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3D CADASTRE FOR PROPERTY REGISTRATION AND LAND MANAGEMENT IN AKURE, NIGERIA

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ABSTRACT

The entity called land is one of the basic elements of human existence. As a matter of fact, land is the basis of any meaningful development because no human development can do without land. Then, there is need to protect, preserve and manage it for continuous and sustainable utilization. Land administration is a part of global initiative adopted for managing land, through a model referred to as Land Administration Domain Model that support both cadastre and 3D cadastre. It is no news that the world we live in exist in three dimensions (3D) but the cadastre representation of the real world has been two dimensions (2D). Although, it was so based on the level of available technology then. New trends in the field of land administration systems are strongly pointing towards 3D cadastres. However, this research work focused on the Design of 3D Cadastre for Property Registration and Management in Akure. Satellite imagery, SRTM data, building heights information are spatial and non-spatial data that were captured for this study. ArcGIS 10.3, Sketch up Pro 2018 and Autodesk AutoCAD 2007 were all combined to process the acquired data. Arc Scène of the ArcGIS was used to query and analyzed the designed 3D Cadastre database. 3D Cadastre database was successfully produced. The Level of Detail, LoD for the buildings were defined as LoD 3 with the use of sketch up and were visualized in 3D. The result shows the benefit, capability and strength possessed by 3D Cadastre over 2D cadaster. Future research to be explored is to be able to generate multiple 3D building models at once and the Level of Details (LoDs) linked to Building Information Model (BIM).

KEYWORDS: 3D cadastre, Level of Details (LoDs), Land administration, LADM

1. INTRODUCTION

The fact that 2D cadastre cannot give sufficient detail information about property above or beneath the earth surface, and then there arose the need for 3D cadastre (Stoter et al 2004, Stoter et al 2011, and FIG Publication 2018). Before now 2D parcel registration is the common norm for ownership application on land, practices by many countries in world but in the real sense, the world is actually in three dimensions which implies that the earth was never depicted to capture the XYZ nature of it (Babalola et *al*, 2015B), Shojaei (2014) and Shojaei *et al*, (2015) look at cadastre as an orderly and official depiction of land plots, which incorporates for each plot a special identifier. The portrayal incorporates text records on characteristics of each plot. The prototypical (a first structure

from which different structures are created or replicated) method for recognizable proof is an enormous scope map that gives data on plot limits. A Cadastre is plot-based land information that has total up-to-date records of land when it comes to rights, responsibilities and restrictions (Vinay *et al*, 2017). It is well regarded as the major source of information concerning rights or interest of ownership on land. It has been identified as the center focal for land administration systems (Zho W et al 2018). A cadastre that records and gives focus into the rights and restrictions not (only) on plots but on 3D property units is referred to as 3D cadastre (Stoter, 2004). 3D property units which simply means the amount of space to which an individual is permitted to own in real rights. It is equally applicable to a single person owning and using a parcel of land.

Aien et al., (2012), Aien et al., (2013) explained that, 3D cadastre is such cadastre that records and gives understanding into freedoms and limitations on pacels (a plot of land) yet on 3D property units. 3D cadastres would help the board of 3D right, limitation and obligations. A 3D cadastre ought to be equipped for putting away, controlling, questioning, examination, refreshing, and supporting the perception of 3D land privileges, limitations and obligations. 3D cadastre would have the option to deal with so much circumstances as covered structures and utilities that restrict the property from being enrolled by legitimate and hierarchical viewpoints utilizing a 2D cadastre.

LADM is a model that upholds the improvement of the application programming and information quality administration in land organization framework which makes it productive for different countries to develop their own packages based on the standard LADM. It thus equally has the ability to deal with the existing 2D cadastre, also the 3D cadastre land administration (Babalola et al, 2015), (Lemman 2012). It offers a vital generic spatial representation model, based on its applicability globally, for different spatial units which are ordinary land parcels, legitimate spaces around structures, lawful spaces around networks or public/private utilities (Lemmen 2013, Thompson *et al* 2015, Choon T L et al 2010 and Choon T L et ai 2013)

Cities in Nigeria are gradually developing into megacity and as a country there is need to be preparing for what cities are turning into in terms of infrastructure and space management which in recent time has resulted in the development of complex structures being developed. But these structures are not well represented in property registrations which are usually done in 2D format. The Ministry of Lands and Housing in Ondo state has over the years registered land only in 2D paper plan, which makes land acquisition rigid, slow, records are missing and has been challenges in land administration system in the study area. This pose a problem as the key players in this sector are demanding for more realistic property registration (3D Cadastre registration) that clearly show who owns what, where is the property located and how it was acquired in the rights, restrictions and responsibilities of the land owner. 2D cadastre has failed in this regard, which then call for a more robust, reliable and detail approach property registration for proper land administration. 3D cadastre will vividly reveal ownership of what is above and on the surface of the earth. This is why this study hope to solve the afore stated problem. Some cities in the country are ranked as one of the fast-growing cities in Africa, cities such as

Lagos, Abuja, and Port Harcourt can adopt the model of this research as a pilot project. In this regard, this study focused on the design of a 3D Cadastre for Property registration and management in Akure, Ondo State, Nigeria.

