOR
YEAR OF CONSTRUCTION: 01-JAN-1995
TYPE OF STRUCTURE: CONCRETE

(d)

DESCRIPTION: STUDENT SERVICE CENTER
BUILDING ID: CS
NAME OF OCCUPANT: SONAM JAMTSHO
CID: 11107002105
CONTACT NO: 17452720
NO.OF FLOOR: 1
NO. OF UNITS: 2
YEAR OF CONSTRUCTION: 01-JAN-1999
TYPE OF STRUCTURE: CONCRETE

(e)

(f)

(g)

Fig. 8.(a) Information about staff's residence (b) Information about academic building, (c) Information about administrative block and (d) Information about student service center, (e) Information about transmission pole, (f) Information about compound lighting, (g) Information about transformers

Fig. 9 below represent the online geodatabase of JNEC campus overlayed on the satellite image. The online geodatabase can also be viewed via JNEC website (http://jnecdb.jnec.edu.bt/#16/26.8593/91.4614). The legend on the online map can be used to modify the base map.
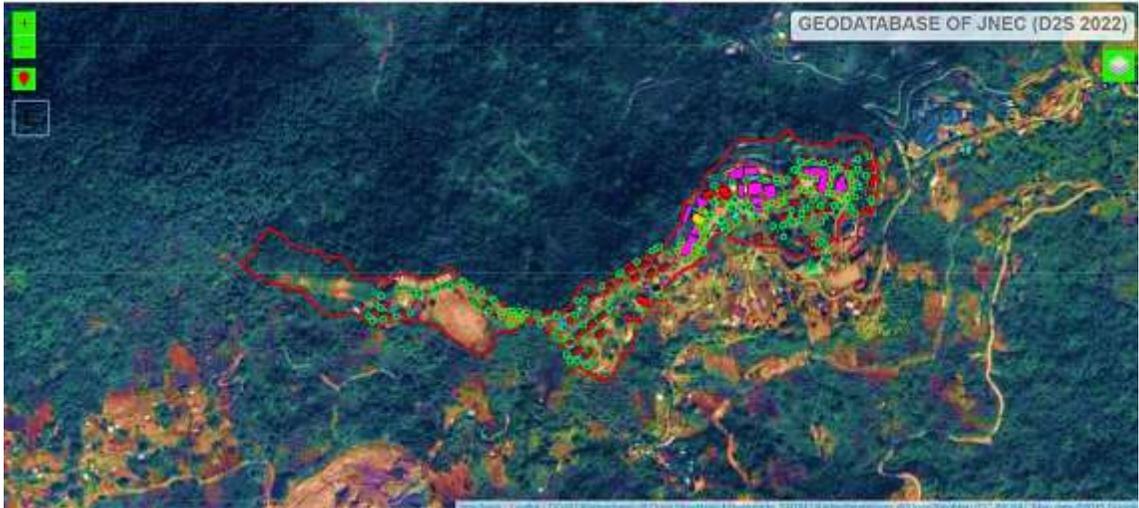
Fig. 9. Online base map overlayed on google map

IV. RECOMMENDATION AND FUTURE WORKS

The following conclusions and recommendations are made based on the result analysis;

- The existing coordinates within the JNEC campus done by TS06 are legitimate because the deviation of coordinates with regard to RTK is within the range of centimeters (<10cm). As a result, TS06 is more reliable than RTK.
- This project recommends to utilize the geotagged photos to be added to the web map to acquire a better idea of the site and obtain more information about it.
- In addition to the geotagged photographs, a 3D model plan can be inserted to the web map to obtain a better grasp of the inside view and know where everything is.

V. CONCLUSION

The complete collection of modules in the system has been thoroughly tested. The data for the college was taken from trustworthy sources. Shapefiles for the college's buildings, electric poles, lamp posts, and transformers are included in the map. The map was rendered in the browser using Web Map (QGIS Plugin:

QGIS2WEB). It has been designed with the capability of retrieving college information from a database. Zooming in, out, panning, and refreshing the map are all now available. Functionality has been built to connect geographic and non-spatial data. The ability to query the map using the identity option has been developed, which opens a window with the desired data. It is created in such a way that three various types of base maps (Google satellites, open street map, and open topo map) can be utilized simultaneously, depending on the user's preferences.

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