Integrated GIS-Database for Effective Property Rate Collection and Management-A Case Study*

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Abstract

The potential of property rate as a source of revenue has least been realised by most local assemblies/municipalities in Ghana. Thus, local assemblies turn to depend more on the central common fund for developmental projects and provision of services for the citizens. In this study, a geodatabase was created to facilitate effective collection and management of property rate for the Tarkwa-Nsuaem Municipality. Questionnaires were administered to gather data on immovable properties and their owners in the study area. Spatial data was acquired using Garmin handheld GPS receivers. An entity relational (ER) model was developed from which a database was created in Microsoft Access and then integrated into ArcGIS geodatabase. This technique was adopted to allow incorporation of user-defined data model into the ArcGIS schema that hosts the final database. The results revealed that out of 100 buildings used for the purpose of this study, 51 building owners were found to have defaulted in the payment of their property rate for 2016, and 49 owners have fulfilled their property rate obligations. Querying the system displays building owners' information that could be used to track or notify property rate defaulters. This study clearly shows that an integrated GIS-Database could help provide a more efficient collection, tracking and management of property rate revenue. Findings of the study confirms the fact that property rate payment is generally low in the country; less than 50% of building owners usually pay their property rates to the assembly yearly. It is recommended that the assembly adopts the proposed GIS-database for tracking property rate defaulters in the study area. Also stringent measures should be taken to combine education and law enforcement so as to enjoin property owners to comply with their task obligations.

Keywords: Property Rate, GIS, Database, Tracking, Effective Collection

1 Introduction

Property rate is the amount of money a local assembly charges on an immovable property every year (Alupungu *et al.,* 2012). It is a product of the value of the property and a rate imposed by the local assembly. Usually the rate levied on a property is determined by several factors. These factors include: the classification of property zone, the type of property, and the purpose or usage of the property. The rating authorities divide an assembly into classes or zones based on some socio-economic considerations such as existing amenities. The purpose for which the property is used also determines the amount of the property rate. Properties may be used for residential, commercial, industrial or mixed use purposes (Agboklu, 2013). In Ghana, the rateable value of properties are often determined by the land valuation division of the Lands Commission.

Almost all local governments worldwide rely on property rate for payment of local services (Slack, 2010). It is therefore essential for the success of fiscal decentralization and financing of local infrastructure and service delivery (Boamah, 2013). Property rate serves as a key source of revenue for local assemblies in most developed countries. For instance, property rates constitute 100% of local revenue generated in Australia and Ireland, 99% in the United Kingdom, 93% in Canada and 72% in the United States of America (Braid, 2005). Revenue from property rate in most developed countries amounts to more than 2% of their Gross Domestic Product (GDP) (Bahl, 2009).

Despite the immense contribution of property rate in developed nations, its potential is generally under-exploited in most developing countries. Property rate constitutes less than 4% of all revenue in developing and transitional countries (Bahl, 2009). According to Yeboah *et al.* (2008), the actual revenue collected as property rates is less than 20% in most local assemblies in Ghana. This reduces the capability of many local assemblies to develop and to provide services to the citizens. The yield from property rate in Ghana is extremely low due to the following: weak or poor administration, poor enforcement mechanisms, inadequate tax coverage area, and difficulty in identifying property owners (Tahiru, 2013).

Local assemblies, for instance, Tarkwa-Nsuaem Municipality is unable to collect much of the property rate due to the lack of proper system in place to assist in identification of properties and their owners. There is also lack of updated records on property rate rolls, as well as no system to verify payment done by property owners (Tahiru *et al.*, 2014). The current process of collecting property rate in the municipality is mainly manual with a little digital component, it is cumbersome, inefficient and prone to fraud. Due to the manual

processes involved in the collection of property rate, management is unable to detect defaulters (Tahiru *et al.*, 2014).
It is in the light of these challenges that this study sought to create a geodatabase for effective collection, tracking and management of property rate in the Tarkwa-Nsuaem Municipality using an integrated GIS-Database approach.

2 Resources and Methods Used

2.1 Resources

The Tarkwa-Nsuaem Municipality is one of the 22 administrative Metropolitan, Municipal and District Assemblies (MMDAs) in the Western Region of Ghana. Tarkwa lies between latitudes 4° 50 ′ N and 5° 20′ N and Longitudes 1° 59′ W and 2°10 ′ W and shares boundaries with Prestea Huni-Valley District to the North, Nzema East District to the West, Ahanta West District to the South and Mpohor District to the East (see Fig 1). The Municipality has a total Land area of 978.26 km^2 (Anon., 2015).

The study used primary data collected through administration of questionnaires and field measurements using Garmin hand held GPS receivers obtained from the Geomatic Engineering Department. Secondary data was also obtained from the Tarkwa Nsuaem Municipal Assembly (TNMA). ArcGIS 10.1 and Microsoft Access were the main software used. The Garmin Handheld GPS receivers and a Samsung digital camera enabled both the spatial location and the pictorial view of the immovable properties to be captured and incorporated in the geodatabase.

