Development of a GIS-Based Land Records Management: A Case Study*

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Abstract

Lands Commission (LC) cannot be mentioned without the tags of record manipulation, inefficiency, and ineffectiveness. This is due to the manual nature of the duties conducted at the records office under the Public and Vested Land Management Division (PVLMD), tasked with managing all records for the LC and retrieving or updating them when necessary. In order to achieve the vision and mission of the organisation, this research sought to develop a Geographic Information System (GIS) based Land management system for the LC, using Tamale as a case study. In a QGIS environment, land records such as ledgers, registers, town sheets, maps, and layouts were integrated through georeferencing and digitisation. The system allows easy query of records by entering the site coordinates, generates a search report, allows viewing layouts, and documents in PDF format, and also allows the updating of records with just a click of a button instead of going through the old-fashioned method of combing through manual documents before carrying out this same task. The system, when adopted and implemented, would improve the work of the institution as speed, efficiency, and security are assured.

Keywords: Lands Commission, Land Records, GIS

1 Introduction

The Lands Commission (LC) was established by Articles 258–265 of the 1992 constitution and was strengthened by the Lands Commission Act 2008; Act 767 gave the legal basis for four land sector agencies to merge as divisions. They are: the Land Valuation Division (LVD), the Land Registration Division (LRD), the Survey and Mapping Division (SMD), and the Public and Vested Land Management Division (PVLMD). The vision of the LC is to become the center of excellence for land service delivery, and the mission is to provide high-quality, reliable, and efficient services in geographic information, guaranteed tenure, property valuation, surveying, and mapping through teamwork and modern technology to stakeholders (Anon., 2014).

The LC has a lot of flaws in its job delivery in terms of time and efficiency, which is in contrast to its vision and mission (Adeboye and Mensah, 2017). For instance, there is poor attention and a lack of innovation. The Commission's records department, also known as the "heart" and the "brain" of the LC, in many cases works directly under the Public and Vested Land Management Division. The department's task is to carry out duties such as the keeping of land records, managing and updating all land transactions, and providing reports on parcels of land (Deane *et al*., 2017).

The International Standard Organisation defines records as "information created, received, and maintained as evidence and information by an organisation or person, in pursuance of legal obligations or in the transaction of business" (Anon., 2016). It either forms part of the transaction or provides proof. They are subsequently maintained and managed by or on behalf of those responsible for the transactions (Anon., 2000).

Notwithstanding this, the department is still reliant on the age-old methods of creating and maintaining land records. This system consists of manual surveys, cloth-bound cadastral maps, and non-uniform structures of record of rights. Currently, each region maintains this database as a hardcopy register (Patil, 2014). The method of keeping and retrieving the information makes it almost impossible for the LC to deliver its duties (Tagoe and Mantey, 2011).

Apiah (2013) also expressed that the information management system currently operating in the country is mainly manual. Data and information are kept in the form of hard copy graphical maps, cadastral data, and textual records. The linkage between these manual records is poor, and there is difficulty in accessing data. Keeping records up-to-date in the land agencies is therefore a challenge. All these seriously constrain the operation of the land sector agencies. Furthermore, land records are deteriorating with use, and this deterioration is compounded by the substandard conditions under which many of these records are stored and the extensive use to which they are subjected through the retrieval and re-filing of the ageing manuscript documents (Cox, 2006). As there is no backup system, the records may also be at risk of disasters such as fire or flood. On the 22nd day of March

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2012, clear evidence of a disaster occurred when part of the LC head office records was burned down.

According to Vinay *et al*., 2003, data entry and verification of legacy data, regular updating of the records because of mutations, unstructured data, and language issues, and land records maintained on paper and cloth are in very bad shape. Duplication on similar media is cumbersome and will result in similar maintenance problems after a few years. Updating boundaries or title information by hand is highly time-consuming. All of these constitute a significant land records management problem (Wayumbi and Ayugi, 2017).

When records are well managed, they serve as instruments of accountability and as authoritative and trusted sources of information (Smith *et al*., 2015). The potential benefits of land records can be maximised when they are carefully managed. Recently, new know-hows for data collection and processing, together with increasing requirements of users, have directed attention to the need for enhanced land records management approaches.

Such approaches are concerned with the effective grouping of resources in order to achieve a set of goals. These goals may include enhancements to the; coverage, content, compatibility, and reliability of access to the information and the likelihood of incorporating other data. The ultimate aim is to meet the needs of users more efficiently, effectively, and equitably (Patil, 2014). This research seeks to develop a land information system based on a written program where the various ledgers, registers, plans, and maps can be integrated digitally to enable easy access to information. This is to boost the performance of the day-to-day activities of the records department and to increase their general output. The study area will be the Airport Road Residential and Sagnarigu Dungu Kukuo West Extension Residential Areas in Tamale.