2. STUDY AREA

The study area is Ijapo estate which is one of the major estates in Akure that is well laid out by Ondo State Government. It cut across both Akure South and North Local Government Area of Ondo State in Nigeria. Ijapo estate is among the modern estates in Akure with a lot of modern houses including hotels and recreational centers. It is located geographically within Latitudes 7° 15' 09" N to 7° 16' 54" N and longitude 5° 10' 42" E to 5° 13' 16". The study area has very good road networks that connect to other part of Akure Town.

Below is the map of study area showing map of Nigeria, Ondo State and map of Akure South and North Local Government Area with Ijapo Estate as the study area.

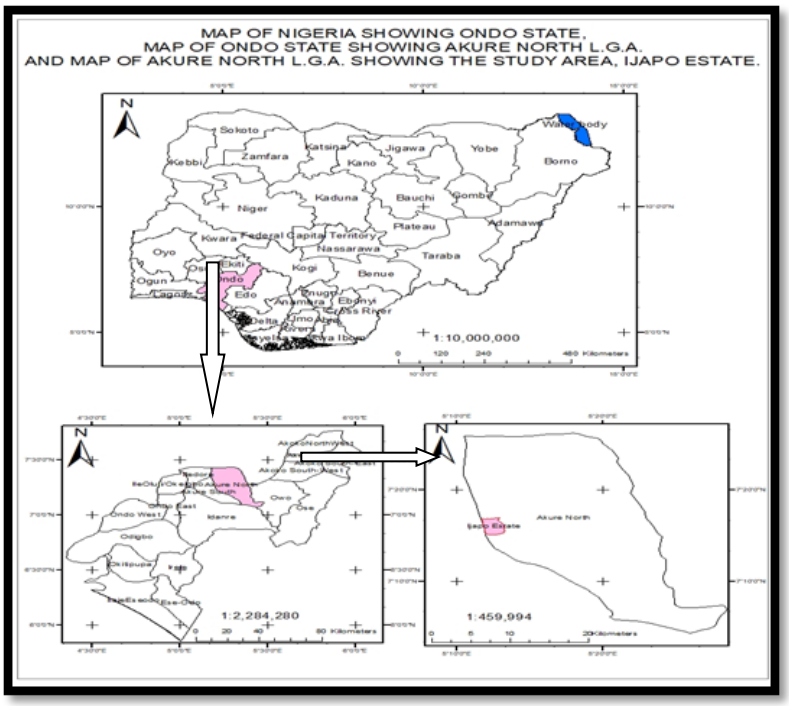

Fig. 1: Map of Study Area.

Abidoye and Oluwadare (2019) did a study on 'Geospatial Requirements for Implementation of 3D Cadastre and Its Potentials for Sustainable Land Governance in Nigeria'. They investigated the requirements and the potentials of 3D cadastre implementation for sustainable land governance in Nigeria, their paper highlights the need for experts and government organizations in land matters to advocate more on the advantage of executing 3D cadastre and suggests purposeful endeavors that will incite

both general society and confidential support towards an officially improved cadastral practice for best acts of land administration.

Ahmed Hamid (2016) in '3D Modeling for Urban Cadastral Registration, Management and Administration; case of Bahir Dar Town, Ethiopia', analyzed the materialness of Aerial photograph and CGA (Computer Generated Architecture) script for mechanized 3D articles displaying, plan cadastral data framework for ordinarily claimed private structure and business focuses, look at lawful and institutional parts of 3D property data and portrayal framework for land enrollment, the executives, organization, metropolitan preparation and dynamic cycle in Bahir Dar town by applying 3D GIS methods.

Babalola S. O. *et al.* (2015A), in their paper titled 'An Analysis of 3D Situation as a Prospect for Land Administration Domain Model (LADM) in Nigeria: A Malaysian Initiative'. The paper viewed Nigeria as a contextual investigation way to deal with Malaysian 3D property circumstance since land organization in the two nations is comparative. Malaysia has effectively evolved and taken on 3D property improvement and execution in a large portion of their urban communities throughout the long term. The fruitful execution of 3D circumstance in Malaysia as a drive for Nigerians was examined.

With the review, t is clearly showed that 3D cadastre is a recent area of study in this part of globe where continent like Europe, Asian, America have gone a bit ahead in both research and implementation. Although, a few research papers have present in this area in Nigeria but none work on the designing of 3D cadastre for the country. Again, not many researchers in this area of study have adopted the used of AutoCAD, ARCGIS and Sketch Up combined together to produce 3D cadaster.

3. METHODOLOGY

The method adopted for the Design of 3D Cadastre for Property Registration and Management is based on the conceptual framework in fig. 2. The primary and secondary data were combined to achieve the purpose of the research. Primary data is the coordinate collected to know the extent of the study area with a differential GPS while Satellite imagery from Google earth were extracted with terra incognita 2.45, SRTM data from USGS earth explorer were downloaded for the study area which served as the secondary data. Four major software were used for this study viz; AutoCAD 2007, ArcGIS 10.3, Sketch Up Pro 2018 and Microsoft Word 2007.