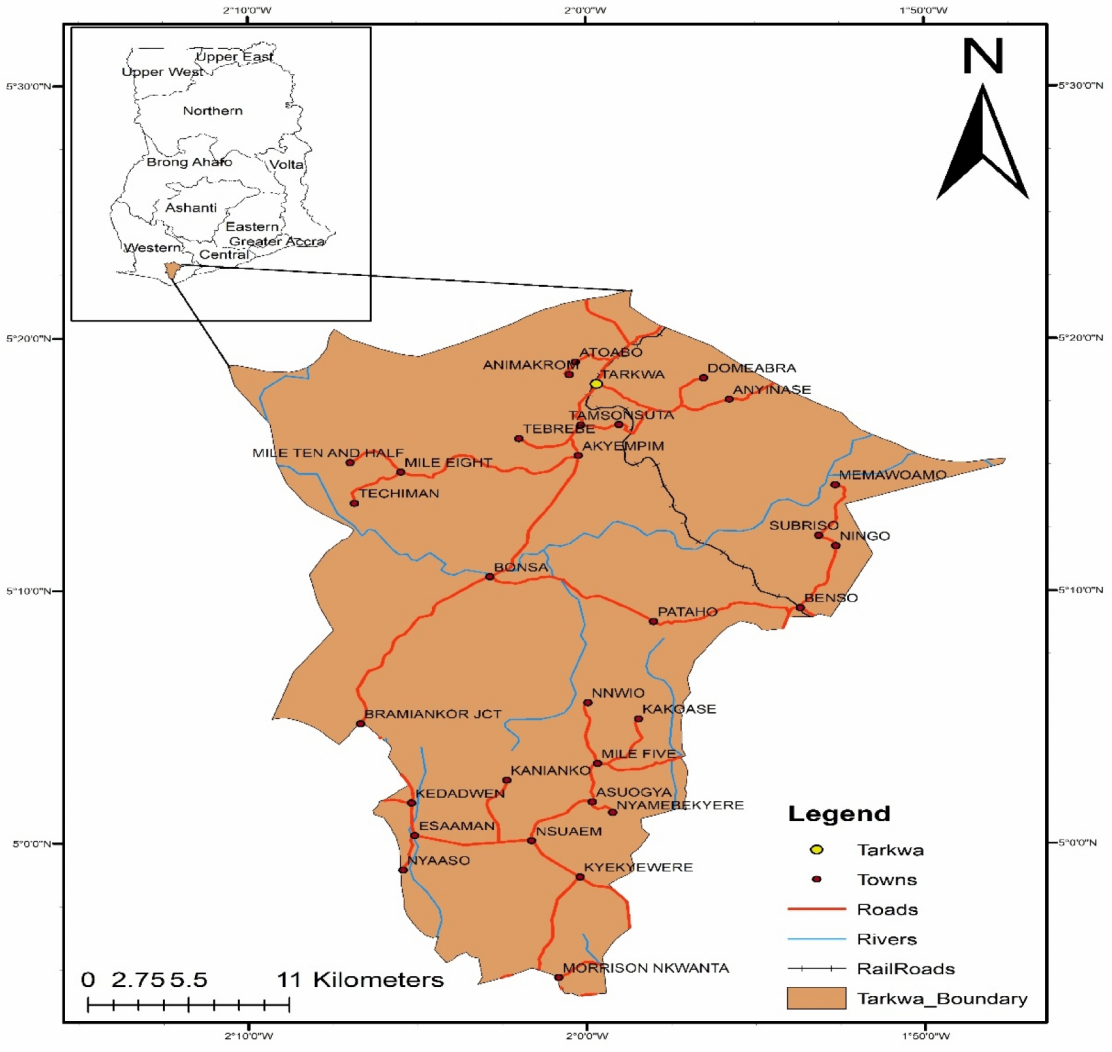


Fig 1 Map of the Study Area

2.2 Entity-Relationship Model

An entity-relationship (ER) data model is a high level conceptual model that represents the information structure of a problem domain in terms of entities and their relationships (Chen, 1976). The model incorporates some of the important semantic information about the real world environment that are necessary for the proper functioning of a system. The ER model is represented by diagrams that show how data will be represented and organised by the various components of the final database. The modelling methods focusses on relationships and the interactions among entities. Relationships require special attention in the development of databases since they hold information together and because their realisation in relational databases is particularly important. Conceptual data modelling process is iterative and could best be achieved using the ER Model (Riccardi, 2002). In this study an ER-diagram, which defines the conceptual diagram for databases, was created for effective collection and management of property rate in the study area (see Fig. 2). More literature on entity relational modelling could be found in the following references (Batini *et al*., 1989; Song and Chen, 2009; Codd, 1979; Ling and Lee, 2008).

2.3 Data Processing and Database Creation

The data was organised and processed using the appropriate software such as Microsoft Access and Excel 2016, ExpertGPS and ArcGIS 10.1 software. The ER diagram representing the information structure of the property rate problem was translated into tables; entities as well as their relationships were converted into suitable tables in Microsoft Access 2016 using the attributes as tuples in the related tables. Relational database was adopted because it avoids data duplication, restricts inconsistent data entry, allows complex queries using structured query language (SQL), offers better security to the data and caters for future requirements (Teorey *et al*., 1986; Cattell, 2010).

A form was also developed in Microsoft Access for future update of the database. The database was then exported into the ArcGIS software where the positions of rateable buildings were shown as a feature class. The database was then joined with the geodatabase.

2.4 Classification of Buildings

The buildings were classified based on type, usage or purpose and payment status of the property rates in the study area. Table 2.1 shows the various categories of buildings in the study area.

Table 2.1 Classification of Buildings

Property Usage	Property Type	Property Rate Status
Residential	Storey (1, 2, 3 or 4)	Paid
Commercial	Flat	Not Paid
Mixed	Compound	
Industrial		

2.5 Creating Thematic Layers

Thematic layers are usually created using lines, polygons or points as geographic features. In this study four thematic layers were created by digitising *i.e*. buildings, roads, routes and rivers thematic layers (see Fig. 3).

2.6 Geodatabase for Rateable Buildings

A geodatabase was created to store all the three feature classes by indicating the data type and attributes of the features after linking the database from the Microsoft Access to the attribute table obtained from the feature digitising. The geodatabase consisted of property owners' information as well as information of the properties in the study area. The geodatabase was subsequently hyperlinked with some photo IDs captured during the field data collection. The inclusion of photos helps in easy identification of property rate defaulters as well as property owners' details for tracking purposes.

