Generating Automated Land Use Taxes in Kano State, Nigeria Using Cadastral Records and Geospatial Information System

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Keywords: Cadastre, Land parcel, Land use tax, Land record, Spatial display, GIS, Python programming, Database, Kano

SUMMARY

Tax collection on Land uses is one of the tangible ways a government can generate revenue to enhance good governance and the development of infrastructures for its citizens. Kano municipal is one of the most populous and commercial hubs in Nigeria, as such, there have been a lot of business activities taking place, which are spatially related to land records. The collection of land use taxes in the area using the existing method has been tedious, slow, time-consuming, and prone to errors and corruption, among other things. Therefore, to improve on the existing method, there was a need to adopt a science-based approach using cadastral records available in the State Land Bureau for Land Management and Kano State Office of Surveyor General. This paper explained how the cadastral survey records were utilized to generate land use charges for various land use categories using classified python programming codes and geoprocessing technology in the ArcGIS software environment. The technology involved the use of land parcel database attributes like size, location, land use type, ownership, and rate per square to assign recommended or exact land use tax ideal for each land record and to produce output by way of spatial display of the property as a map template as well as attribute information attached to the land parcel. The system also incorporated the recovery of previous years' unpaid tax charges in case of nonpayment and added them to the current year's bills. It is however programmed to accommodate changes in rates of tax charges and updates for every incoming year. Adoption of this new method of land use tax collection has since its inception witnessed an upward inflow of land revenue generation in the Kano State Bureau for Land Management and could be applied anywhere for the same purpose. The ArcGIS software was similarly used to make a comprehensive database for land tax records and verification of claims and various resolutions. It is recommended that this method be adopted by various government agencies dealing with land use tax collection for better and improved revenue generation.

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1. INTRODUCTION

Tax generation of all kinds, in all forms legally possible, is a welcome development for governments at all levels and this idea serves as a medium for bulk revenue generation in which various meaningful development projects are executed. In the context of Nigerian state governments, over-dependence on monthly Federal allocation for executing projects and payment of staff salary in the civil service has proven colossal inadequacy and resulted in huge debt accumulation from one government generation to another without any sign of lessening in the severity of these debts. These factors and many more, including uncertainties of crude oil prices in the world markets and constant agitation for control of oil resources by the oil-producing states in southern Nigeria, necessarily compelled the Kano state government in the year 2016 to review its revenue potential in the state.

Utilization of land-related taxes became a cardinal choice because of the state's land use development, ranging from residential, commercial, industrial, and agricultural purposes. The state government then made an upward review of all land-related charges and enacted edicts and made amendments to the existing land use laws in the state to generate more revenues from the available cadastral data. This proposal was responsible for the development of land use charges (LUC) which consisted of the sub charges such as Ground Rent, Tenement Rate, Property Tax, and Infrastructure and Maintenance Charges.

However, other vital services which involved records of transactions for the rights and privileges of land title holders were fully incorporated to generate more revenue. They include the Change of Ownership (Assignment); Change of Purpose; Sub-Division of Land; Contravention of Land Use; and Re-grant of Title.

Related literatures have been reviewed to identify an existing gap in the subject area, that would form the bases for which this paper would focus on the evaluation of the mechanism for the automation of land use charges. However, the papers were mostly centered on property taxation which is mainly derived from the property values estimated by registered estate surveyors and valuers.

In some reviewed literatures, some researchers took into account, the extreme difficulty involved in the collection of these taxes, and that a well-administered property tax will guarantee an autonomous, predictable, and potentially lucrative source of revenue for a local authority, however, it has been often argued that the primary problem of taxation is poor administration (Monkam and Moore, 2015; Kelly, 2000; and Bird and Casaregra de Jantscher, 1992).

Tax administration, generally, involves the interpretation and application of tax laws into practice (Muhammad and Ishiyaku, 2013). Property tax administration could be defined as the management and supervision of the execution and application of property tax laws and related acts by the government or state. Plimmer and McCuskey (2010 reported that an administration is so fundamental that the decision on responsibility is often central to the success of property

tax. Property tax administration covers assessment, billing, appeals, collection, and enforcement (Plimmer and McCluskey, 2016).

