WEB-GIS BASED UTILITY MANAGEMENT SYSTEM: A CASE STUDY OF DEEP HOUSING, POKHARA, NEPAL

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ABSTRACT

The utilities are very essential for smoothening the daily life of people. There has always been an issue for maintaining and updating information related to utility networks. The major problem is in the linkage between spatial and non-spatial components of the utilities. The research addresses the issue of lack of proper planning of utility networks with consideration of other utility networks existing in the vicinity. This paper presents a web-GIS based utility management system in addressing such problems. The system consists of all the utility layers like transmission line, drainage, water supply, etc. in a web-map, the functionality of querying the layer's information, sharing maps, generating the reports, and some spatial operations like distance and area measurement, mechanism of addition or removal of the utility on the specific location by system administrators. The work also provides a customer support system that helps clients with issues submission and administrators with issue tracking for the maintenance of the utilities. Deep Housing, Pokhara, Nepal has been chosen as a case study. The data was collected through GPS, drone survey, and existing non-digital sources. The system is advantageous especially in the time of maintenance, updating, and planning of any utility features of the area of interest. This research work is beneficial for the government as well as private institutions for urban planning, smart city projects, real estate companies, etc.

INTRODUCTION

The increase in urbanization of any place demands more lands to be developed for public infrastructures like roads, buildings and utilities like drainage, sewer, electricity, etc. There is a strong mutual relationship between each utility network. Repairing or updating one utility affects another utility in one way or another. In large cities, there is a great difficulty in managing all the infrastructures without some common system that binds them together. This problem is more severe in developing countries like Nepal where cities are not planned prior to their establishment. There are no systematic recordings of any kind of utilities with service providers so that they can be used for future planning and use. Until now, people have always relied on hard copy maps to manage such facilities.

A Geographic Information System (GIS) is a computer system for capturing, storing, querying, analyzing, and displaying geospatial data (Chang, 2016). Spatial data are interlinked with attribute data to give complete information about any feature. GIS comes to play as a problem-solving tool through different spatial analysis for these kinds of data. GIS can be used as a tool in both problem solving and decision making processes ranging from a small volume of data to bulk. All achievements of relating attribute information to spatial information of different utilities in a certain area have been able to transform a mapping unit into an information package (Ajwaliya et al., 2014).

In the context of major cities of Nepal, the development activities lack smartness in the sense that they are not done sustainably and without proper planning. This results in a burden to the country's economy. Therefore, in this paper, a housing area has been chosen to develop its utility management system with basic services to the clients. This system is completely scalable to major cities.

Located in the northern part of Pokhara, Nepal; our study area, Deep Housing is situated in the latitude and longitude of 28˚15'8.55" and 83°58'38.32" respectively. The total area covered by our study area is 31502.5 m^2.

Related Works

There is great difficulty in managing utilities information handled by analogue methods. Each set of data is stored in separate map sheets, which is difficult in maintaining and updating. The databases are not managed and maintained in a format, which everybody can understand. A fine combination of the utility sector and GIS is seen in developed countries these days. GIS is helpful for planning, management and operating utility industries like telecom, internet service provider, energy, water supply, etc. With the help of GIS, data of the utility sector is presented visually in an understandable form, which helps in easy tracking and attention. The actual structure of the distribution system is modelled and tasks are performed according to our needs. Complexities of the utility network can be reduced and web GIS can improvise resource management. The Internet has played a valuable role in the visualization and presentation part. Web-enabled management systems have been established in some areas. The information thus obtained has also been used for decision-making (Jamil et al., 2015).

Different kinds of web GIS systems have been practiced in different regions of the world. The paper by Patel and et al. presents a design model of a GIS for a web-based utility management system. The application contains physical information about the utilities layers along with their visualization, thus it has the potential to manage the scattered data into a single platform. It provides interactive Graphical User Interface (GUI) along with basic GIS functionalities over the web for users (Ajwaliya et al., 2017).

Okello and et al have documented the use of a web GIS system for the water utility management at Copperbelt University, Zambia. They studied the drawbacks of paper-based utility maps and tried to overcome them with a better system more based on spatial data organization, manipulation and visualization. They concluded that the use of GIS reduces the overall cost for maintenance and facilitates the end-users with a web based centralized system with accurate and updated information. The researchers were able to create an effective and efficient web GIS water management utility system using PostGIS, QGIS and GeoServer. The framework for the web GIS was structured to provide a centralized system with web based access to accurate and updated information on utility spatial information throughout the university. The results of the study showed successful integration of PostgreSQL/PostGIS database with QGIS for desktop mapping and GeoServer for web mapping. These tools provided both visualization and analytical functions that create patterns and relationships from diverse data sources (Okello et al., 2017).