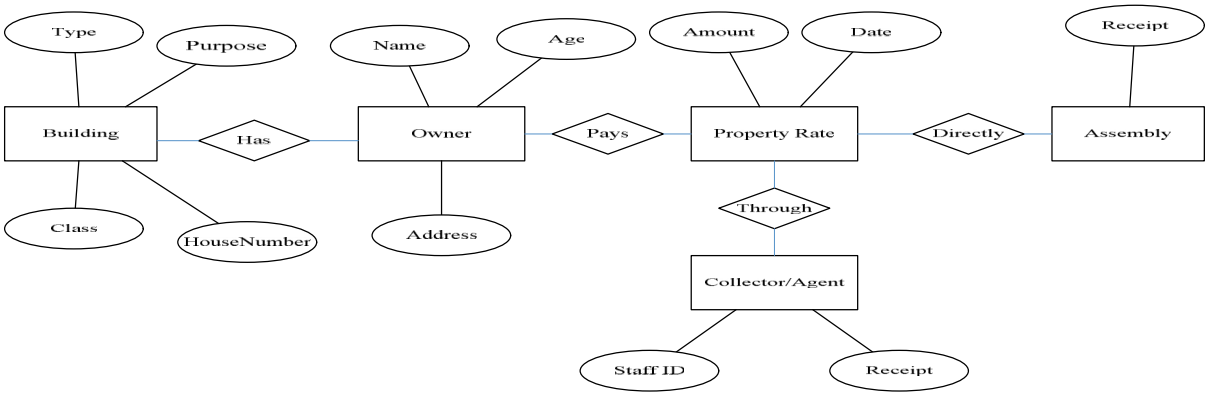


Fig. 2 An ER-Model for Property Rate Collection and Management

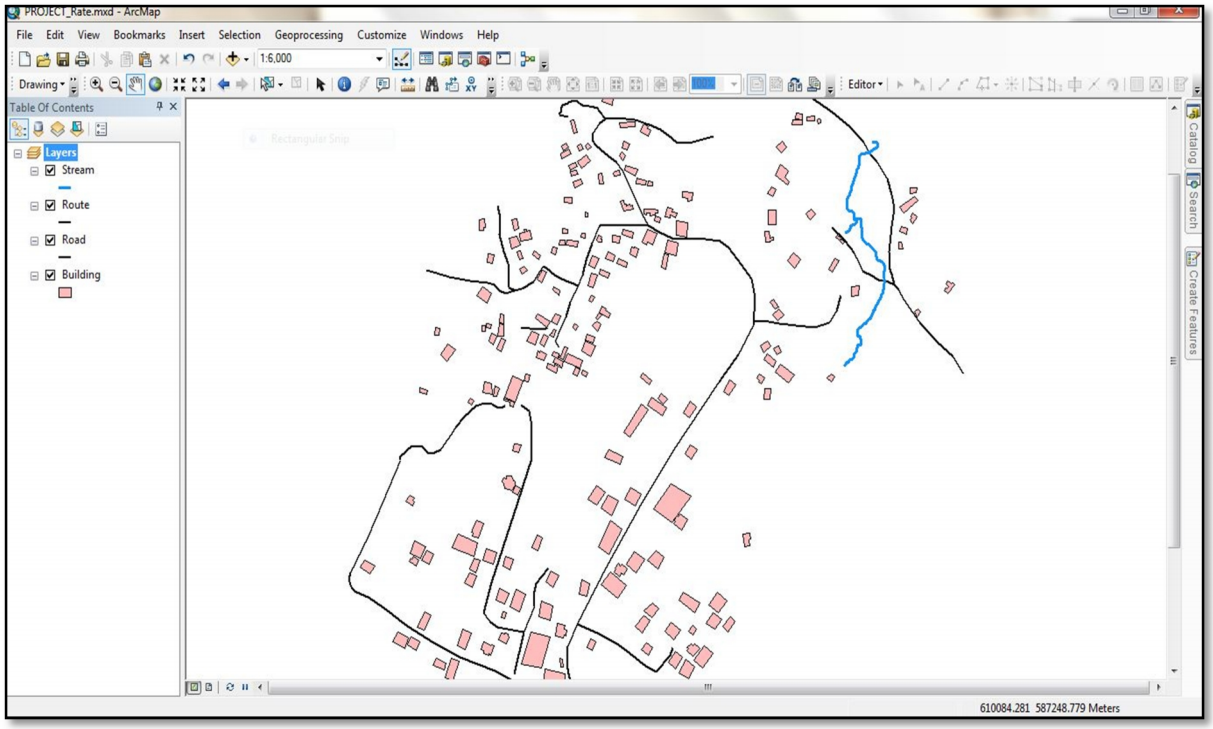
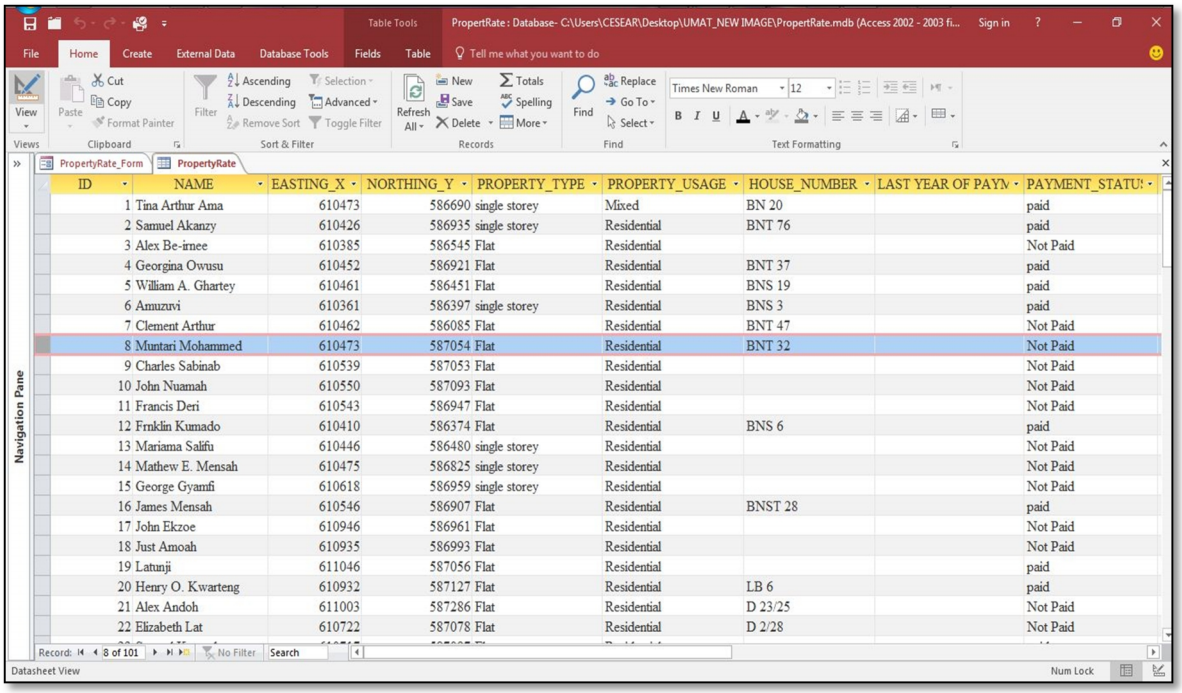