- **Data Processing**

The image obtained for the study area was geo referenced in ArcGIS with the coordinates gotten from the differential GPS processed data, followed by creating layers which are required for the study. The features were digitized into their respective layers, then the tables for the layers database were populated with more data captured for the study indicating building heights obtained and types of buildings were inputted into the building layer database (USGS 2020).

Conceptual Framework for Methodology

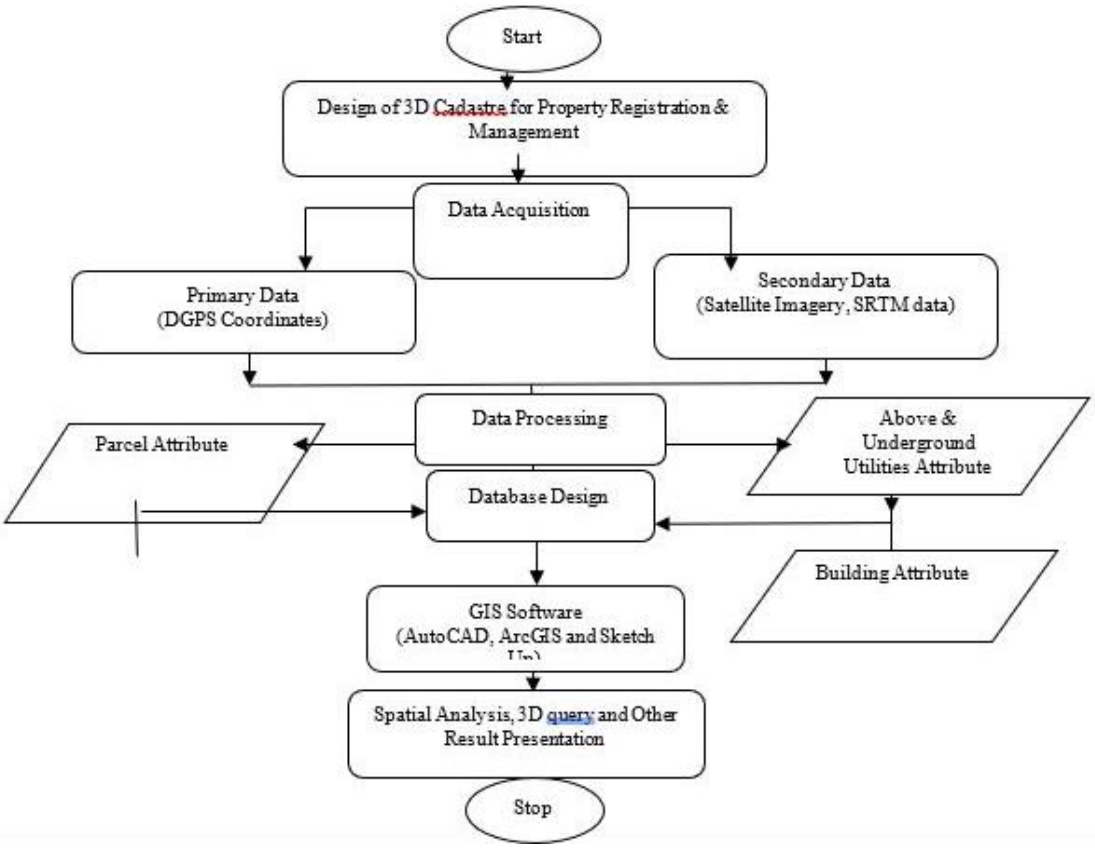

Fig. 2: The framework for the research work.

4. RESULTS ANALYSIS

Here the focus is on analyzing and getting result from the 3D cadastre database designed for property registration of the study area. Also, the workability of integrating various data source with related land dataset and the possible interoperability of different software to be able to operate with GIS software in other to achieve the aim of this research. Some sample queries and analysis were performed from the designed 3D cadastre database followed by discussion on their relevance to the research.

- **Layout Blocks Database Query**

Every layout design starts from complete perimeter survey to layout blocks, then individual parcels or plots subdivided from the blocks. GIS 3D cadastre put that into consideration while creating the database for the study. Query search was carried out on the layout blocks database to test it workability and this was done in ArcScene of ArcGIS 10.3. This query to be executed to know the numbers of layout blocks that has more than twenty (20) parcels in them. This query is referred to as single criteria query. The syntax and the query result can be seen in figure 3.