Similarly, Bird and Slack (2002) delineated three key steps involved in the property tax administration process. Property tax is an annual levy mainly on land and buildings usually paid by the owner to the state. Property taxation is widely recognized as the most progressive, viable, efficient, and equitable means of generating revenue for municipal/local government. Property taxes need to be valued on a more objective basis (Dale and McLaughlin, 1999) to achieve equitable assessment.

In property valuation for taxation purposes, there are fundamentally two broad approaches – the market-based approach and the area-based approach. The market-based approach is based on capital and rental value, while the area-based approach is based on plot size. Although the market-based method is more correct, it requires expertise, and market transaction data, and is time-consuming, more expensive, and difficult for people to comprehend.

It is on the background of these papers reviewed above, efforts were made and proved excellent in combining the property tax, tenement rate, infrastructure maintenance charges, ground rent, and other chargeable services offered on land properties in one mathematical algorithm using GIS tools.

1.1 Study Area

The study area for this paper is Kano State, Nigeria, one of the 36 States, located in the northern region of the country and the most populous state in Nigeria. It was founded in the year 1967 and the state covers an approximate area of 20,131km^2 currently.

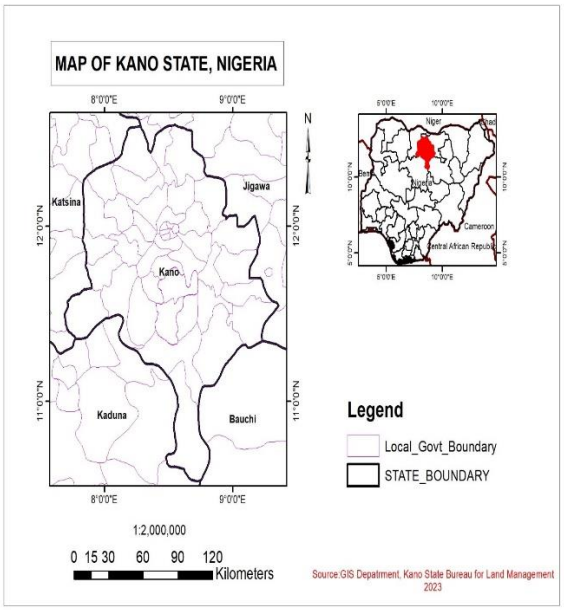


Figure 1: Map of Kano State, Nigeria

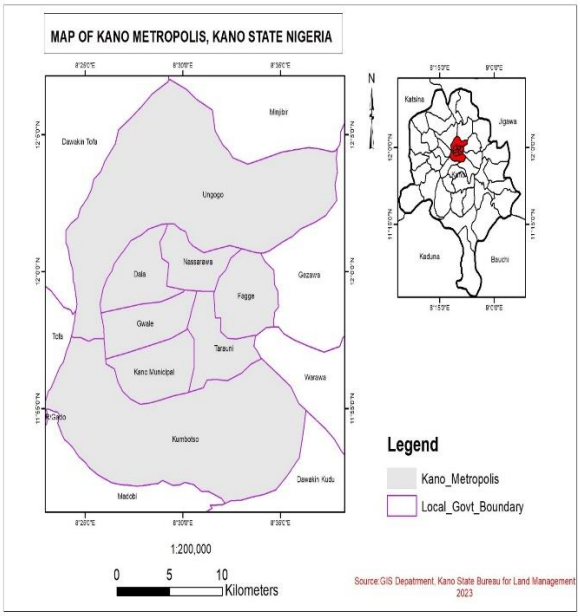


Figure 2: map of Kano Metropolis.

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this work included but were not limited to the Survey Plans; Layout Composite Survey Plans; Intelligent Chat Sheets; Topographical Maps; High-Resolution Satellite Imagery; Scanners; Computer Sets; Digitizing Tablets; Printers; Esri ArcGIS 10.5, and Python IDLE, (Pandas, Jupyter Notebook).

These listed materials were used in the data capture for the conversion of the data from analogue to digital formats respectively.

2.2 Methods

2.2.1 Data Sources, Acquisition, and Processing

The entire data used for this work was sourced from Kano State Bureau for Land Management through the departments of Cadaster, Survey, and GIS, the majority of which were in analogue formats and they were acquired mostly from ground/field survey, aerial photographs (photogrammetry), generated as far back as the 1970s and maintained to date.

