WEBGIS APPLICATION FOR CADASTRAL SURVEYS

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SUMMARY

Cadastral surveying in Ghana is characterised by a high number of survey beacons that are widely distributed. Local authorities usually communicate the coordinates and other attribute information of these beacons to users in paper form. Basically, the users require these attribute information of the control pillars to process cadastral survey-related data and to identify a control beacon that is closer to their specific site of survey. The constraint of sharing data in paper format leads to delay in timely provision of essential information for processing cadastral data. This work, thus, seeks to provide a technological solution (WebGIS) that can be accessed by a large number of users (both onsite and remote), has a lower cost, is easy to use and maintain for the dissemination of the attribute information of the control pillars to the geospatial community and also enable the users realise the spatial distribution of the control beacons.
WebGIS, a combination of the web and GIS is one platform that is currently on the rise allowing the exchange of geospatial information among multiples of users across the globe. It allows the integration of multisource data on a single platform using a 3-tier architecture, removing the constraint of distance in accessing data of geospatial objects. WebGIS is thus suggested as a solution for the identified geospatial need, to store the data and present them to the users on a web browser.
In this work, a prototype of this proposed solution is being developed, taking into consideration the geospatial needs of the users, obtaining data from the authorities in charge of the survey beacons in the locality. For the standardisation of the system to be developed, the standards and specifications of the Open Geospatial Consortium for the exchange of geospatial information using web services among a large audience will be the building block. The application will then be presented to the users in a more user-friendly web environment. Thus, the final application will display map layers, attribute information of the control pillars and allow the user to perform basic operations. Also, an additional feature will be implemented for the management of cadastral survey transactions.
Although the proposed system will be an optimal solution, further improvement will be necessitated to serve additional needs of the users such as the capability to store observed survey data in a database. Also, higher capacity servers will be needed to reach a larger user community.

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1. INTRODUCTION

Cadastral surveying is based on collecting and processing observation data to determine the position of a feature on the surface of the earth, using relative or absolute positioning technique (Biagi, 2009). In both techniques, the attribute information of a control beacon is required in order to process the data to determine the coordinates of boundary corners. Thus, as a characteristic, a denser network of control beacons are usually found in an area which could be used for the survey and its attribute information used to determine the position of a feature.

A big challenge that is faced by surveyors is identifying a control beacon that is closer to their site or area of survey and obtaining the needed coordinates and other attribute information for processing the observed data. In Ghana, the Survey and Mapping Division of Lands commission is the sole authority mandated to regulate practice of cadastral surveying and to manage control beacons across the country. The attribute information of the control beacons are thus communicated to the surveyors in paper form after a request for this information has been made. This is very inefficient considering that the SMD processes a very large number of requests for cadastral plan or map approvals.

In her address during the 18th Surveyor's Week and 54th Annual General Meeting (AGM) of the Ghana Institution of Surveyors, the president of the institution addressed many issues regarding mapping and cadastral survey transaction management in Ghana. Firstly, there is a lack of comprehensive and digital map created using modern technology to support delivery of geoinformation. There is also a lack of database to support land information system, which frustrates the ability to provide the requisite information to support bodies such as the local assemblies and Ghana Revenue Authority.

Thus, a technological solution that can be accessed by a large number of users (both onsite and remote), has a lower cost, easy to use and maintain is being sought after for the dissemination of the attribute information of the control pillars to the geospatial community and also enable the users realise the spatial distribution of the control beacons. Also, cadastral survey transactions is characterised by distinct entities that require database application for their efficient management.

WebGIS, a combination of the web and GIS is one platform that is currently on the rise allowing the exchange of geospatial information among multiples of users across the globe and enable users to also realise the spatial relation between features. It allows the integration of multisource data into a single platform using a 3-tier architecture (data, application and presentation layers). This has the advantage of removing the constraint of distance to access attribute information of geospatial object. Also, compared with a traditional GIS application, WebGIS does not require the installation of any software program for accessing GIS functionalities. WebGIS is thus suggested as a solution for the identified geospatial need, to store the data and present them to the users on a web browser. For details about WebGIS, the article of Battistella et. al. (2022) is recommended.