Syntax:
Select From Layout_Block
Where:
'Parcel_No' >= 20

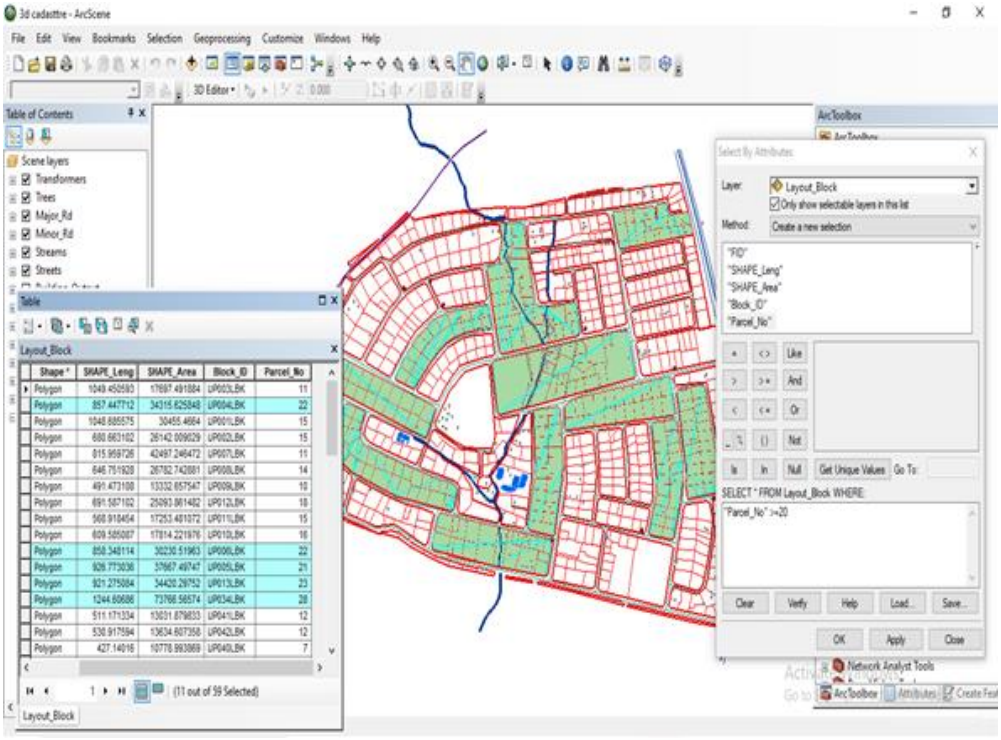

Fig. 3: Result of Layout Blocks that contains more than 20 parcels in them.

- **Parcels Database Query**

The parcels database needs to be tested, to ensure that the database was well design. Each parcel in a layout possesses their individual area. The query executed here is to know the parcels that are less than 1000 Square metres. This query is also a single criteria query. The syntax and the query result can be seen in figure 5.

Syntax:
Select From Parcel
Where:
'Shape_Area' >= 1000

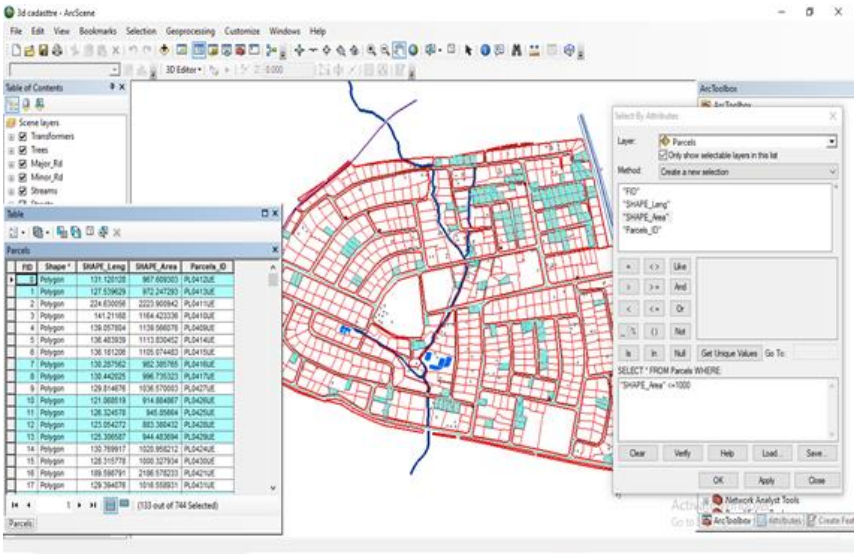

Fig. 4: Query result for parcel area that are less than 1000 Square metres.

- **3D Building and Parcel Database Query**

Building is one of the major features that can be found on a parcel of land that is why database was created for buildings in Ijapo Estate for this study. Since, 3D cadastre is a way of registering and giving insight into rights and restrictions not (only) regarding parcels but on 3D property units (Stoter, 2004, Stoter *et al* 2011) 3D property units, it implies 3D structures on or below the land. The query was initiated for a building name 'New Day Medical Centre'. The 2D hyperlink file in Jpeg format was first searched out before the 3D building query see figure 5. The syntax and the query result can be seen in figure 6.