The processing aspect of the spatial data was carried out in the GIS department which is fully equipped with all the necessary equipment and manpower to carry out this task efficiently. At the start of the project, about fifty thousand land parcels were captured and attributed. Various land use categories were assigned different rates, domain table of values was created to incorporate these rates and to appropriately assign them according to their land use purpose, location, density, and other considerations such as the penalty for defaulting payment, land use contraventions, re-grants, subdivision, assignment, etc.

A comprehensive geospatial template map was generated and served to every parcel location as a demand notice. The map template consisted of a geometrical outline of the target property defined by its size, its abortive information, location, street, district, and local government names, and centroid coordinates of the parcel. Other vital information contained in the outlook of the template are the owner name, address, file number, property land use classification, and property value.

Importantly, the entire computation aspect of the land use charges which would be displayed as dynamic fields and are uniquely different for each property displayed. These dynamic fields were managed and manipulated from the database of the attribute table which was codified with python scripts for computation processing and display of results. Land use charges from 1999 to 2015 were classified as recovery and calculated cumulatively; the year 2016 upward to date (2023) were calculated independently.

The summation of the total amount payable was then displayed at the lower midsection of the template while taking into consideration any if any and then the final balance was displayed at last. It should also be noted that the template was designed to consist of static (fixed) and dynamic (varying) fields. The dynamic fields of the template change for each plot parcel whereas the static fields are common to all plots. The file number of each land title was used to

call each plot and instantly get its land use charges and other information (spatial and non-spatial) fully displayed in the template (demand notice).

The methodology employed in the development of this activity involved the conversion of all parcel records obtained from the survey department to digital soft copy format. The topographical maps and layout composite survey plans were scanned with very high dots per inch pixel values which allowed for a high-resolution display of the raster at varying scales. They were then imported into the ArcGIS software environment as raster data sets, a uniform spatial reference was then assigned to each of the raster data sets and they were georeferenced using a minimum of four control points.

A root mean square error of less than 1% was obtained in all the rectifications therefore that proved sufficient for the purpose. Digitization and attribution of all plots on the survey plans were carried out for all the available data scanned. Individual survey plans were traversed using the coordinate geometry (COGO) tools in ArcGIS and the exact polygon size for each of the survey plans was obtained and subsequently attributed duly.

The process continued for all the available data for the entire state with the bulk of it centered in the majority of the metropolitan local governments namely; Gwale, Kano Municipal, Nassarawa, Tarauni, Fagge, Dala Ungogo, and Kumbotso LGAs respectively. Independent quality control checks were carried out to ensure the correctness of data entry.

The entire attribution process conformed with the geospatial database schema based on the name of the plot owner, plot number, layout plan number, block number, location, district local government, the Surveyor, date, history, and many more. These fields were designed on the bases of data types for each field such as short or long integer, double, float text, etc.