1.1 Study Area

The study area is within Sagnarigu District, and the capital is located at Sagnarigu. It was one of the six (6) districts created in the Northern Region in early 2012. It was taken out of the Tamale Metropolis by Legislative Instrument (LI) 2006. The district was inaugurated on June 24, 2012, with the aim of redirecting developmental projects to the communities north and west of the Metropolis (currently Sagnarigu), which were comparatively less developed as compared to the urban areas in the Metropolis. The Sagnarigu District has 79 communities, comprising 20 urban, 6 peri-urban, and 53 rural areas (Abu, 2015).
The district covers a land surface area of 200.4 km^2 and is bounded by the Savelugu/Nanton Municipality to the north, the Tamale Metropolis to the south and east, Tolon District to the west, and Kumbungu District to the north-west. Geographically, the district lies between latitudes 9° 16´ and 9° 34´ north and longitudes 0° 36´ and 0° 57´ west. Fig. 1 shows a map of the Sagnarigu District. Sagnarigu, compared to other districts in the northern region, has a single rainy season, which generally extends from May to October. Average annual rainfall ranges from 600 mm to 1100 mm, with temperatures varying from season to season.
The district has fewer water bodies in comparison to other districts, attributed to the high groundwater table. The few periodic streams available are mostly used for agricultural and farming purposes, which is the main economic activity for the citizens. Traditionally, the area represents diverse ethnic groups and highly respected chieftaincy roots with the Yaa Naa, the highest traditional overload, and Sagnari-Naa, the highest chief and president of Sagnarigu's traditional area.

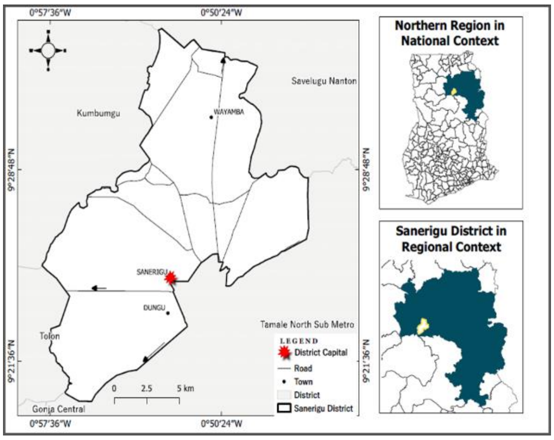

Fig. 1 Map of Sagnarigu District

2 Resources and Methods Used

2.1 Resources

The data used for the research consist of digital spatial datasets, boundary map of Sagnarigu District within the Tamale Metropolitan Area, primary data from site, data from Survey and Mapping Division, fifty (50) town sheets and four (4) layouts from Lands Commission and Town and Country Planning Department. Also copies of one hundred and fifty (150) registered land documents were also used as shown in Table 1. The following software were utilised; MS Excel, AutoCAD version 2007 and QGIS software 3.6. The devices used in capturing data for the research include; Trimble GPS dual frequency receivers, Canon canoscan lide 250 scanner and Canon T3i camera.

Table 1 Data Type and Source

Data	Type	Source
Boundary map of the study area at a scale of 1:2500	Secondary	Tamale metro, Town and
Site coordinate	Primary	Airport road residential area,
Town sheets at a scale of 1:2500	Secondary	Lands Commission, Tamale
Layout of the study area	Secondary	Town and Country Planning,
Site coordinates	Secondary	Survey and Mapping
Copy of registered land document	Secondary	Lands Commission, Tamale

2.2 Methods Used

2.2.1 Reconnaissance

Familiarity with the study area was done to ascertain the extent of work in terms of pillaring and demarcation of the plots and in conformity with the layout provided by the Town and Country Planning Department and other data received from the Survey and Mapping Division of the Lands Commission. It also helped in the choice of equipment to be used for the data capture, which will enable further preparation of the site for the field work. Fig. 2 shows the researcher relating the layout of the area to some ground control points. Fig. 3 shows the flow diagram of the procedures used in conducting the research.

Fig. 2 Site Reconnaissance to Relate the Layout to the Ground Pillars

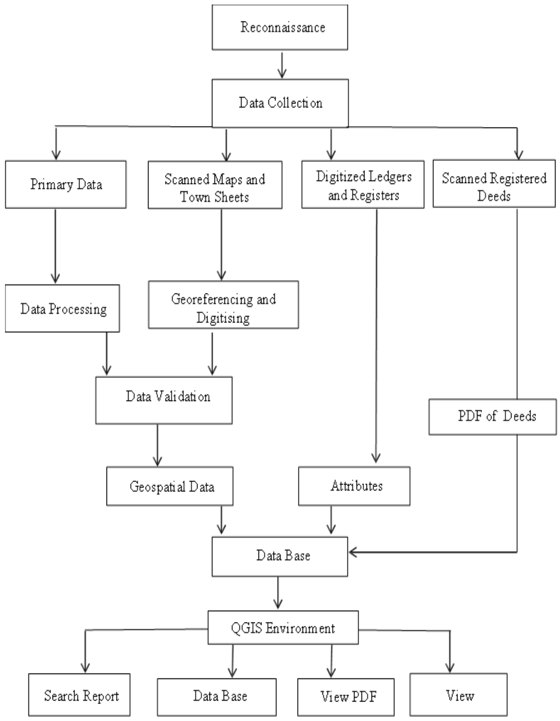

Fig. 3 Flow Diagram for the Research

2.2.2 Data Capturing

Primary and secondary data were used to achieve the objective of the research. Trimble dual frequency GPS receiver was used to obtain coordinates of some pillared site on the ground within the georeferenced map of the study area in order to validate the georeferenced work. It was also used to survey some sites to validate the maps. Table 2 shows samples of the primary data captured. The secondary data were extracted from the georeferenced maps and town sheets for validation and for carrying out the whole task to achieve the objectives of the research. Figs. 4 and 5 show images of the secondary data sources.