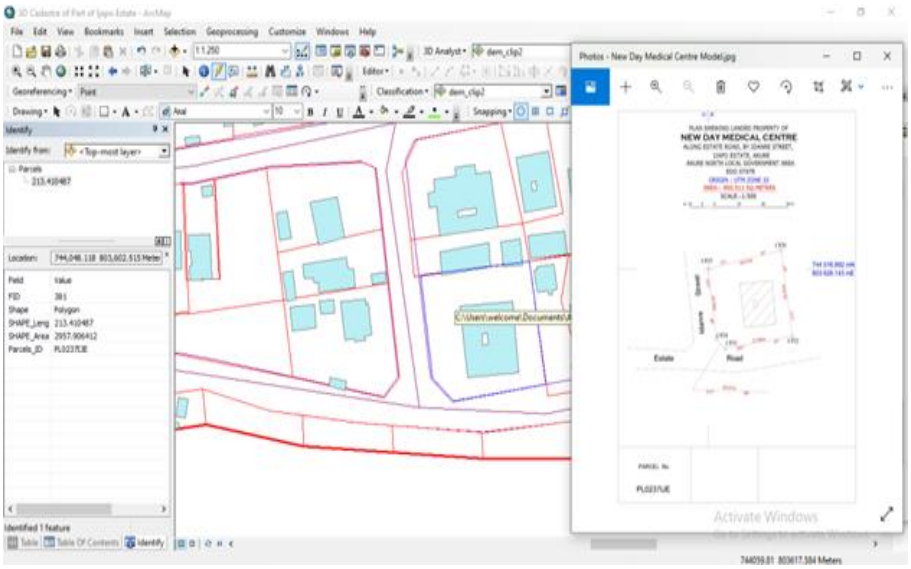

Fig. 5: Hyperlink search for 'New Day Medical Centre' parcel through its Parcel ID.

Syntax:
Select From Build_CAD
Where: 'B_Name' = 'New Day Medical Centre'

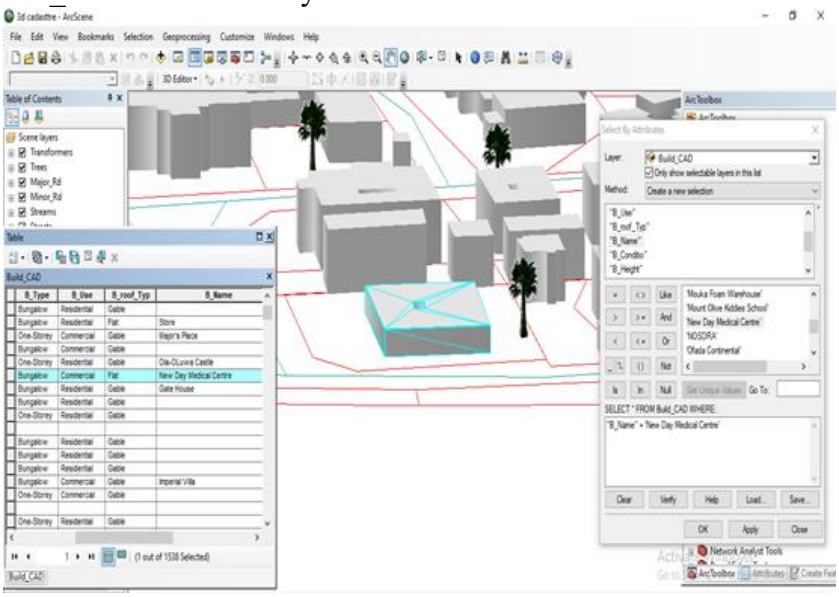

Fig. 6: Query result for Build name 'New Day Medical Centre' with LoD 1.

To further enhance the building LoD, it was exported to sketch up through collada file, then redesigned and exported back to ArcScene with LoD 3 as indicated in the figures below:

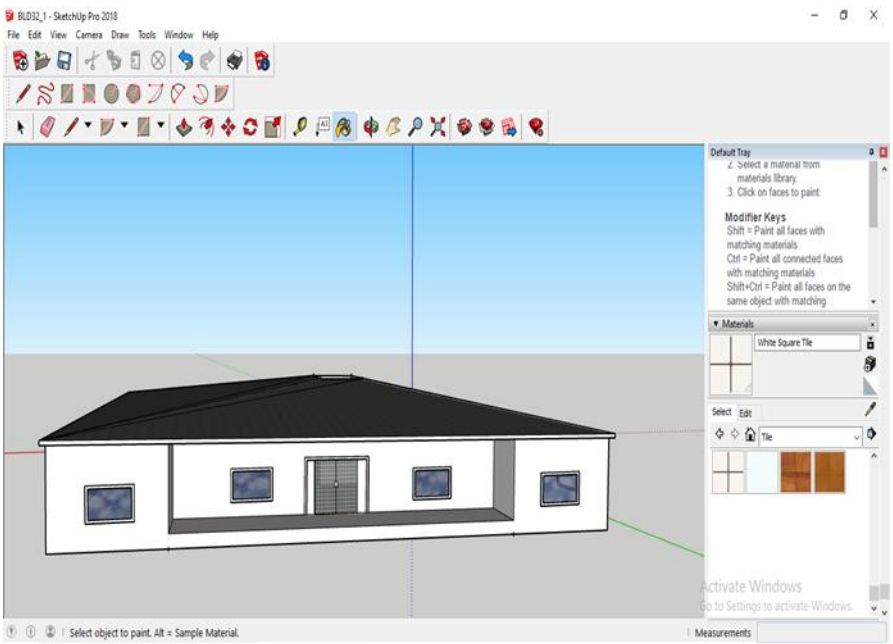

Fig. 7: 'New Day Medical Centre' building designed in Sketch up pro.