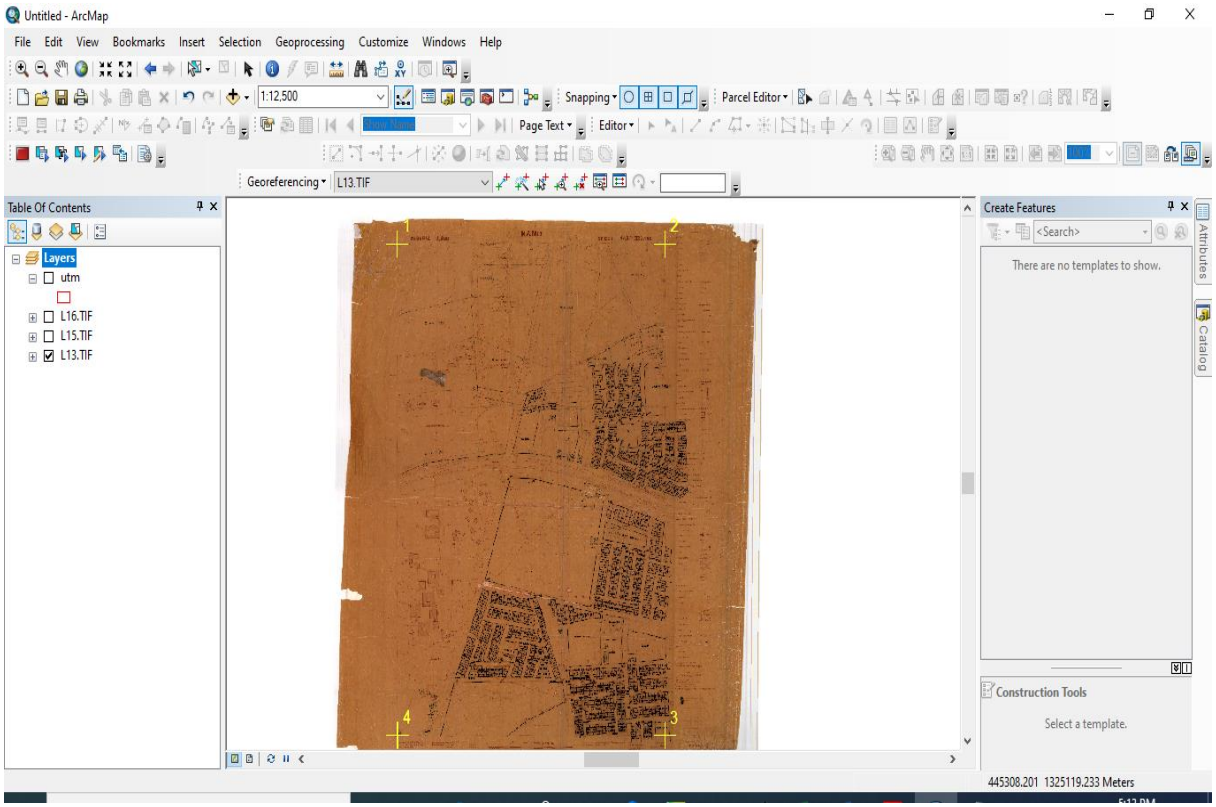


Figure 3: Scanned Sheet of Composite Survey Plan

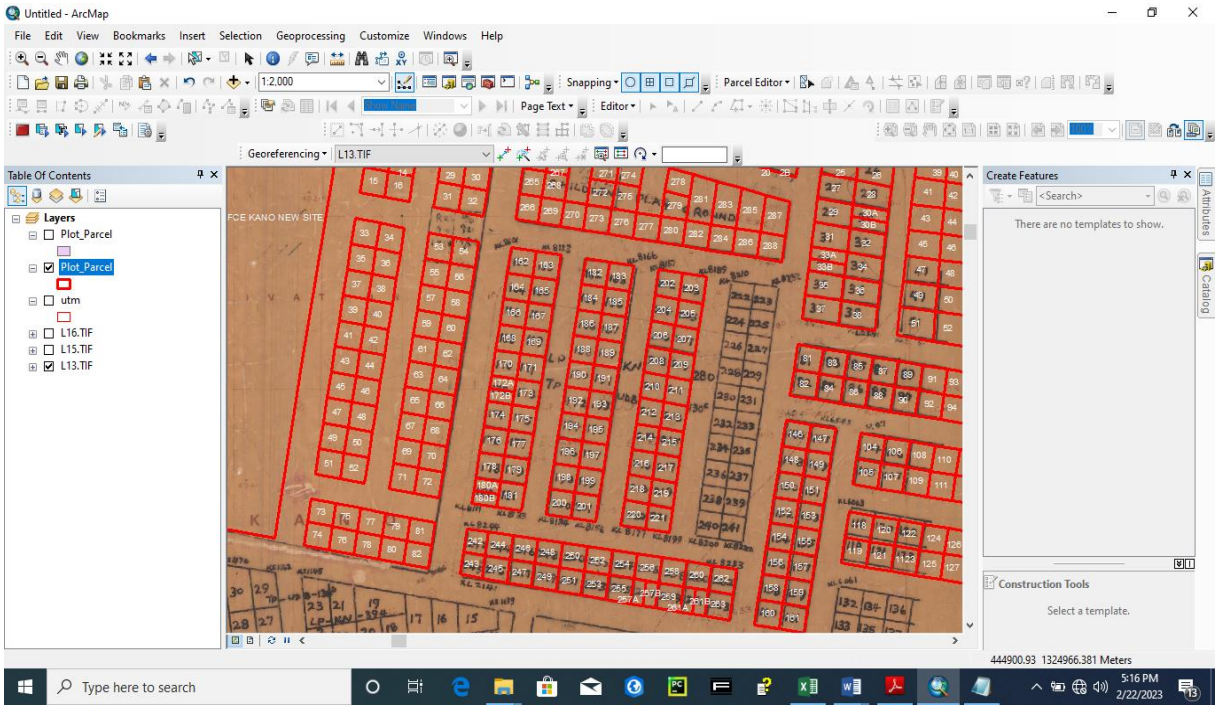


Figure 4: Digitized and Attributed Survey Data in ArcMap

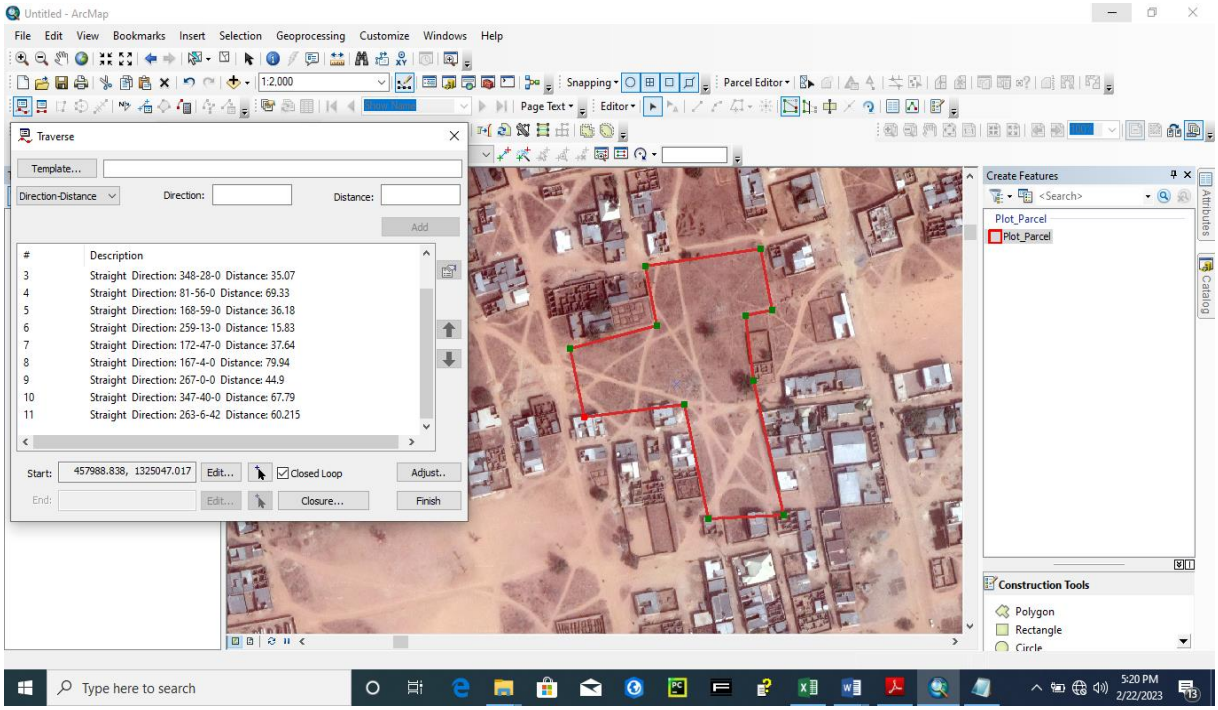


Figure 5: Scanned Sheet of Composite Survey Plan

However, several other field data types used in the computation of the land use charges were created in the same geodatabase using python programming codes/scripts as shown below. The following fields were created as such using the same codes but with different headings for each.

They were created for the following headings; LUC_2016, LUC_2017, LUC_2018, LUC_2019, LUC_2020, LUC_2021, LUC_2022, and LUC_2023 respectively.

The letters 'LUC' stand for Land Use Charge which in turn consisted of the following categories of charges; Ground Rent (GR), Tenement Rate (TR), Property Tax (PT), and Infrastructure Maintenance Charges (IMDC). The GR is a function of geometrical size (area) and assigned rate, TR and PT are functions of the property value of the title while IMDC is fixed for residential, commercial, industrial, and agricultural.