Fig. 3 Snap shot of Thematic Layers

3 Results and Discussion

3.1 Results

The results of the study show a database and map of property owners in the study area. A snapshot of the database of property owners in Microsoft Access is shown in Fig. 4 while Fig. 5 shows a form for updating the database. Fig. 6 shows a snapshot of the database in ArcGIS. A map of the property types is shown in Fig. 7 whereas a map of the property usage is shown in Fig. 8. The property rate payment status of the owners in the study area is shown in Fig. 9.



ID	NAME	EASTING_X	NORTHING_Y	PROPERTY_TYPE	PROPERTY_USAGE	HOUSE_NUMBER	LAST YEAR OF PAYM	PAYMENT_STATU
1	Tina Arthur Ama	610473	586690	single storey	Mixed	BN 20		paid
2	Samuel Akanzy	610426	586935	single storey	Residential	BNT 76		paid
3	Alex Be-irnee	610385	586545	Flat	Residential			Not Paid
4	Georgina Owusu	610452	586921	Flat	Residential	BNT 37		paid
5	William A. Ghartey	610461	586451	Flat	Residential	BNS 19		paid
6	Amuzuvi	610361	586397	single storey	Residential	BNS 3		paid
7	Clement Arthur	610462	586085	Flat	Residential	BNT 47		Not Paid
8	Muntari Mohammed	610473	587054	Flat	Residential	BNT 32		Not Paid
9	Charles Sabinab	610539	587053	Flat	Residential			Not Paid
10	John Nuamah	610550	587093	Flat	Residential			Not Paid
11	Francis Deri	610543	586947	Flat	Residential			Not Paid
12	Frnklin Kumado	610410	586374	Flat	Residential	BNS 6		paid
13	Mariama Salifu	610446	586480	single storey	Residential			Not Paid
14	Mathew E. Mensah	610475	586825	single storey	Residential			Not Paid
15	George Gyamfi	610618	586959	single storey	Residential			Not Paid
16	James Mensah	610546	586907	Flat	Residential	BNST 28		paid
17	John Ekzoe	610946	586961	Flat	Residential			Not Paid
18	Just Amoah	610935	586993	Flat	Residential			Not Paid
19	Latunji	611046	587056	Flat	Residential			paid
20	Henry O. Kwarteng	610932	587127	Flat	Residential	LB 6		paid
21	Alex Andoh	611003	587286	Flat	Residential	D 23/25		Not Paid
22	Elizabeth Lat	610722	587078	Flat	Residential	D 2/28		Not Paid