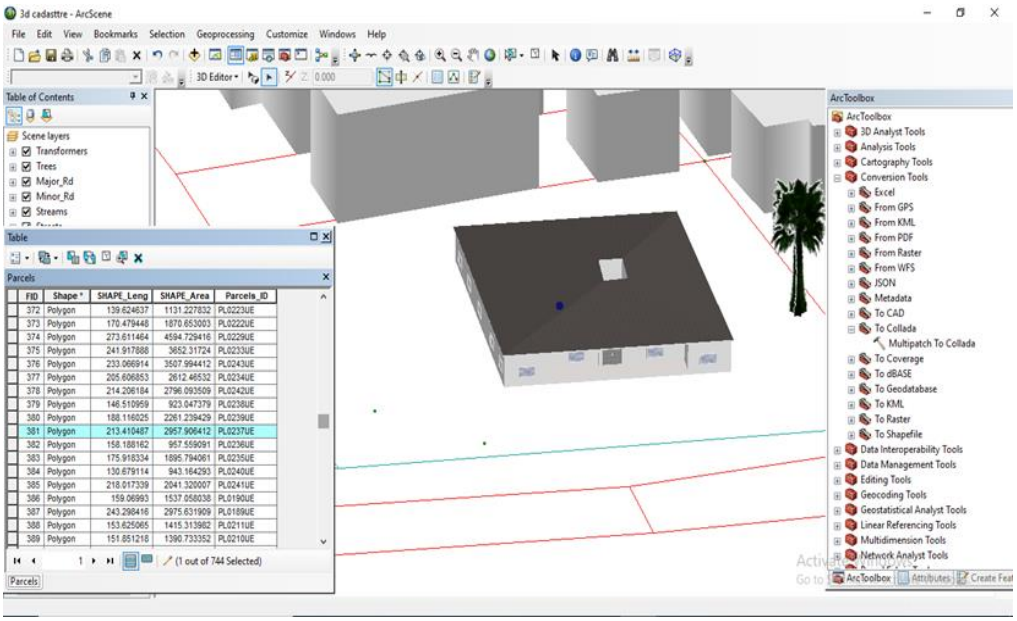

Fig. 8: Query result for Build name 'New Day Medical Centre' with LoD 3.

- **Analysis of Area Liable to Erosion/Flood in 3D Cadastre**

There is a river that flows through Ijapo Estate layout called 'Ala River'. Although, in the layout design the river was given some level of consideration along it flows path but in this 3D cadastre study there is every need for analysis to be carried out on property that are within the river flow direction for future effect of erosion or flood along the river bank. Neighbourhood analysis which is a buffer operation in ArcScene was carried out. A buffer of 20m distance was initiated along both side of the Ala River to see the number of buildings that will be affected. The result of the buffer operation shows that about 87 buildings will be affected by be erosion or flood if the river should flow beyond it banks. The figure 9 and figure 10 shows the result.