In this work, a prototype of this proposed solution is being developed, taking into consideration user needs. For the standardisation of the system to be developed, the standards and specifications of the

Open Geospatial Consortium for the exchange of geospatial information using web services among a large audience will be the building block. The application will then be presented to the users in a more user-friendly web environment. Thus, the final application will display map layers, attribute information of the control pillars, allow the user perform basic operations and manage cadastral transactions.

2. STUDY AREA

The chosen area of study is the central region, located in the southern part of Ghana (longitude (-2.16490, -0.36309) and latitude (5.03239, 6.28912)). It has an area of 9651.794 km^2, divided into 13 areas in the classes of district, municipal and metropolis. The population of the region in 2021 was 2,859,821, which represent a population density of 296.3 per km2. Thus, it is anticipated that acquisition of land and land related transactions will increase in the near future, thus the need for their management.

3. DATA SOURCES

Table 1 gives a summary of the data types used and their geometry. Except the station coordinates data, data for all the other features were obtained from a third party website that can be accessed using the link here. The station coordinates data were however obtained from the local authorities that manage control beacons in the region. A total of 10,736 station coordinates were obtained. A data clean up was done to remove double entries, null values, incomplete data and those stations that are not within the boundaries of the area of interest (i.e. those that are outside of the Central Region). The number reduced to 8148. The data to feed the database needed for the management of the cadastral transaction will be supplied from the daily cadastral transactions of an independent surveyor being partnered for the project.

Table 1 Data Source

Feature	Data Type	Geometry
Administrative boundary	shapefile	polygon
Railway	shapefile	line
Road	shapefile	line
Water areas (lagoon)	shapefile	polygon
Station coordinates	csv	point
Water lines(rivers and streams)	shapefile	line

4. METHODOLOGY AND SYSTEM DESIGN

The project commenced using the waterfall approach of software development. This was necessary to ensure that a step is completed before subsequent stages are commenced. The main stages of the waterfall approach followed are feasibility study, requirement analysis, design, development and testing, deployment and maintenance.

4.1 Design Considerations

In this stage, the main components of the application were identified to meet the needs of the user.

4.1.1 Database

The entities that could be involved in a transaction of cadastral survey type needed to be identified and the possible relationship between these entities were done. This was done in accordance with the Survey Act, 1962 (Act 127) the legal framework responsible for regulating the practice of cadastral surveying in Ghana. The identified entities and their roles are:

- User: the user refers to the end-user of the proposed application being developed.
- Control beacons: this refers to the control beacons that might be used in the execution of cadastral surveys. The entity object contains the attribute information of the control beacon that is required for the processing of the cadastral survey data and for its identification in the geospatial space.
- Licensed surveyor: the licensed surveyor is an individual who is legally licensed and permitted to practice cadastral surveying in Ghana.
- Agents of licenced surveyor: these are individuals who do not have the licence to practice surveying but are attached to a licensed surveyor and work for him.
- Customer: this refers to an individual who has acquired land and requiring for cadastral plan or documents to be prepared for him or her.
- Survey map: this is the end product of a cadastral survey.
- Customer jobs: these contain the details of the customer request for documentation of his or her acquired land parcel(s).
- Job submissions: these refer to the documents that are submitted to the Survey and Mapping Division for the approval of the Director of Surveys.

The other entities identified in the Survey Act, 1962 (Act 127) but not considered in this application are the Director of Surveys, Official Surveyors and individuals or institutions that, according to the act, have varying ownership of interests in land. Among other roles, the Director of Surveys is responsible for ensuring that the specifications of the Survey Act are met in the conduct of cadastral transactions while the Official Surveyors are the surveyors that work in the Survey and Mapping Division of Lands commission that, just as the Licensed Surveyors,

have the legal permission to practice cadastral survey in Ghana. It is anticipated that these entities will be considered in future development of the application so that cadastral survey transactions in Ghana in its entirety will be efficiently managed with the application.