Table 2 Primary Data (Site A)

BEACON INDEX		
Beacon	Co-ordinates	
	X (Feet)	Y (Feet)
SGN/B117/2017/1	175 5103.38	955 094.71
SGN/B117/2017/2	175 5206.41	955 110.76
SGN/B117/2017/3	175 5190.42	955 220.62
SGN/B117/2017/4	175 5087.56	955 204.04

Table 3 Data for Setting Out (Site B)

BEACON INDEX		
	Co-ordinates	
Beacon	X (Feet)	Y (Feet)
SGN/1	175 6917.60	955 428.91
SGN/2	175 6905.95	955 532.65
SGN/3	175 6802.84	955 518.76
SGN/4	175 6813.74	955 417.70

2.2.3 Georeferencing and Digitisation

The process of Georeferencing and digitising of the planning schemes were done to orient the schemes to the same ground position. The layout was then digitised with the town sheet in the AutoCAD environment as DWG and later converted to DXF to enable the data be manipulated in the QGIS environment to achieve the research objectives.

2.2.4 Data Validation

Two methods were used to check data accuracy; ground truthing, and setting out of some selected parcels of land within the study area and the outlier detection text. The ground truthing was done on selected pillars (Table 4), and were plotted onto the digitised map to check it accuracy and whether it falls in line with same plot (Fig. 4 and 5). Coordinates from some marked out positions were also set out on site to identify how the ground and the spatial map positions are related.

Table 4 Data for Ground Truthing (Site A)

BEACON INDEX		
	Co-ordinates	
Beacon	X(Feet)	Y(Feet)
SGN/B117/2017/1	175 5103.38	955 094.71
SGN/B117/2017/2	175 5206.41	955 110.76
SGN/B117/2017/3	175 5190.42	955 220.62
SGN/B117/2017/4	1755087.56	955 204.04

Fig. 4 Sample Town Sheets and Layout before Georeferencing and Digitising

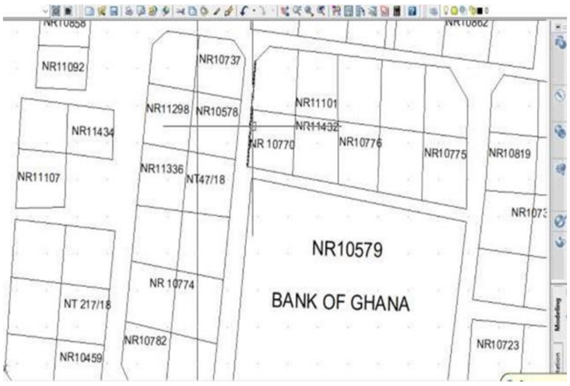

Fig. 5 Digitised Town Sheet in AutoCAD

2.2.5 Exporting of data from AutoCAD to QGIS

Drawing Exchange Format (DXF) files of parcels together with their corresponding noted proposal numbers and (or) deed numbers were obtained using AutoCAD and were exported to QGIS environment for further manipulation and analysis. Fig. 6 Shows exported data from AutoCAD to QGIS.

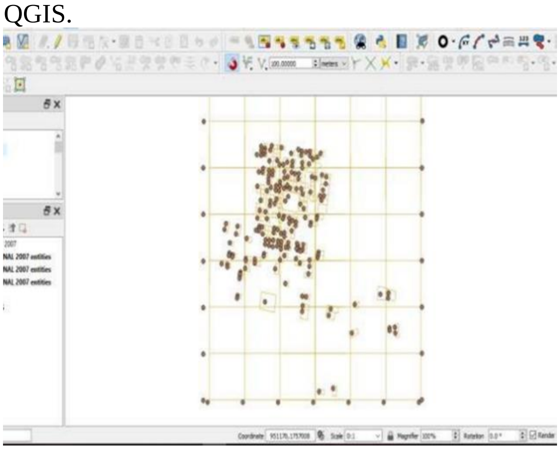

Fig. 6 Exporting of Data from AutoCAD to QGIS

2.2.6 Data Cleaning

The parcel which are to be derived from the DXF files needed to be checked for geometry errors (which includes snapping errors, invalid geometries and lines containing dangles). The GRASS toolkit in QGIS, which has embedded algorithms that allows the removal of the earlier stated errors by for a “threshold value” within which to snap lines, remove dangles, etc, was used to correct all these errors. Figs. 7 to10 shows the processes employed in cleaning the data and removing errors from the DXF file.