Figure 6: Result of Python Codes Used for Adding Attribute Field into the Database

Having accumulated enormous data by way of conversion from analogue to digital format, we then developed and wrote several python codes and created the following geospatial processing elements, namely;

- Folder (LUC_Folder)
- File Geodatabase (LUC_Gdb)
- Feature Classes (LUC_Polygon)
- Feature Dataset (LUC_Dataset)
- Topology (LUC_Topology)
- Parcel Fabric (LUC_Fabric)

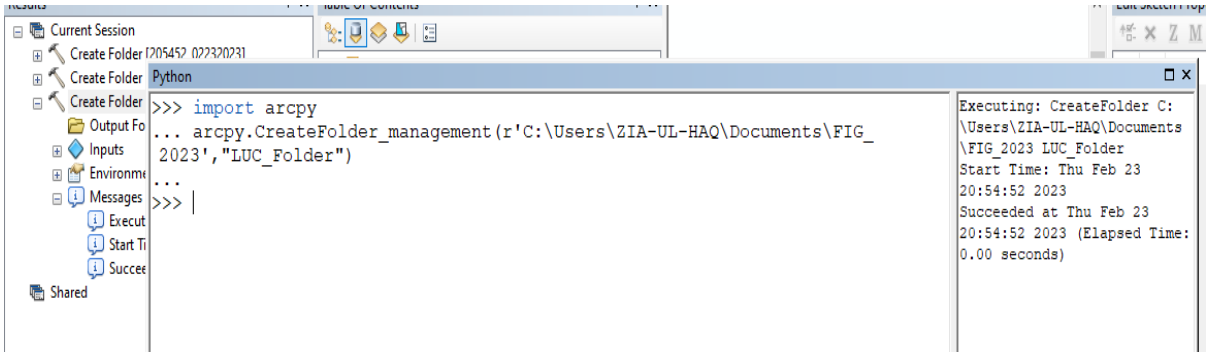


Figure 7: Result of Python Codes Used for Creating Working Folder (LUC_Folder)

The screenshots in figure 7 showed the codes for creating all the above-listed terms, however, full details of how the topologically guided data was formed would not be discussed herein. The main purpose of creating the topology was to ensure that the spatial data's integrity conform to certain cadastral rules and free of all errors such as overlaps, undershoots, disjoints, etc., while migrating the data was to ensure conformity to cadastral survey standards.