4.1.2 Map View

This is the section where decisions for the display of the map were made. Basically, the tools needed for the development of the WebGIS application were identified and these are as shown in Figure 1.

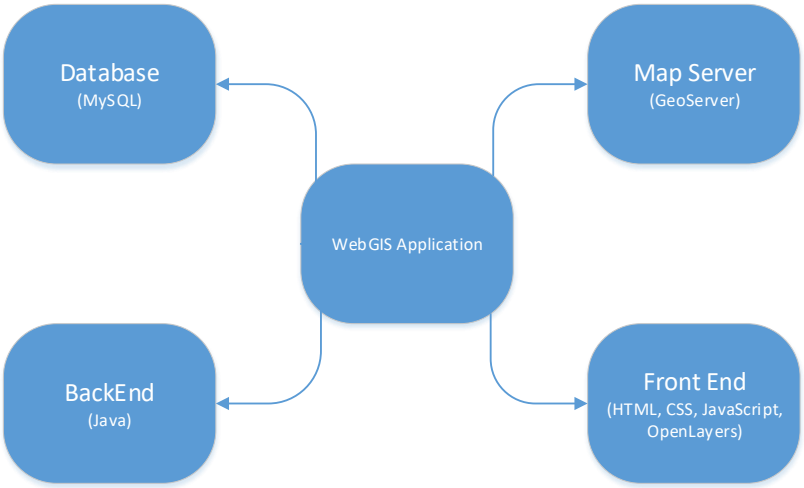

Figure 1 Components of WebGIS

In Figure 1, the components used are briefly described below.

- Database: In this component, the structures of the tables to store the data needed for the running of the application were designed.
- Map server: this was the component used for storing the shapefiles of the road, railway, boundary etc. needed for display on the map meant to assist in understanding the nature of the area in which a control beacon is located.
- Backend: in this component, the methods and attributes needed for accessing the database tables were specified.

- Frontend: in this component, the presentation view of the application was designed. This was done taking into consideration the needs of the end user and addition of features to improve the interactive nature of the application.

4.2 Implementation

The implementation begun with the creation of the database tables. Subsequently, shapefiles for the terrain features (road, water areas, water lines etc.) were stored on the map server. This was done following the OGC standards for the exchange of geospatial information using web services among a large audience. The business methods of the application layer were then developed to access the database and to make the data available for the presentation layer.

Finally, the presentation layer was then implemented for the display of the data. However, this layer is still under development and updates will be made in subsequent releases of the application. OpenStreetMap was used as a base map for the map interface as it does not require any API key. Alternatively, other base maps such as Google Map, Microsoft BingMap, Stamen, etc. could be used to achieve similar purpose.

5. Results and discussion

Figure 2 shows the homepage of the proposed application. It has four menu items labelled as Agent, Customer, LicensedSurveyor and Beacons.

- Agent: this redirects to the page where it is possible to see the details of all the agents and the license numbers of their affiliated licensed surveyors. The page also contains a link to the page where one can add a new agent to the database.
- Customer: this redirects to the page to see the list of all the customers as well as a link to create add a new customer to the database.
- LicensedSurveyor: this redirects to the list of all the licensed surveyors and shows the details of each, including his or her license number.
- Beacons: this redirects to the map view where the beacons are shown as well as the elements for interacting with the application. Currently, there are 3 elements available on the map view that allow interaction with the user. This scale bar gives information about the scale at which the map is being viewed, the legend that shows which layers are being viewed on

the map and the mouse position element that gives the coordinates of the current mouse position. The items in the legend can be turned on or off for better analysis of the terrain features that are surrounding a control beacon.