METHODOLOGY

The data required for conducting the research has been collected using different techniques like drone image capturing, GPS surveying and digitization technique. Thus, collected data from different sources were arranged and the layers of different utility components with the help of GIS desktop software were created. The data was managed by using the relational database system in PostgreSQL. The database helps to connect and relate the geometry of each layer with their attribute information. The layers, their geometry types and attribute elements that are imported in the database are given on the following table.

Table 1. Geometry and Attribute of Layers

SN	Layer	Geometry Type	Attribute
1	Road	Polyline	Location information, width, road type
2	Water supply network	Polyline	Location information, distribution type, pipe diameter, overhead tank, boring hole,
3	Drainage network	Polyline	Location information, width, outlet valve, manhole
4	Transmission line	Polyline	Location information, line type, manhole, pad for transformer, H-Pole for transformer, utility panel, junction box, pipe material, phase, NEA supply, generator supply
5	Sewer network	Polyline	Location information, type, pipe diameter, construction material, trench depth, junction point
6	Telephone and television	Polyline	Location information, line type, manhole, cable type, pipe material, diameter of the pipe
7	Street light	Point	Location information, power, pole height
8	Building footprint	Polygon	Location information, current resident, plot number, area, house type
9	Plot	Polygon	Location information, plot number
10	Park	Polygon	Location information
11	Temple	Polygon	Location information
12	Swimming pool	Polygon	Location information

13	Housing boundary	Polygon	Location information

The utility layers are then implemented in a web platform. The frontend is designed using Hypertext Markup Language (HTML), Cascading Style Sheets (CSS) and javascript. The backend is designed using Django (Aratyn, 2018), an open-source python framework. The javascript library Leaflet (Maclean, 2014) is used for the development of mapping functionalities like zoom in/out, panning, adding marker, distance calculation, area calculation, etc.