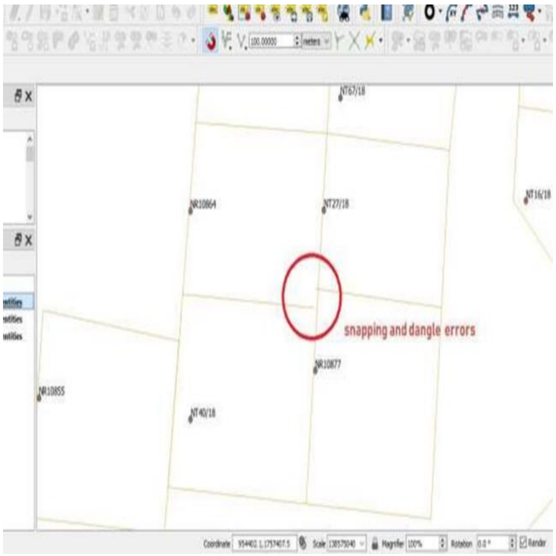

Fig. 7 Using V. Clean in GRASS

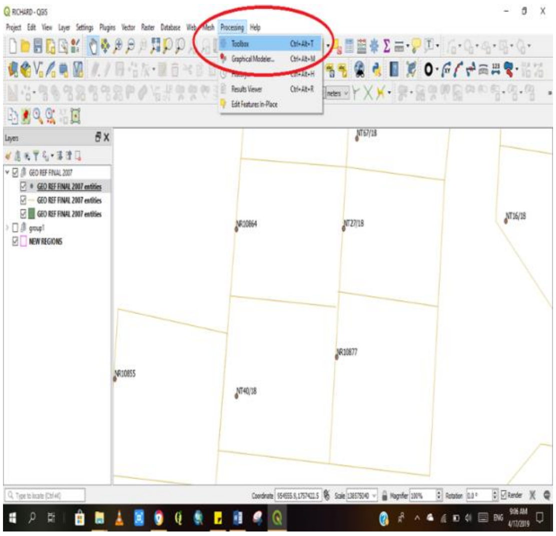

Fig. 8 Command to Clean Imported Data from AutoCAD

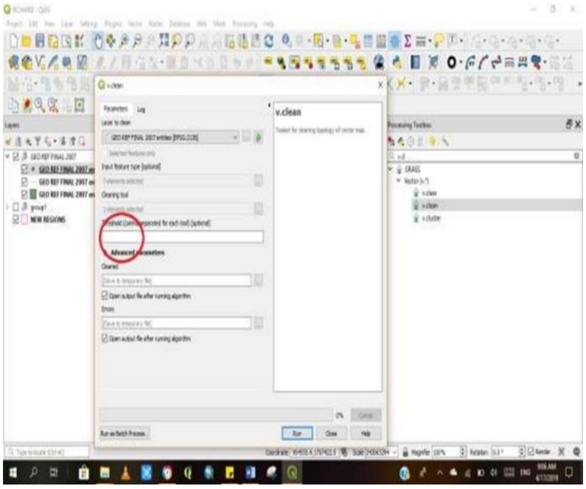

Fig. 9 Command to Remove Errors

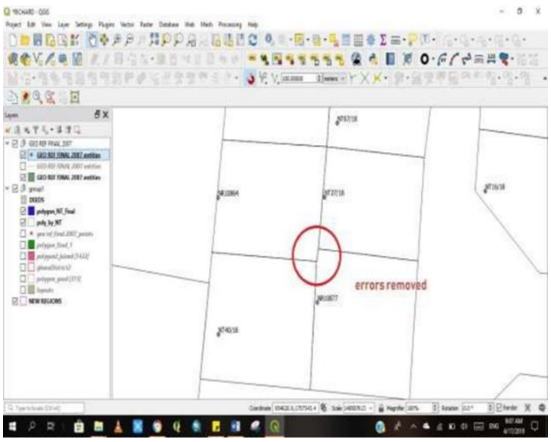

Fig. 10 Errors Removed

2.2.7 Performing the Spatial Join

Next step was to perform a spatial join of the points (from the DXF file) to the “cleaned” parcel polygons and this function is located under vector – data management tools join vector by attributes. Fig. 11 to 13 shows the spatial joint process that adds attributes to their respective polygons.