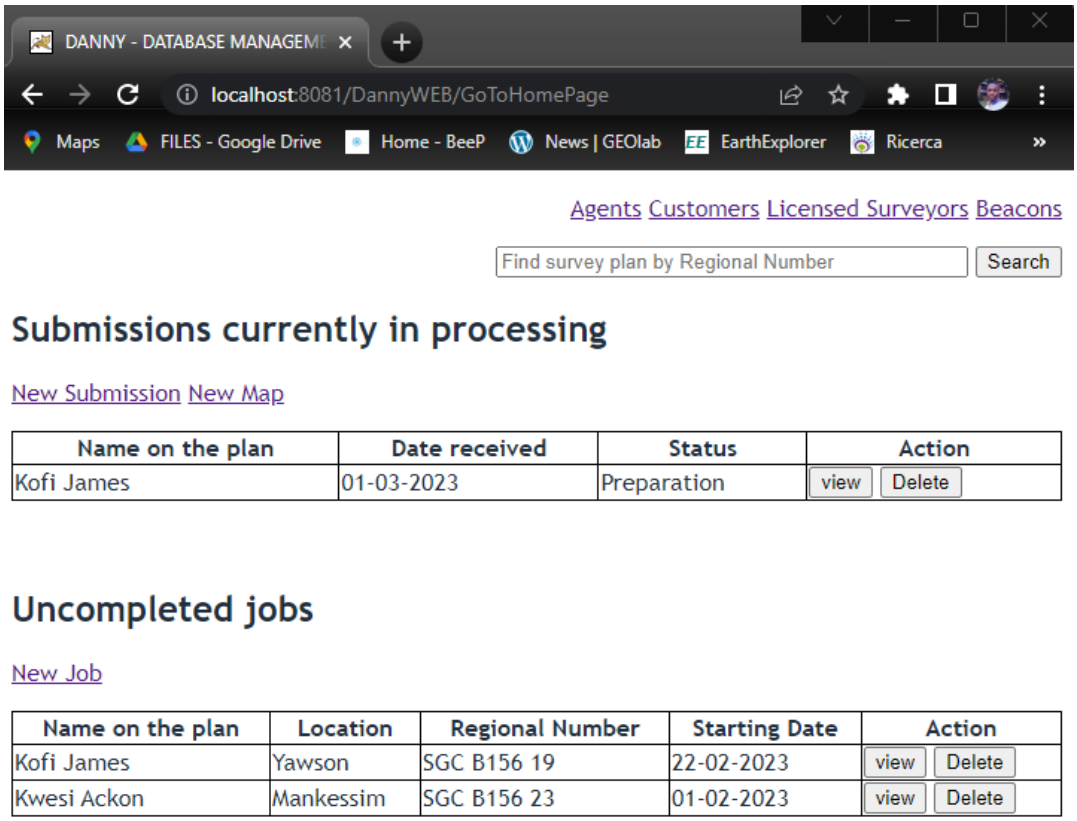

Figure 2 Home Page of the Application

Figures 3 to 6 show samples of the developed pages for creating a new entity object for the database, viewing the details of a job or submission, and showing the map of the control beacons in the area of interest and for viewing the list of agents, licensed surveyors and customers.