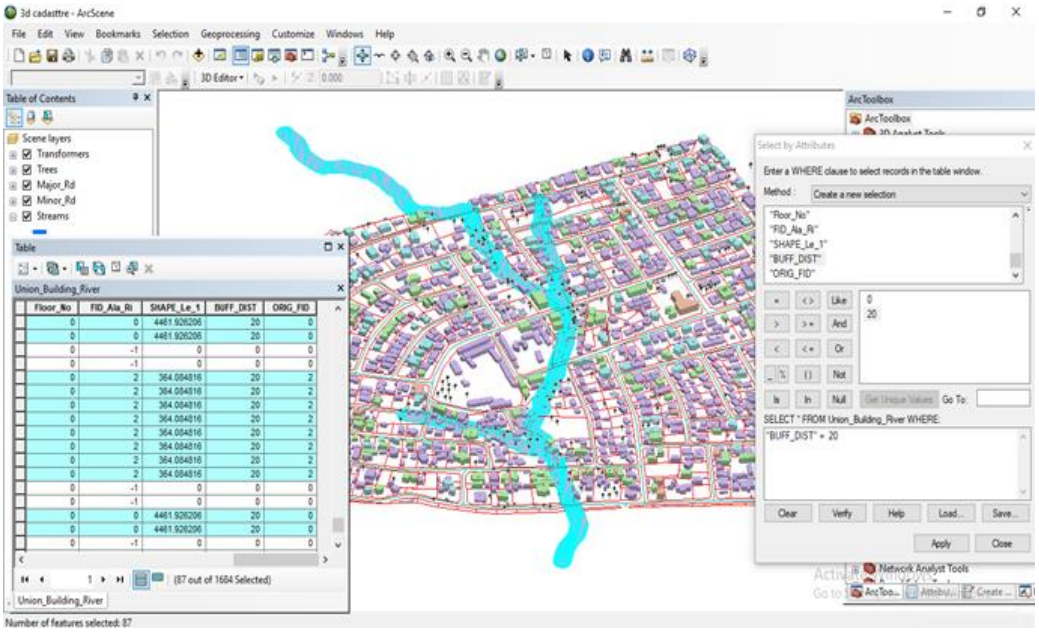

Fig. 9: 20m buffer operation along Ala River in ArcScene.

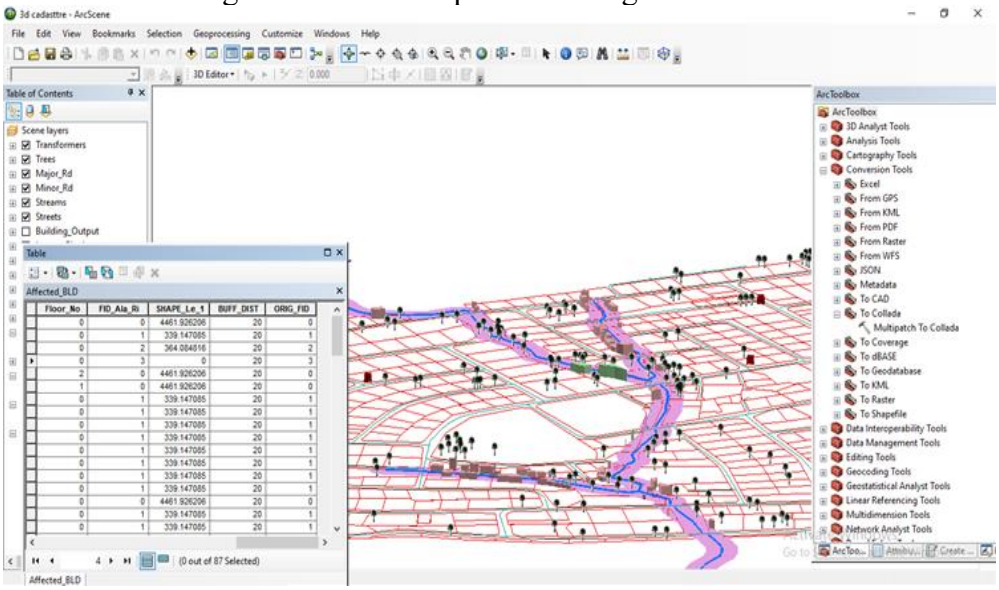

Fig. 10: Extract of the result of buildings and parcels that will be affected.

- **Integrating Digital Elevation Model (DEM) into 3D Cadastre for Property Registration**

The topographic dataset obtained from SRTM data for the study area defines the nature of reliefs. The result is the DEM that was derived from the SRTM data which defines the undulating nature of the terrain within Ijapo estate. By integrating the DEM

into this research forms the basis in which the 3D cadastre property is based. The DEM can be used to know area liable to erosion/flood as explained in this study. With DEM the low and high land can easily be determined. The DEM integrated into the 3D properties it can be seen that the lowest elevation was around the Ala River while highest elevations were along the Ijapo estate expressway, that is, around the first and third gate of the estate. The different between highest and lowest elevation is 35m (i.e. 364 – 329 = 35m) with the estate as shown in figure 11a & 11b.

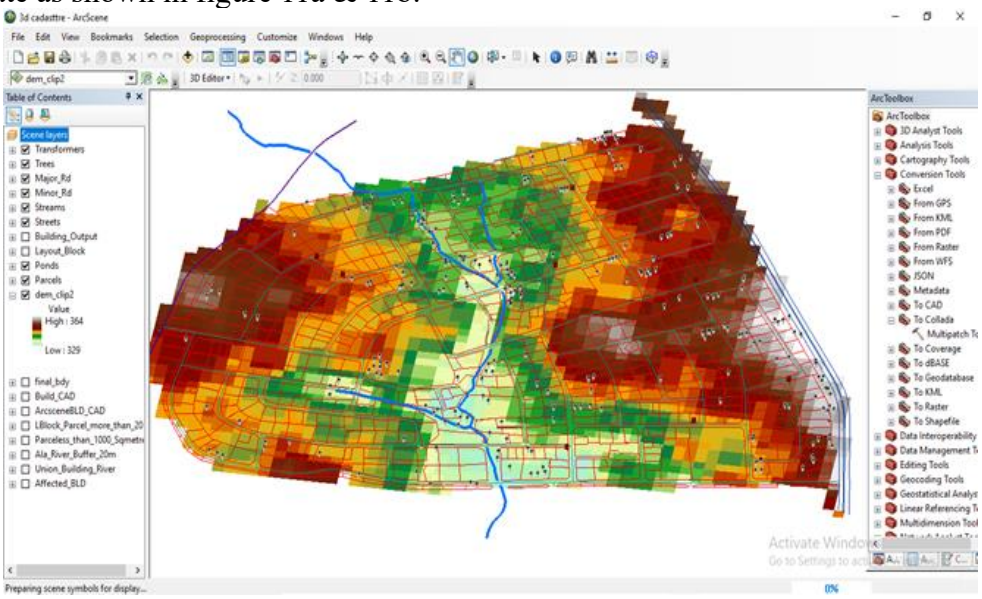

Fig. 11a: Overlay of DEM on the study area layout parcel.