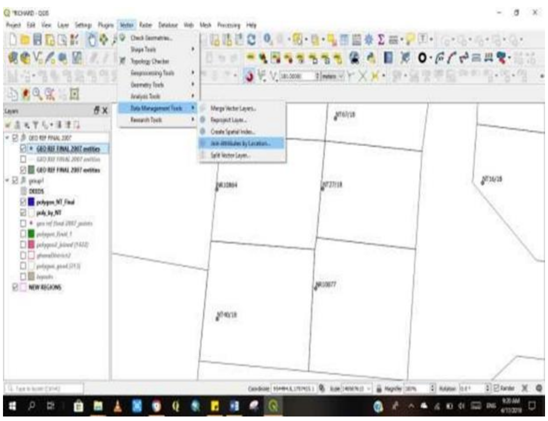

Fig. 11 Performing the Spatial Join

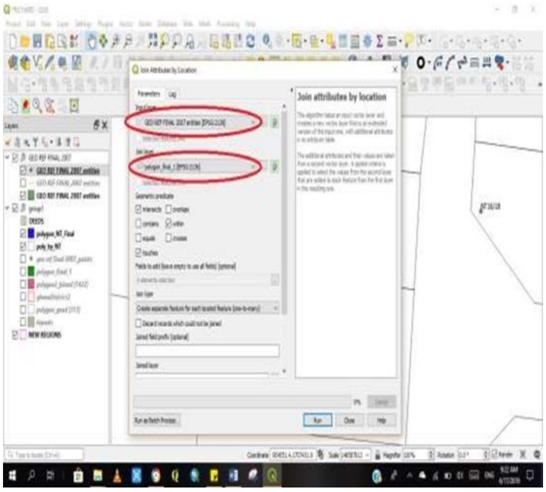

Fig. 12 Spatial Join Command

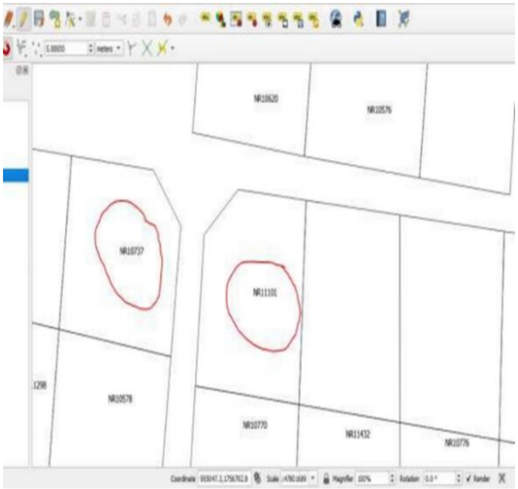

Fig 13 Polygons and Related Attributed

2.2.8 Attribute Join

After performing the spatial join (thus, the polygon now has "Deed No." as an attribute), there is a need to attach the data from the Excel spreadsheet to the polygons. Hence, an attribute join is needed to be performed so that the polygon has the other needed attributes. This is done by right-clicking on the excel file (already loaded into QGIS) – properties – Joins. Fig. 14 shows an excel sheet containing attributes, and Fig. 15 also shows the command to attach all related attributes to their respective parcels.

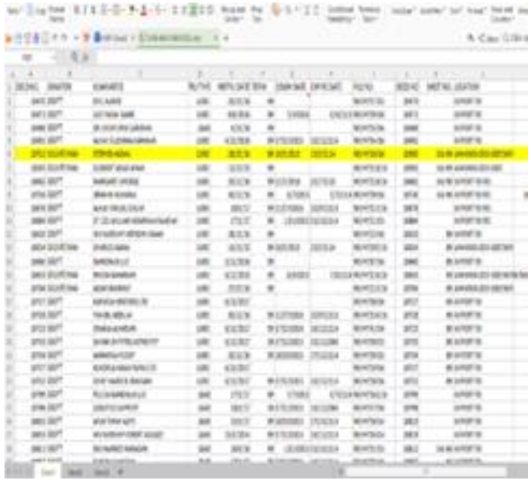

Fig. 14 Excel Sheet Containing Attributes

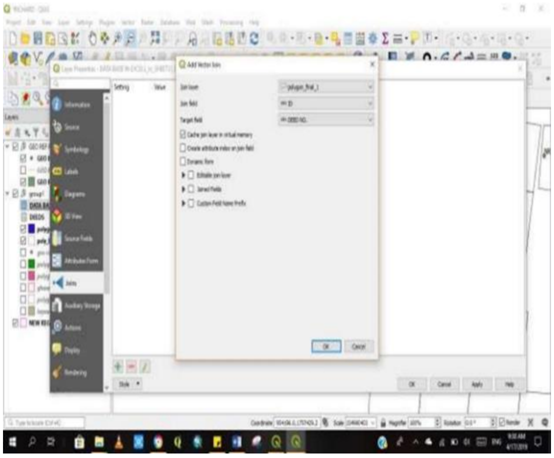

Fig. 15 Command to Attach all Related Attribute to their Respective Parcels

Finally, the polygons now have all the attributes from the excel spreadsheet. A simple click on the polygon now reveals the entire details of the selected polygon. Fig. 16 shows polygons showing all added attributes.

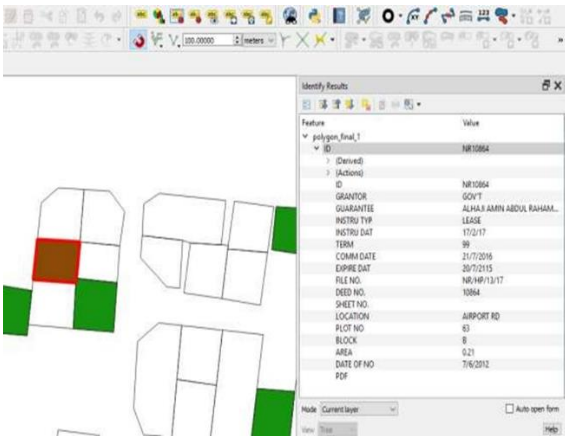

Fig. 16 Polygons Showing all Added Attributes

2.2.9 Attach PDF of Registered Deeds to Attribute Table

QGIS allows for different file formats to be attached to features within the map window (canvas). A new column named “PDF” is created in the attribute table and the file location of the PDF is copied into their corresponding columns.

E.g. “C:/Richard/documents/NR10777. PDF” is linked to column with deed no, 10777 and so on as shown in Fig. 17.