Fig. 4 Snap shot of Database of Property Owners in MS Access

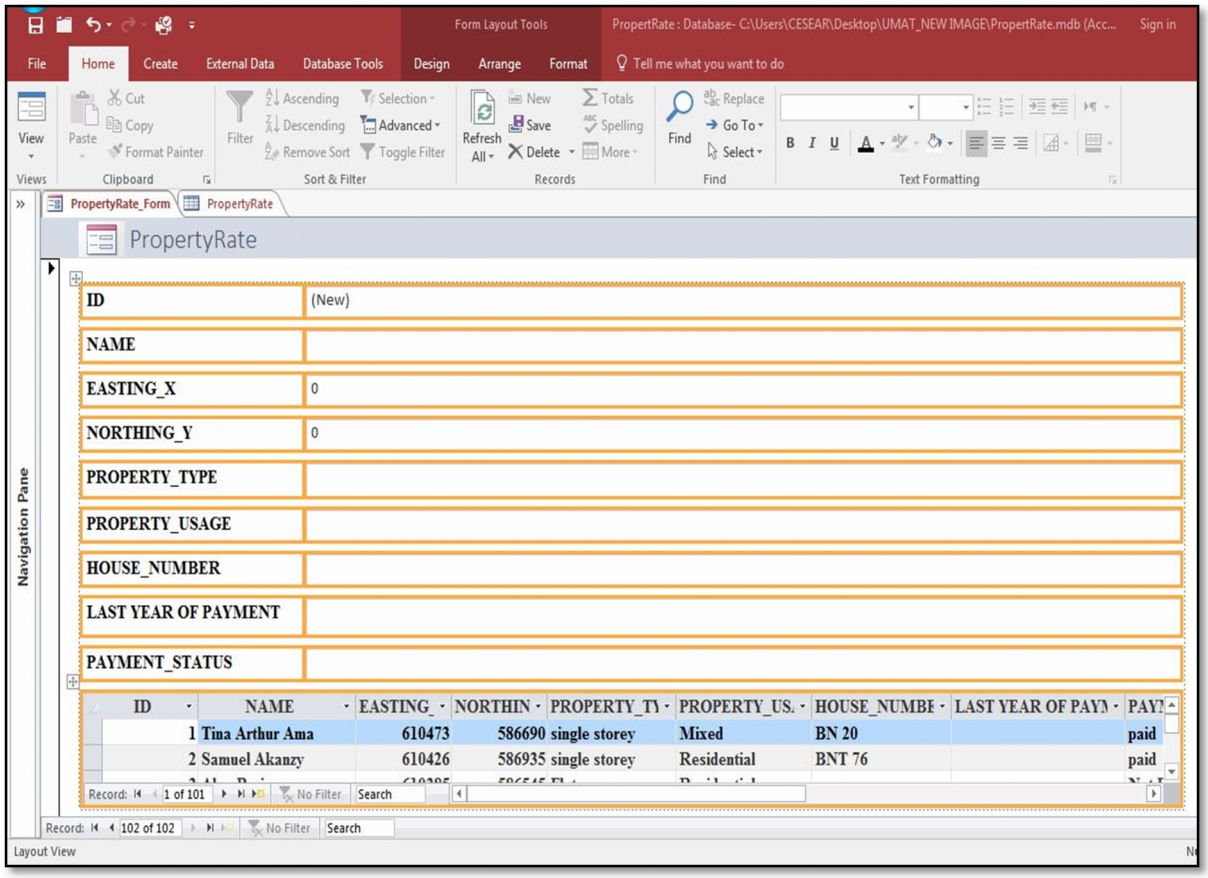


Fig. 5 Form for Updating Database in Microsoft Access

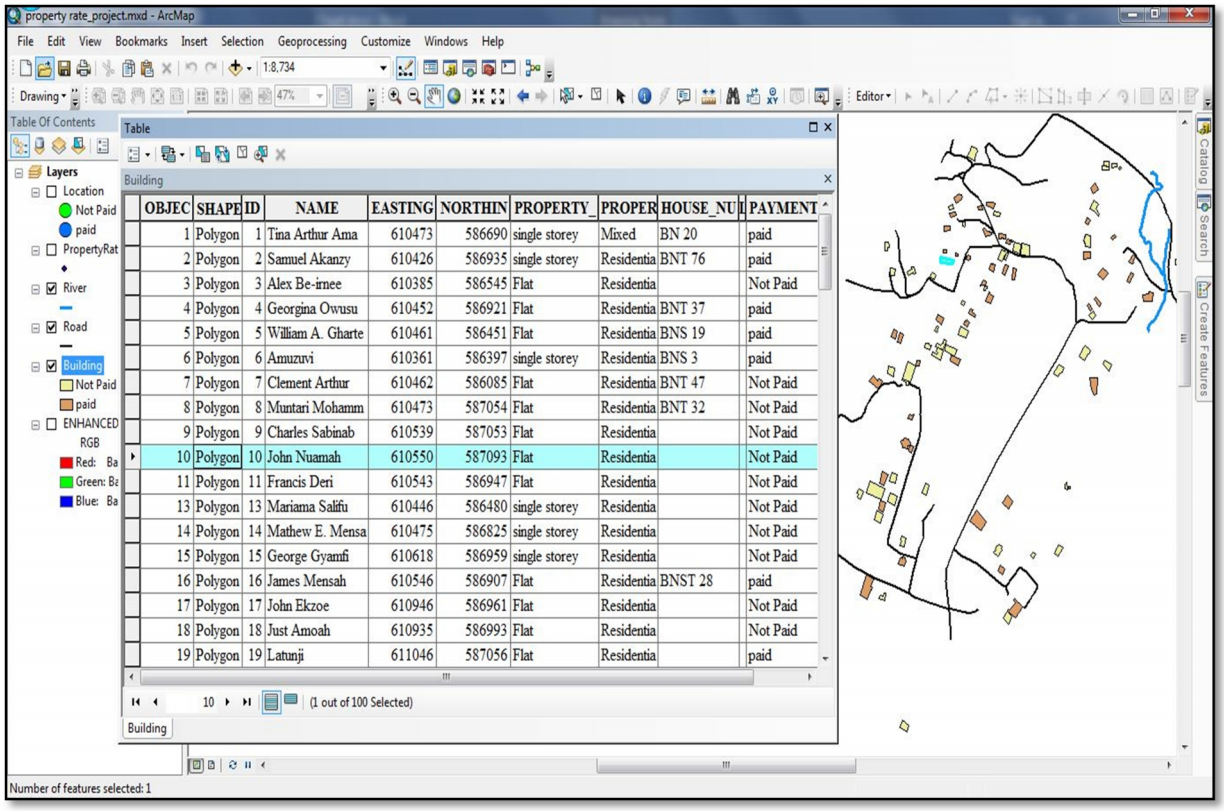


Fig. 6 Database of Property Owners in ArcGIS

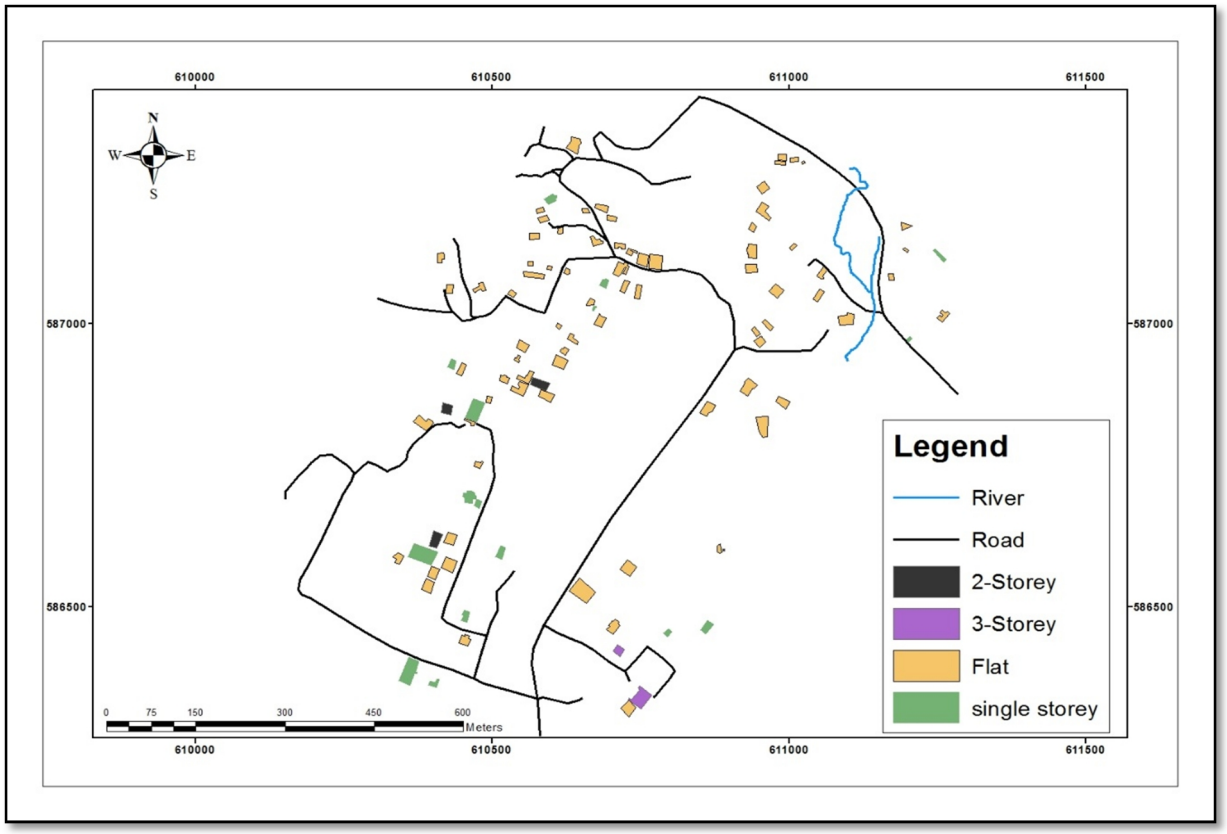


Fig. 7 A Map Showing the different Property Types in the Study Area

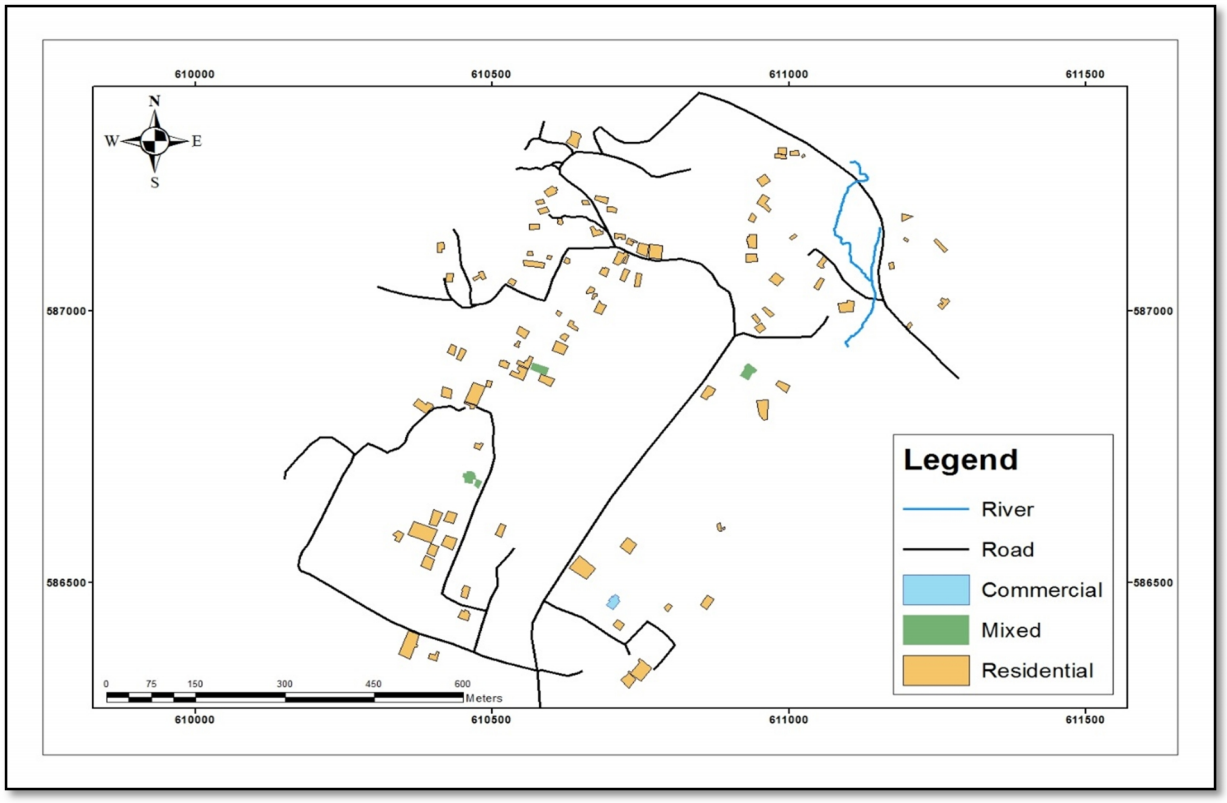


Fig. 8 A Map Showing the Property Usage

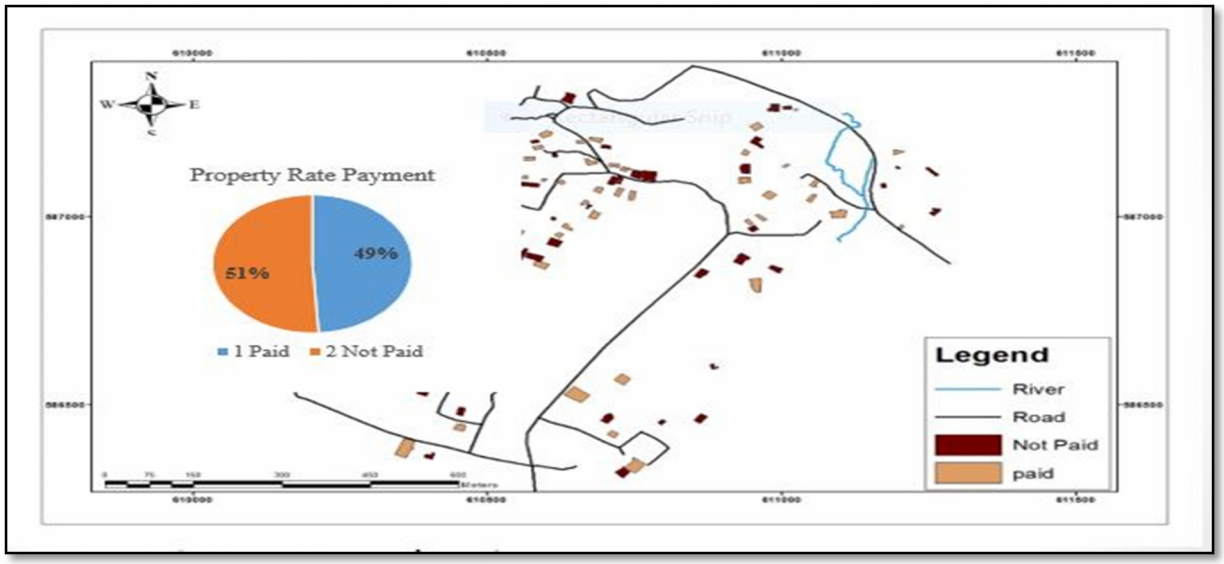


Fig. 9 A Map Showing the Property Rate Payment Status

3.2 Discussion

3.2.1 Database in Microsoft Access and GIS Environment

A database of the property owners in the study area was created in Microsoft Access with the guidance of the ER diagram. The database contains information about the properties and their owners. This information includes: name of owner, type of property, property usage, house number, last year of payment and the property rate payment status. The Microsoft Access was adopted for the database because it is user friendly, the administrator has control over the database security and right to access, and it is a related database analogous to ArcGIS Geodatabase. The compatibility of the Microsoft Access with ArcGIS Geodatabase made it possible for their tables to be linked using the feature identification numbers as a common field (primary key). It is interesting to note that, property owners like all humans may reside outside the study area and may be difficult to geolocate at any point in time. However, a table of their relationship with the buildings, makes it easy for the system to be queried and their property rate records tracked. The forms created in Microsoft Access enables users to update their personal information in the database (see Fig 5). This form could as well be used by anybody with basic computers skills.