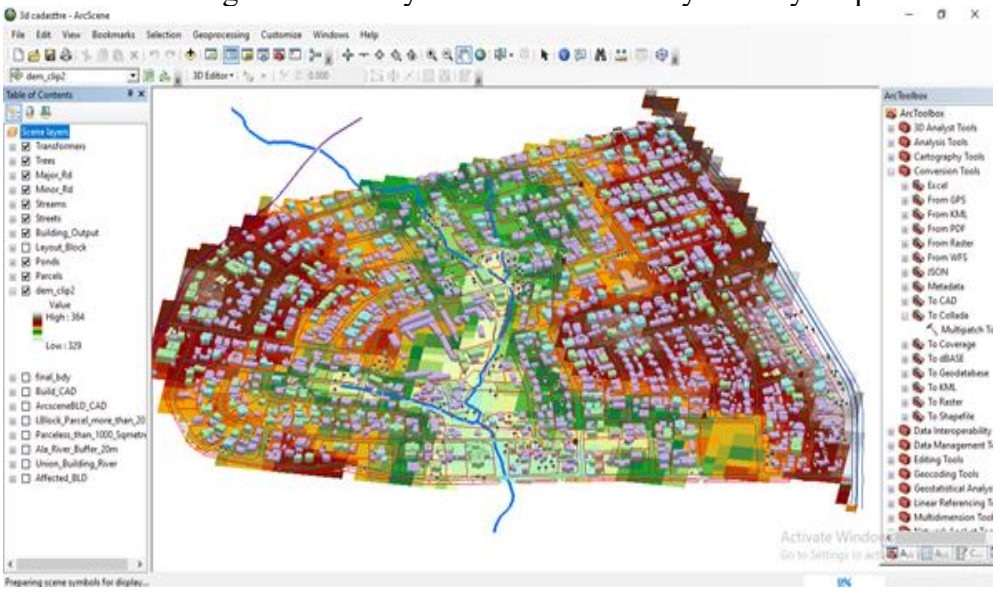

Fig. 11b: Overlay of DEM on the study area parcels and buildings.

5. DISCUSSIONS

When making use of GIS, it possesses endless direction to Geo operations provided the spatial and non-spatial data are inputted in the right format and the other software has a free interoperability file formats that link various software to a GIS software. Several other query and analysis can be performed on this designed 3D cadastre for property registration as far it meets with the spatial database structural format.

Being able to query and retrieve information from the designed 3D database for the study has reveal the possibility of registering property in 3D. The benefit and beauty of GIS technology is making geographical activity of the real world, to be captured in the computer world closer to the real-world activity. The true picture of any spatial objects is 3-dimension and the representation of spatial objects has always being 2D which has a level of restrictions when analyzing elevation in 3D decision. It thus becomes imperative to explore 3D cadastre for property registration so as to capture every aspect of property registration. For instance, in a vacant land, where there is no development on the land an individual applying for such land will be given the topographic data (x, y, z coordinate) of the land. The result of this study will assist land administrators and land managers in the decision making. It will solve a lot of encumbrances on land as everyone will know after their property registration in 3D their rights, restrictions and responsibility. With individual registering their property in 3D, people can easily be advice by appropriate land agencies or ministry ahead of impending natural disaster that may affect where their property is located. It is good to know that, this study covers the aspect of building registration, and the synergy between Department of Lands and Department of Housing of Ondo State Ministry of Lands and Housing. 3D building design can be integrated into owners' parcel of land as already explained in this study.

6. CONCLUSION

The world is change technological day by day, making everything around us becoming smarter than before. This is the reason why this study is important and timely to avail the country what is trending globally when it comes to property registration. The study has been able to show the possibility of registering property in 3D been the core product of this research. Using Ijapo Estate as the study area has real shown countless benefits 3D cadastre will bring to how property units are administered and managed. This study also meet the UN set global millennium development goal for land to be manage and sustainable for future development.

Apart from the fact that our land will be preserved, the implementation of this study will prevent wastage in the land's usage. The benefits attached to 3D cadastre property registration also, the study was able to achieve the set objectives; the need for 2D data in 3D was addressed, Level of Detail was defined as LoD 3 as against LoD 1 through software interoperability with ArcGIS, the required spatial and non-spatial for the 3D Cadastre was identified and role of 3D cadastre property has been unveiled, given answers to the research question in this study.

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