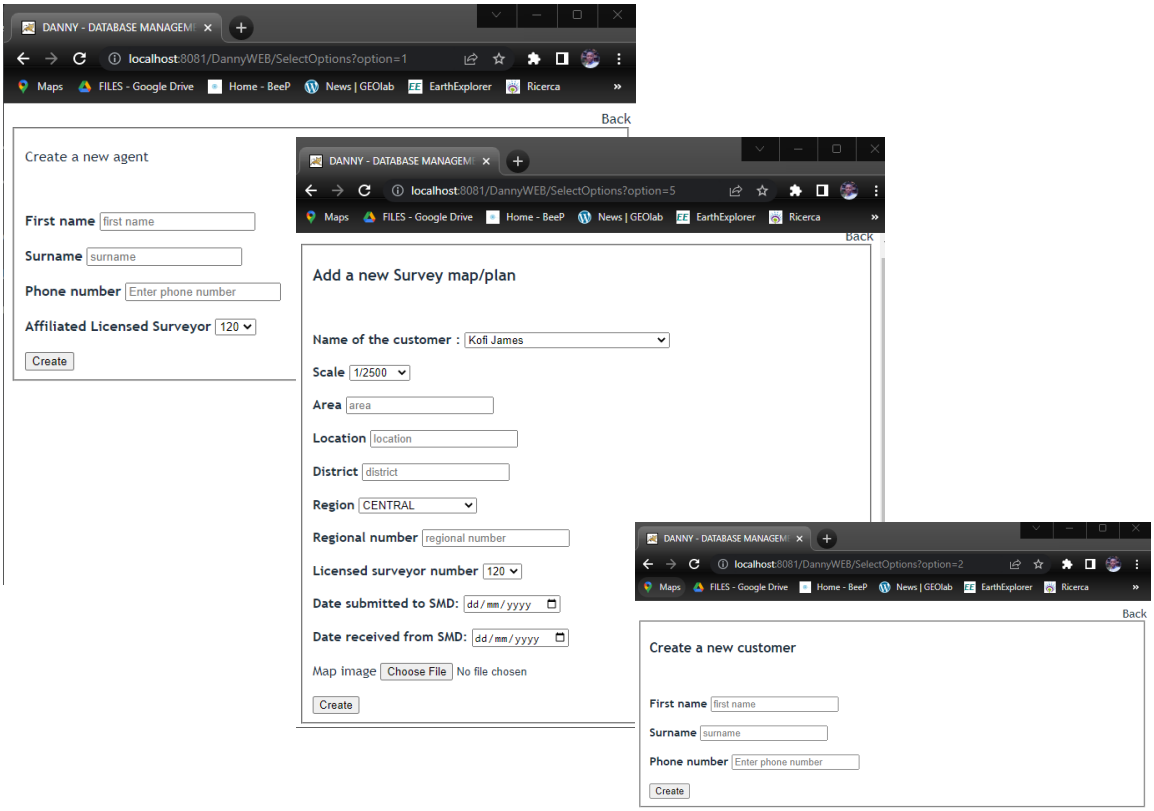

Figure 3 Page for the Creation of a New Entity

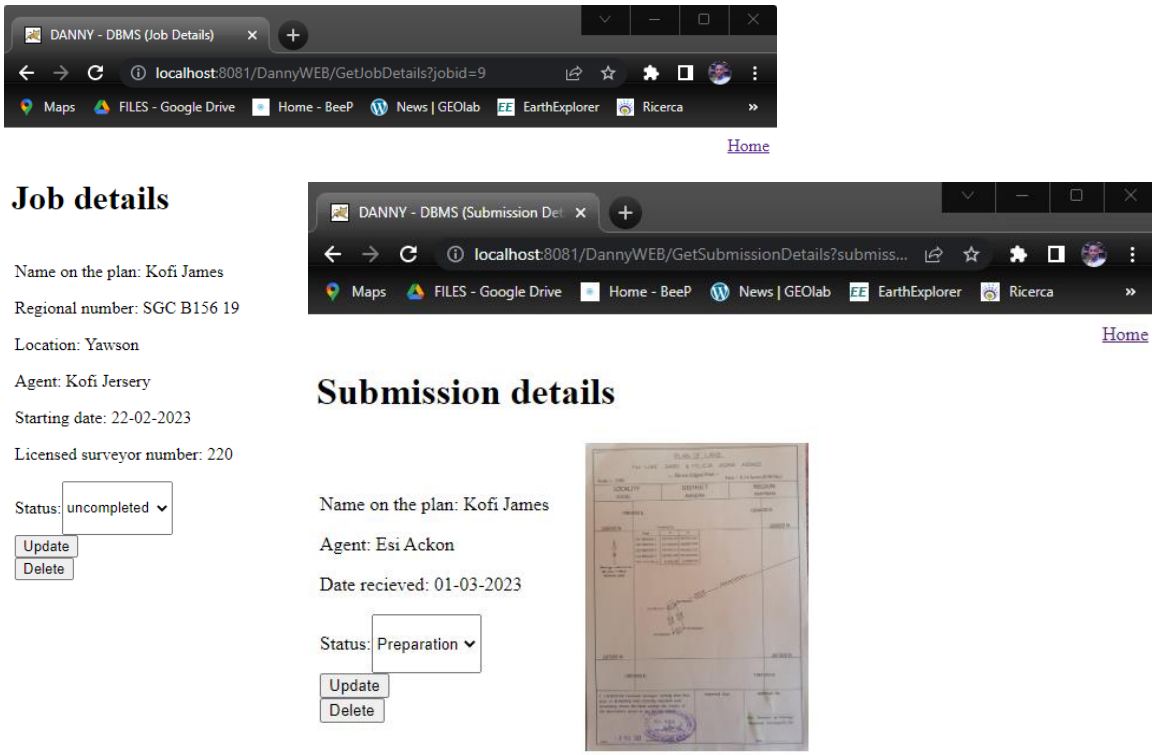

Figure 4 Page for visualising the details of a job or submission.