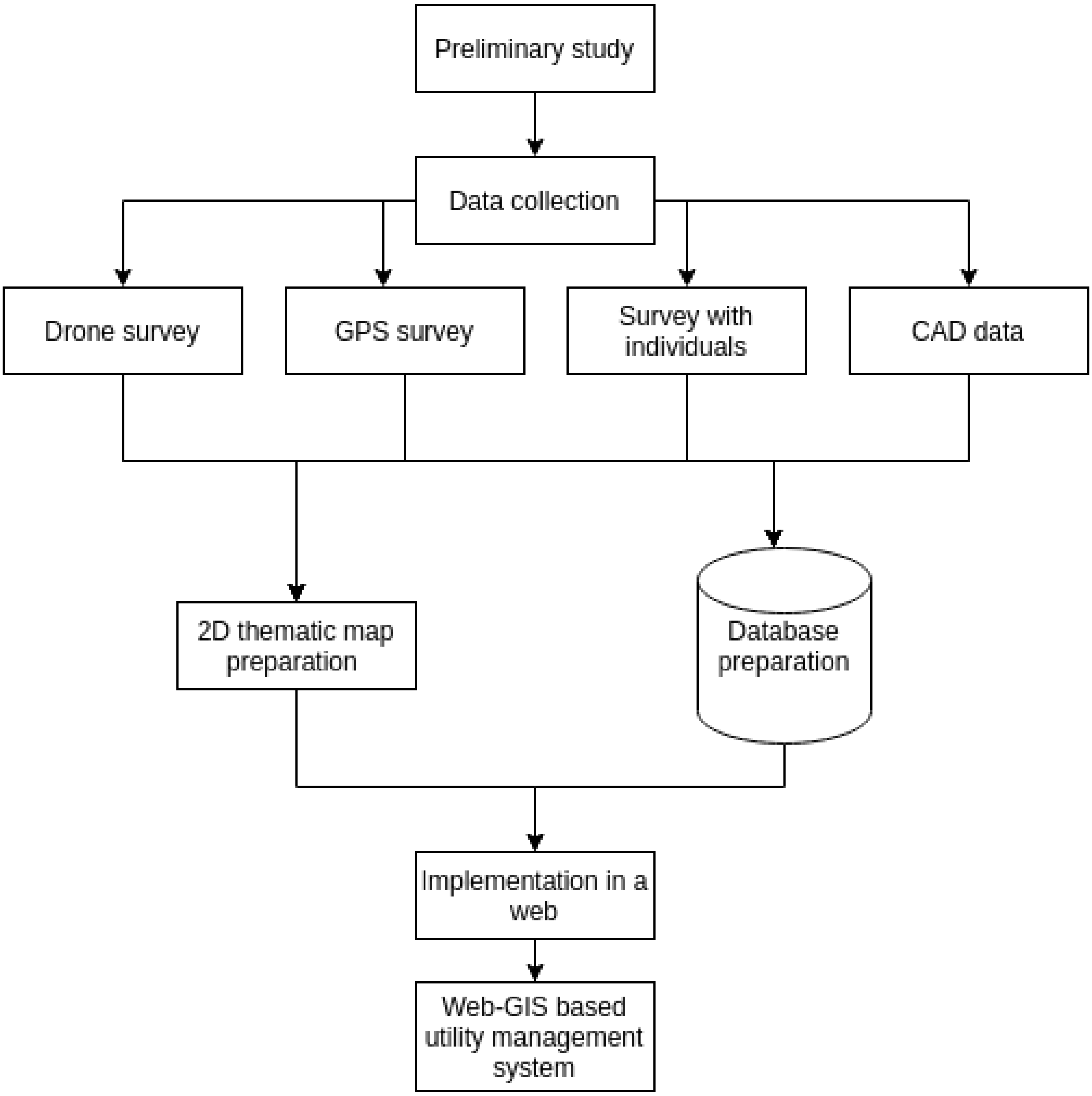

Figure 1. Methodology of Web GIS Based Utility Management System

RESULT AND DISCUSSION

The system provides all the utility networks overlaid with base layers like OpenStreetMap (OSM), Mapbox, and Dark map. The different utility layers available on the system are road network, transmission line, water supply network, sewer line, drainage network, telephone and television network, street light, building footprint, plot, housing boundary, temple, park and swimming pool. The individual layers are visualized along with their attribute information as shown in the figure below. This system helps to analyze two or more layers at the same time and is useful for overlay analysis. The developed system contains basic map functions like zooming in/out, zooming to layer, expanding to full screen, adding marker, adding vector layers, measuring distance and area, printing maps, sharing them and generating reports.

The developed web GIS-based utility management system of Deep Housing, Pokhara is shown below with its components.