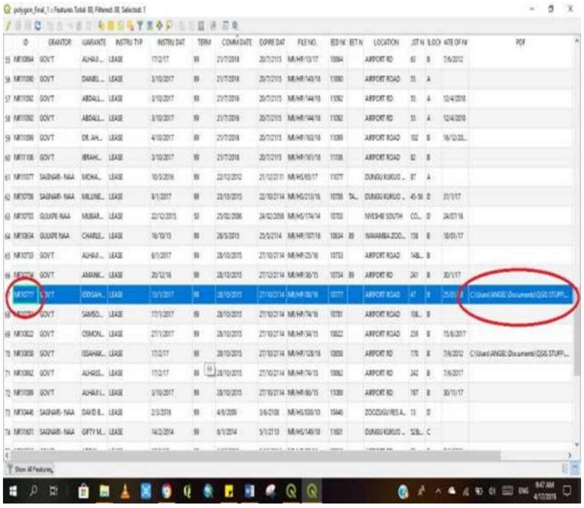

Fig. 17 PDF Attached to the Attribute Table

2.2.10 Command to Open PDF at a Click of a Polygon or Land Parcel

Now the PDF of registered deeds pops open when the parcels containing their corresponding PDFs are clicked on by the “action” icon on the menu bar. This enables easy access to a copy of any registered land document for verification and any other official use as shown in. Fig. 18.

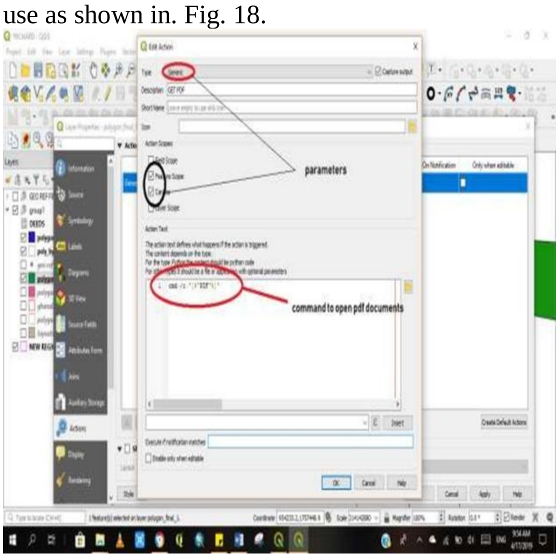

Fig. 18 Command to Open PDF

2.2.11 Searching by Coordinates

The system allows for searching by typing the coordinates of points using a plugin called zoom to latitude/longitude. The typed coordinates can be saved as point layer and can be further connected to form another parcel or polygon in terms of making updates or adding a new parcel. Fig. 19 shows the position of the coordinate highlighted in blue with a red cursor.

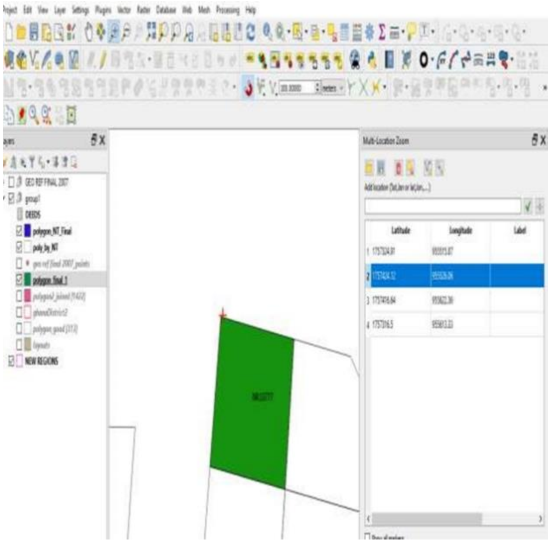

Fig. 19 Searching Parcel by Entering Coordinate

3 Results and Discussion

3.1 Geodatabase

A database is created as an attribute from digitised ledgers and registers in MS excel and further call into the QGIS environment as shown in Fig. 20. This enables the user to view the records of a particular plot or parcel of land at a glance.

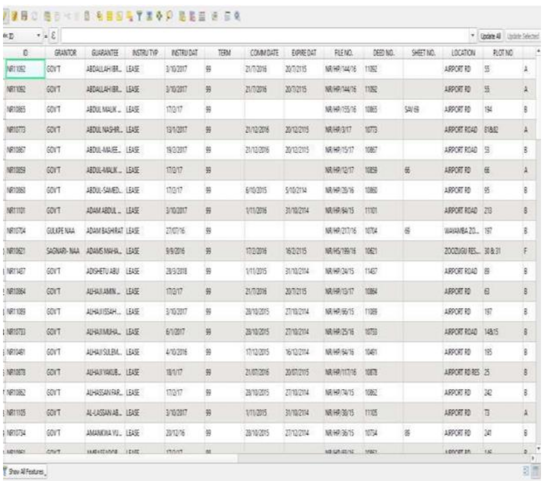

Fig. 20 Developed Attribute Database in QGIS

3.2 Spatial Map

The georeferenced maps, thus town sheets after going through the digitising process in AutoCAD, converted to DXF and taken through the cleaning process becomes the Spatial Map as shown in Fig. 21.