The final Geodatabase created in GIS environment incorporated both the attribute data from the Microsoft Access database and spatial data of the properties. This database allows both attribute and spatial information of a property and their owners to be displayed and tracked. A school of thought is of the opinion that an ArcGIS database alone could be used to provide similar solution. However, the difficulty of geolocating the building owners as features in Geodatabase coupled with the tedium of altering the proprietary data model of ArcGIS makes it prohibitive. The integrated GIS-database approach enables one to see the particular property whose information has been displayed as well as ownership information for tracking purposes. The system developed could be used to serve reminder notices to building owners to make good their property rate obligations.

3.2.2 Property Type, Usage and Payment Status

The various building types, their usage and payment status in the study area have been categorised using different colours to enable easy identification and understanding (see Fig 7). A sample of 100 buildings was used for this study. Out of this number, 15 are single storey buildings, 5 are 2-storey buildings, 2 are 3-storey and 78 buildings are flats. This gives an indication that 78% of the buildings in the study are flats.

The study also revealed that with the exception of 1 commercial building and 3 mixed purpose buildings found in the study area all the remaining 96 buildings used for the study are for residential purposes. This gives an indication that most buildings in the study are mainly residential properties.

Again from Fig 9, the property rate payment status stands at 49% payment of their property rate as against 51% non-payment for 2016. This area is a new settlement with most of the people being educated or having knowledge about property rate yet the payment rate status was found to be below average. Though the 49% payment of property rate in the study is higher than the national average value of less than 20% (Yeboah, *et al*., 2008), it is

sound to reason that there are some bottle necks regarding payment of property rates particularly in developing countries. This is probably due to poor billing of the property owners, lack of information on built-up areas in the municipality/assembly or sheer negligence on the part of property owners. Albeit the assembly needs to put in more efforts in the collection of the property rate. This could be done through education and enforcement of the property rate law.

From Fig. 10 the spatial distribution of defaulter is haphazard and therefore provides no clues as to the reason for the payment trend or otherwise of the properties in question. The brown colour of Fig. 11 shows the payment status and the photo ID shows the particular property. The system, however, gives both spatial and non-spatial information of each property as well as an image which could facilitate easy tracking of defaulters.