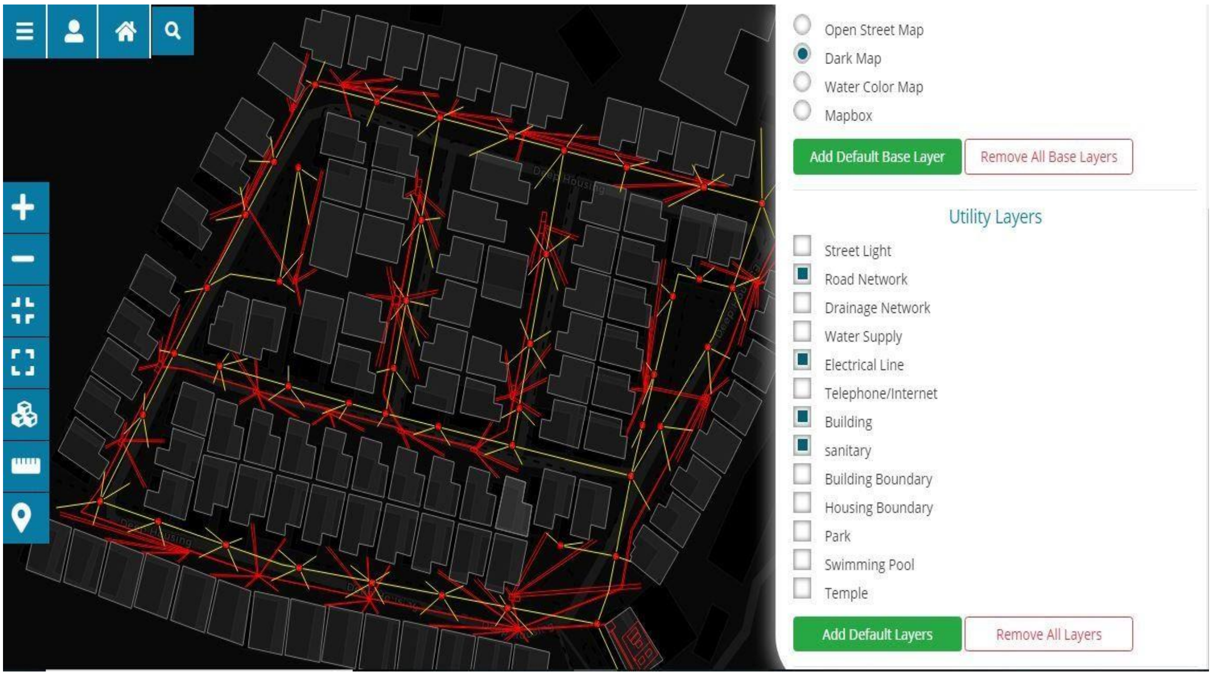

Figure 2. Interface of the Utility Management System

Admin View

The default interface is meant for clients. The system administrators are provided with their respective user credentials for authentication, which can be later changed according to their well. This system provides overall controls to the admins like addition, updation or deletion of the utility layers. The admins have privilege access to the main admin dashboard where they can view a summary of the data, and track issues of the clients for which they can take necessary action.

User View

The users are limited to the functionalities of viewing the layers, submitting the issues and performing basic functions.