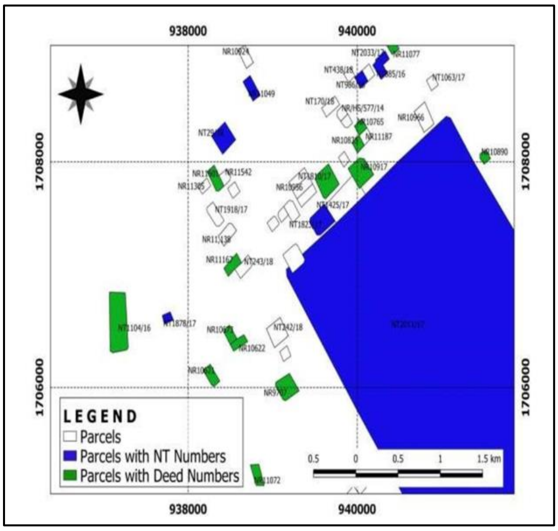

Fig. 21 Developed Spatial Database in QGIS

3.3 Coordinate Entry and Generation of Search Report

The spatial map enables coordinates from site plans to be entered into an interface for the point to show at the exact position on the map as the ground situation may be. Fig. 22 clearly shows a coordinate entered and a point displayed on the map showing the exact position of the coordinate (red mark) in relation to the ground situation. Land parcels as shown in a polygon are linked to the database in Fig. 20; this makes it possible to generate a search report at the click of the identify feature icon on any parcel (e.g., a red-highlighted parcel), as indicated in Fig. 23. Parcels shaded green are registered with DEED numbers, while those in the blue shade represent a noted proposal site with N T numbers.

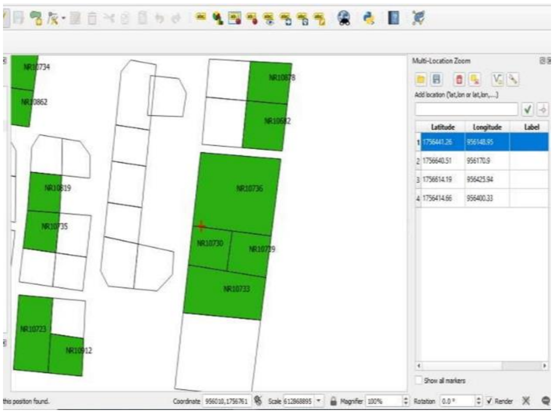

Fig. 22 Coordinate Entry

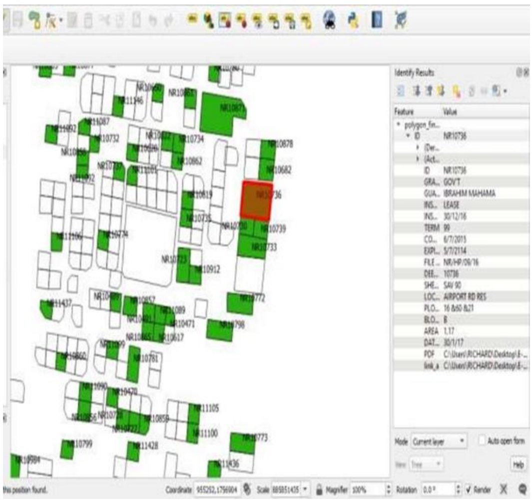

Fig. 23 Search Report Display

3.4 View PDF

Fig. 24 shows a pop-up of the PDF of the respective lease. The PDF pops up after the run feature icon is clicked and further clicking on any of the registered parcels or polygons. The PDF allows for further verification with respect to the deed number, lessee, lessee's name, date of the agreement, commencement and expiration dates, area of the plot, lease period, and parties involved in the transaction and their signatures before the search report is finally printed.

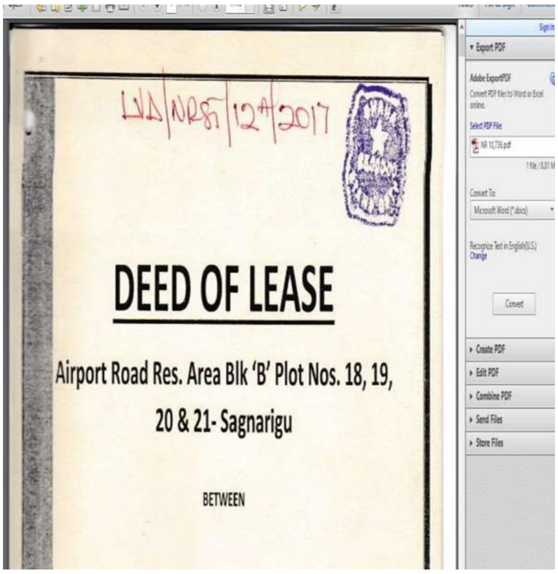

Fig. 24 PDF Pop-up

3.5 View Layout

As shown in Fig. 25, the digitised layout can also be viewed when necessary to ascertain the shape, size and even the adjoining plot of a particular site for further analyses when required.