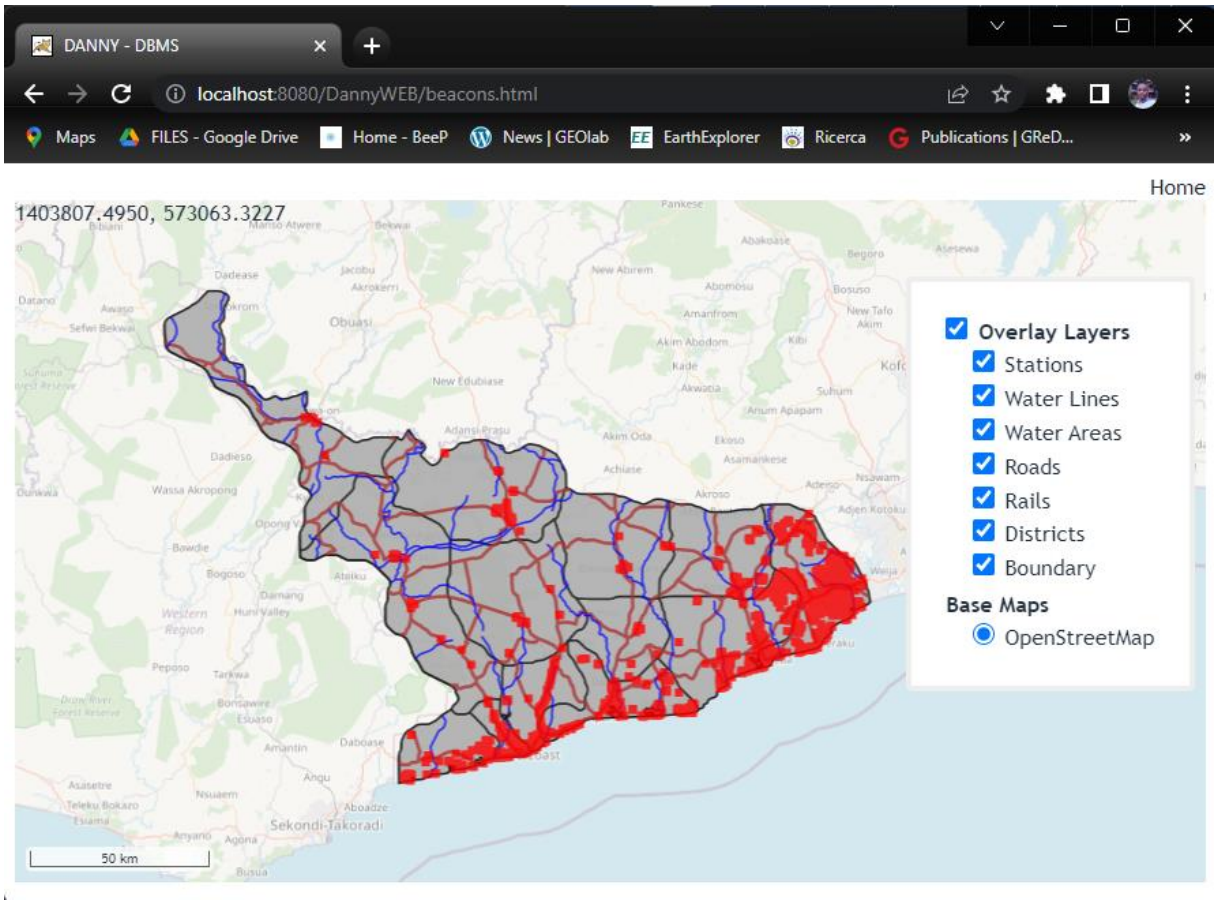

Figure 5 Map view of the control beacons in Central Region

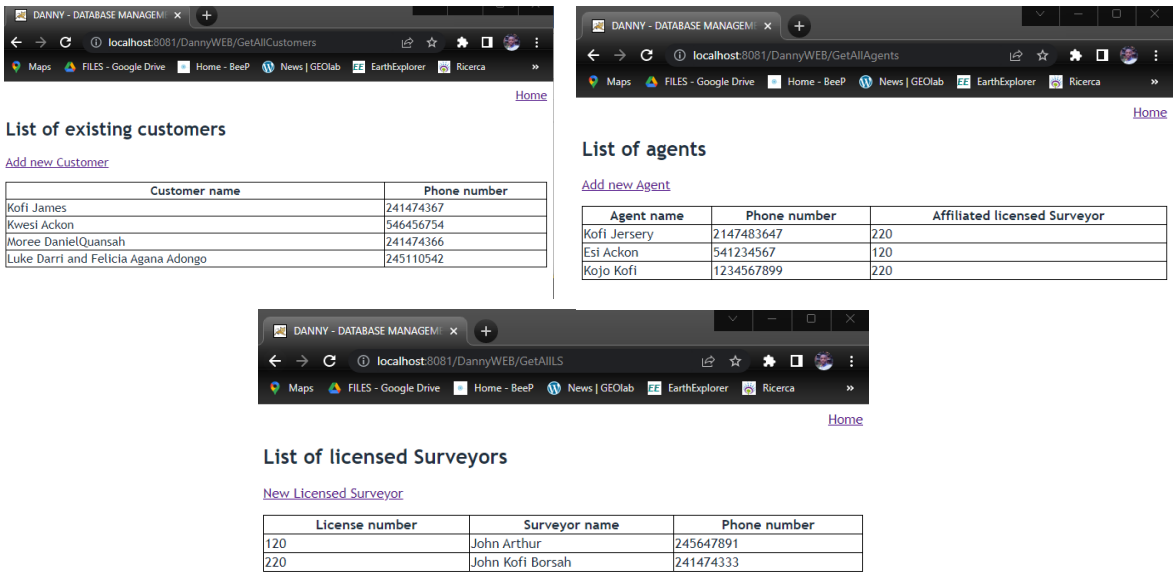

Figure 6 Pages for viewing the list of customers, agents and licensed surveyors

6. CONCLUSION AND RECOMMENDATIONS

GIS has become a valuable tool for the management of geographic information. With the advent of WebGIS, it is becoming much easier to manage geographic information. It is now possible to integrate a database management system with a GIS application for efficient management of information. WebGIS also comes with the additional advantage of not requiring the installation of software or user expertise to visualise the geographic information.
It is based on these that this project has been undertaken for the organisation of cadastral survey transactions in an interactive environment. Currently, the application allows the management of cadastral survey transactions using a database management system and the visualisation of control pillars in the Central Region. It is anticipated that advance features will be added to the developed application to improve its user interactivity.

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