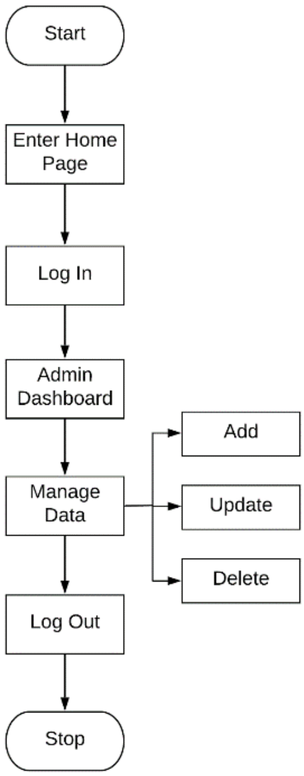

Figure 3. Admin View

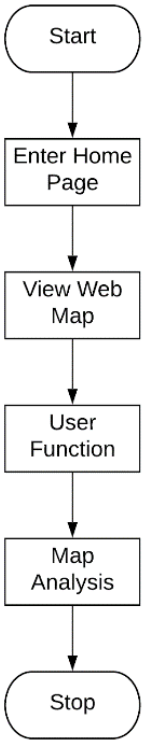

Figure 4. User View

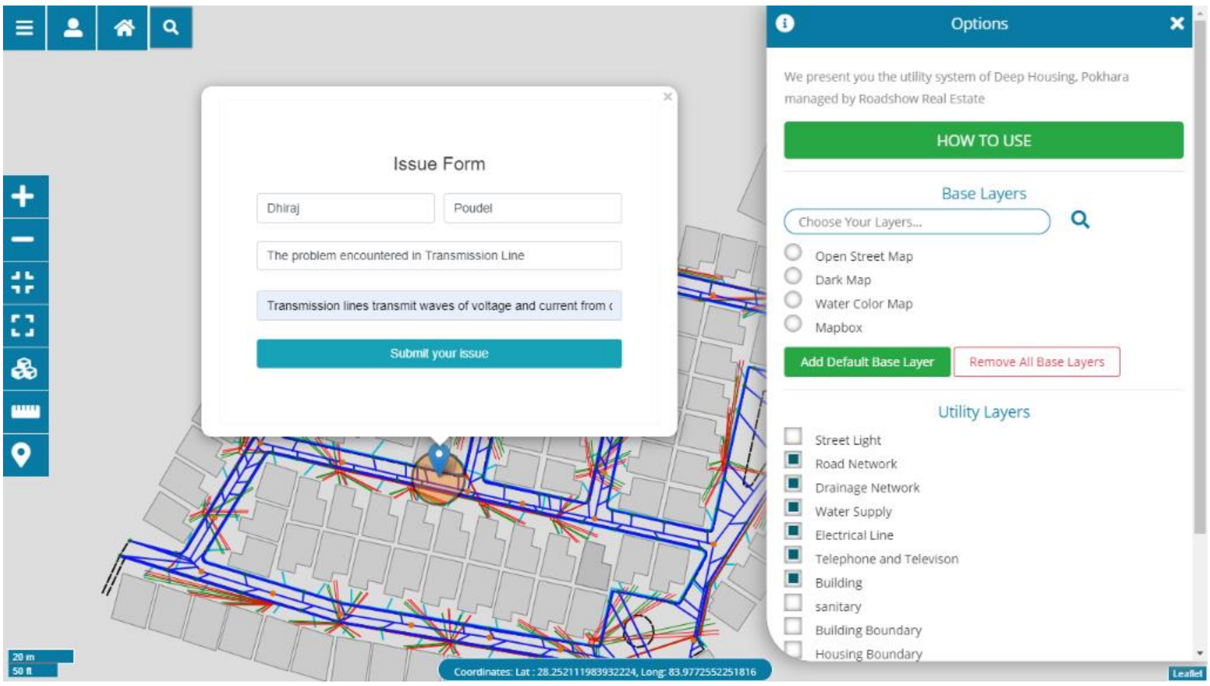

Figure 5. Interface of Client Support Center

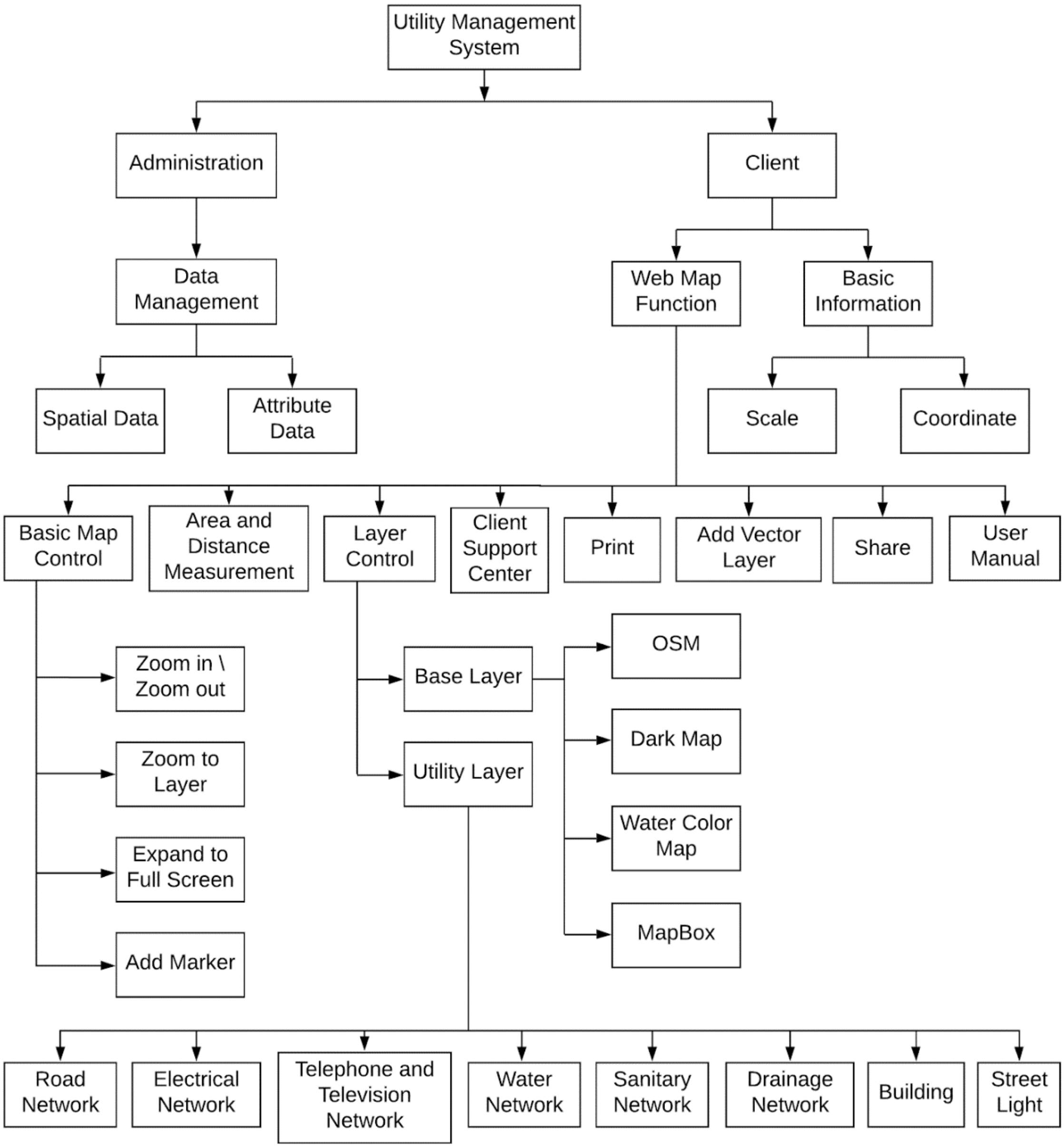

Figure 6. Architecture of the System

CONCLUSION

The web GIS system is an all in one system facilitating different stakeholders with effective and efficient utility services delivery. This system is a cross-platform and easily scalable.

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