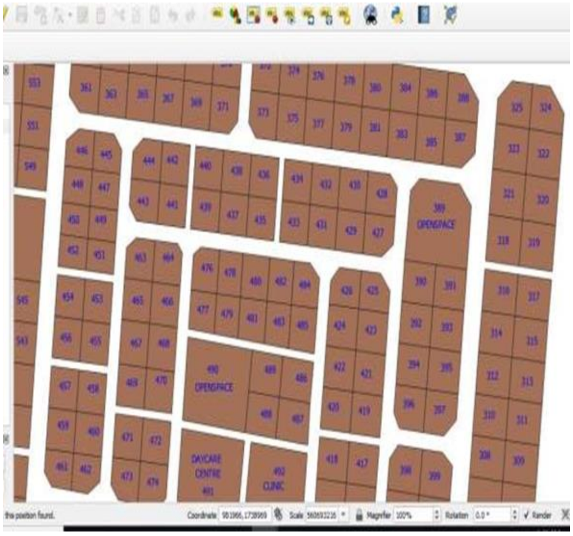

Fig. 25 Layout View

3.6 Updating Records

Finally, the map and the attribute can be updated by adding further parcels (polygons) and information (attributes) as and when a new document gets added to the records for proposal noting or plotting. Its respective attribute can also be edited or updated. Fig. 26 shows how new parcels can be added using their respective coordinates. Fig. 27 displays an interface where the attributes of any newly added parcels are entered.

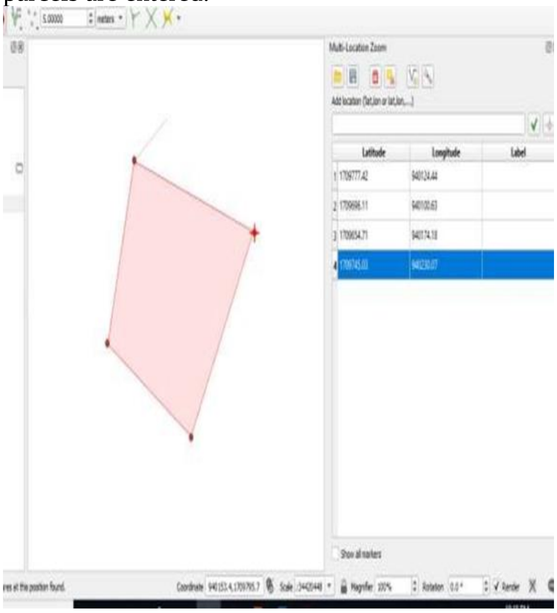

Fig. 26 Updating Records by Coordinate

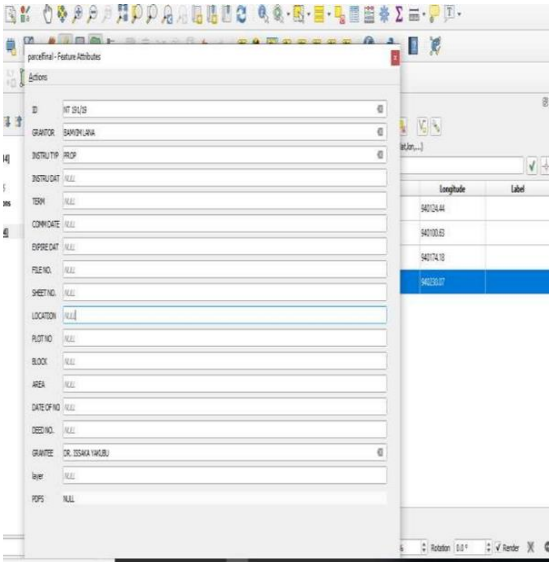

Fig. 27 Entering Record Details (Attribute)

3.7 Comparative Assessment

Table 5 is a comparative assessment of the current system being used and the developed GIS-based system.

Table 5 Assessment of the Developed System

Current System	GIS-based System Developed
Land Searches delivered within two weeks.	Land Searches delivered within a day.
Record reports delivered between 2 weeks to a month.	Records report delivered within a day.
Access to town sheet is difficult.	Easy access to sheet on the database.
Attributes is taken from ledgers and folders.	All attributes are accessed on the database.
Town sheets and maps are damaged beyond use due to frequent usage.	Constant maintenance and update of sheet on the database.
More space is required for storage.	Server is used for storage,
Special and big drawing tables and chairs are required.	Computers are required.
High human security and expensive locks are required.	Reliable password, 2 factor authentication and content management system required to protect the database.
Expensive in maintaining sheets.	Inexpensive maintenance on computers.
Work is done at the office during working days.	work can be done outside office.
It is cumbersome.	It is user friendly.

4 Conclusions and Recommendations

4.1 Conclusions

A geodatabase was created from LC records for the study areas in Tamale. This could simplify the number of documents and ease the difficulties that records staff go through in their daily duties. A QGIS based programme is developed to link all data and documents in records, thus enabling a search report to be generated at a click of a button. A search report and other relevant reports can be produced within a day, as compared to the existing traditional system, which takes two weeks to provide such services. The process of manually making entries on all maps, ledgers, and registers before a parcel can be updated will be a thing of the past, since the GIS-based system enables easy update by just clicking a button and making a few entries, and within a second all the information required will be displayed on the screen and could be saved in pdf format for further processing to continue.

4.2 Recommendations

The age-old method of using papers, books, and folders to keep land records should be replaced with the newly developed GIS-based system, For the LC to become the center of excellence in land service delivery as envisaged in its vision, a modern method of keeping records in a digitised environment is required. It is therefore recommended that this work be adopted and further expanded to all regions by the LC to attract good appraisal from the public.

Almost all government initiatives to digitise the work of the LC have not achieved their intended purpose, lots of scanning of town sheets and documents has been done with the same intention, but none has been successful. It is therefore recommended that all aspects of land data be digitised to enable trust and reliability in the LC. This would facilitate accelerated growth and development of the country since no development is attainable without land.

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