Fig. 10 A Hyperlinked Image and HTML Pop-up Showing a Defaulter

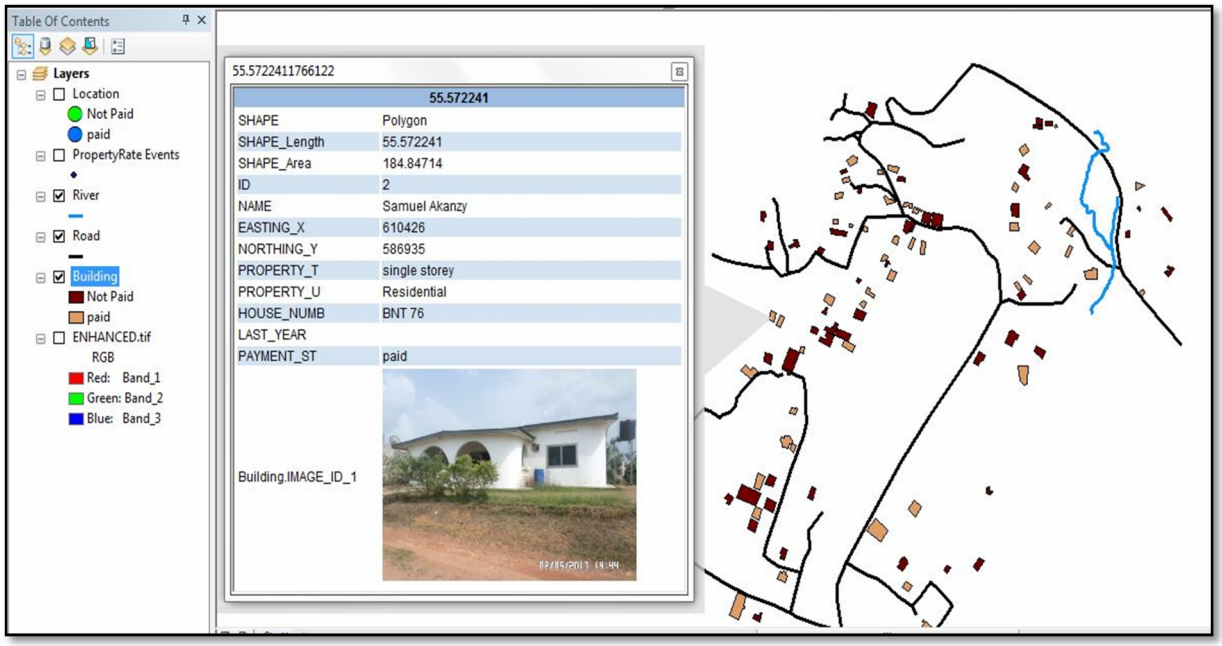


Fig. 11 A Hyperlinked Image and HTML Pop-up Showing Full Payment

4 Conclusions and Recommendations

4.1 Conclusions

The study has demonstrated the capability of integrate GIS-database to facilitate effective property rate collection and management in the study area. The use of ER modelling technique enables a user-defined, client tailored data modelling to be implemented in a database to suit property rate collection and management in the study area. Simple tools like Microsoft Access have been used to provide security of the database prior to its integration with a relatively more complex software (ArcGIS).

The study has confirmed the notion that property rate payment is generally low in most developing countries. Less than 50% of building owners had made payment of their property rate for 2016 at the period of data collection. The study area has proved to have mainly residential buildings with about 78% of them being flats, and therefore findings of this study could be applicable to middle income residential buildings.

4.2 Recommendations

It is recommended that the assembly adopts the proposed system for tracking property rate defaulters for the study area. As the database created makes room for modification, updating and extraction of individual's information, the system should be extended to cover other assemblies in the country and beyond. Stringent measures should be put in place by the Assembly to combine education with law enforcement to enjoin property owners to comply with their property task obligations. This will enable the assembly recover over 100% increment compared to the previous year's property rates collected.

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References

Agboklu, G. (2013), "How a Property Rate Bill is Computed in Accra, Ghana", *http://labone-express.com*. Accessed: January 11, 2017.

Alupungu, E., Appiah, K. K., Mpeanin, G., Owusu, M. A. and Orgen-Woode, E. B. (2012), "Analysing the Sources of Internally Generated Funds and its Contributions; Evidence from Kumasi Metropolitan Assembly", *Unpublished BSc Project Report,* Christian Service University College, 48pp.

Bahl, R. (2009), "Property tax reform in developping and transition countries", *United States Agency for International Development*, pp. 1–3.

Batini, C., Ceri, S. and Navathe, S. (1989), *Conceptual Database Design: An Entity Relationship Approach*, Elsevier Science Publishers BV (North Holland), pp.1-48.

Boamah, N. A. (2013), "Constraints on Property Rating in Offinso South Municipality of Ghana", *Commonwealth Journal of Local Governance,* Vol. 13, No. 14, pp. 77-89.

Braid, R. M. (2005), "Tax Competition, Tax Exporting and Higher-Government Choice of Tax Instruments for Local Governments", *Journal of Public Economics*, Vol. 89, pp. 1789-1821.

Cattell, R. (2010), "Scalable SQL and NoSQL data stores", *SIGMOD Record*, Vol. 39, No. 4, pp.12-27.

Chen, P. P. S. (1976), "The Entity-Relationship Model- Toward a Unified View of Data", *ACM Transactions on Database Systems (TODS)*, Vol.1, No.1, pp.9-36.

Codd, E.F. (1979), "Extending the database relational model to capture more meaning", ACM 1979, *Transactions on Database Systems (TODS)*, New York, USA, Vol. 4,No. 4, pp. 397-434.

Ling, T.W. and Lee, M.L. (2008), "Entity Relationship Model" Wiley Encyclopedia of Computer Science and Engineering.

Riccardi, G. (2002), *Database System Concepts with Website Development Applications*, Addison-Wesley Longman Publishing Co., Inc, Boston, MA, USA, 250 pp.

Slack, E. (2010), *The Property Tax in Theory and Practice*, Institute of Municipal Finance and Governance, Munk School of Global Affairs, University of Toronto, Canada, 17 pp.

Song, I.Y. and Chen, P. P. (2009), "Entity relationship model", In Encyclopedia of Database Systems, pp. 1003-1009.

Tahiru, F. (2013), "Investigating the Challenges in Revenue Collection Process and the Development of a Computerised Solution: The Case Study of AMA Property Rate Collection" *Unpublished MPhil Thesis Report*, Kwame Nkrumah University of Science and Technology, Kumasi, 85 pp.

Tahiru, F., Agbesi, S. and Osei-Owusu, A. (2014), "Investigating the Challenges in Revenue Collection Process: The Case Study of Ghana AMA Property Rate Collection", *International*

Journal of Innovation and Scientific Research, Vol. 11, No. 2, pp. 566-576.

Teorey, T. J., Yang, D. and Fry, J. P. (1986), "A logical design methodology for relational databases using the extended entity-relationship model", *ACM Computing Surveys (CSUR)*, Vol. 18, No. 2, pp.197-222.

Yeboah, K., Johanson, L., and Fiatornu, S. (2008), "Urban Management Land Information System (UMLIS)-Possibilities and Benefits", *The FIG Congress 2008 Facing the Challenges-Building the Capacity,* Austria, 11-16 April, 2008, pp.11-16.

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