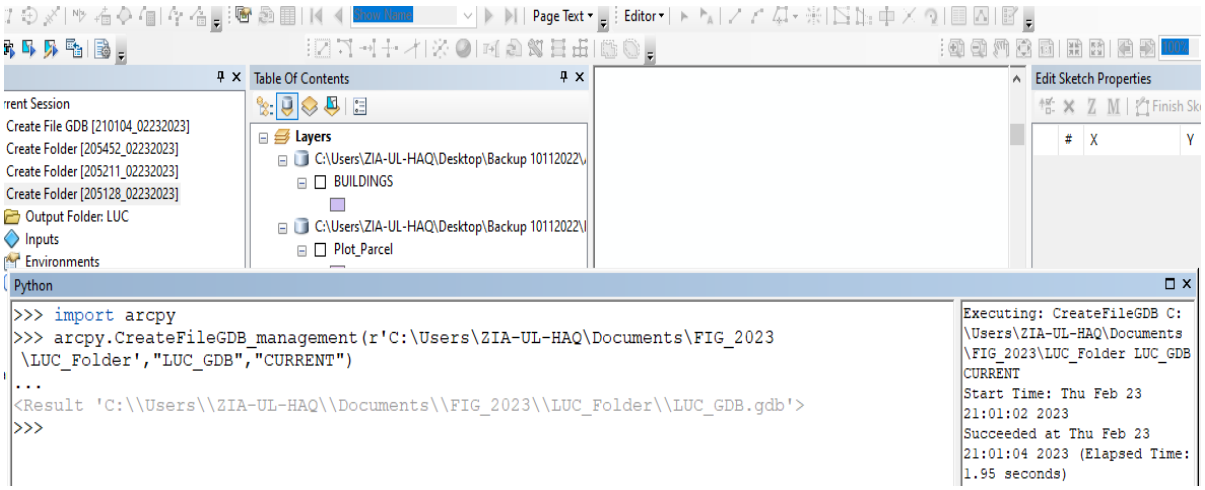


Figure 8: Result of Python Codes Used for Creating File Geodatabase in ArcMap

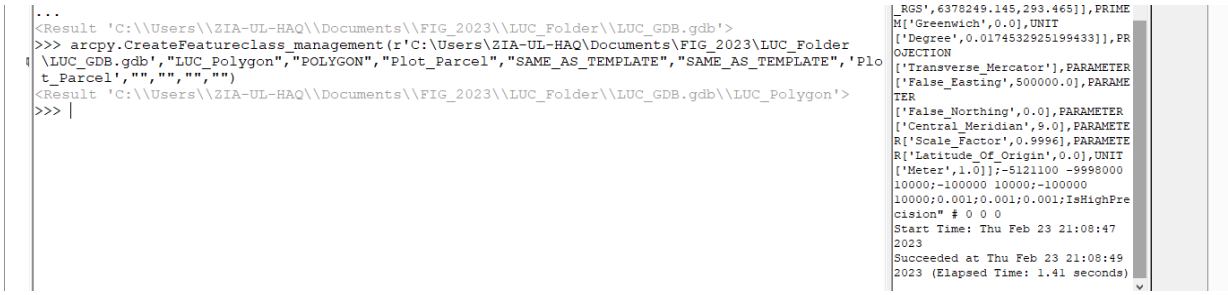


Figure 9: Result of Python Codes Used for Creating Feature Class in ArcMap

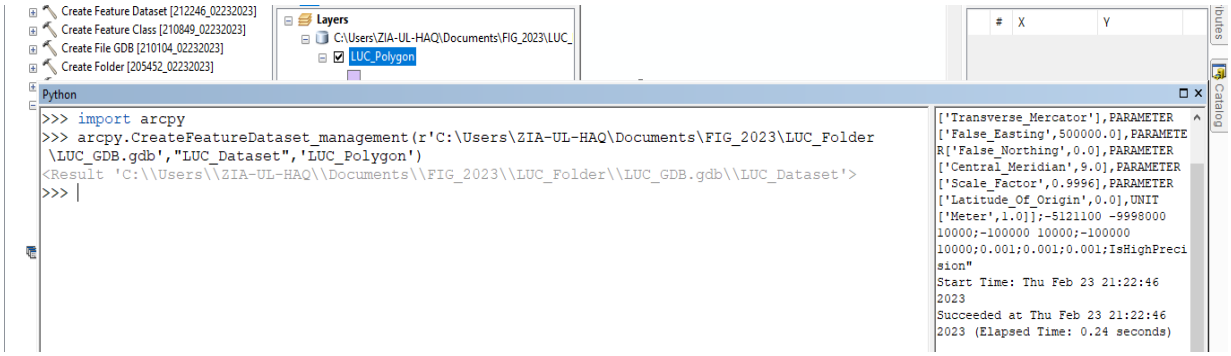


Figure 10: Result of Python Codes Used for Creating Feature Dataset in ArcMap

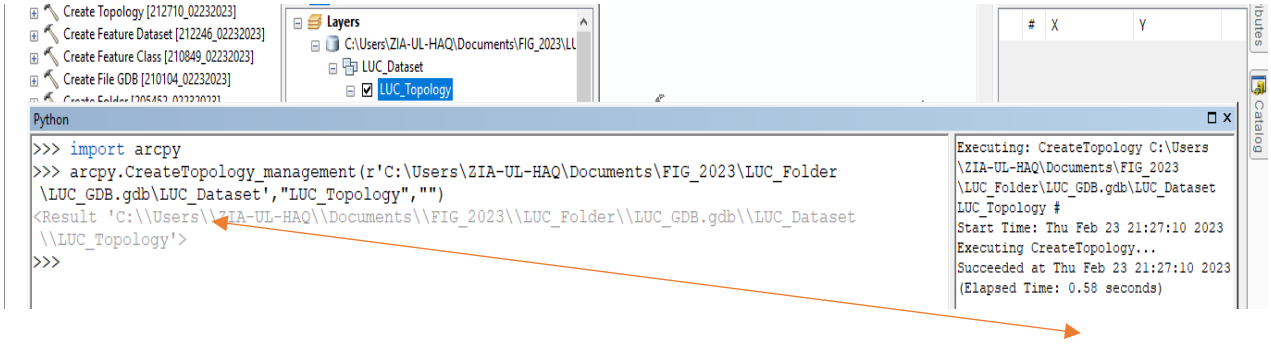


Figure 11: Result of Python Codes Used for Creating Topology in ArcMap

Figure 12: Results of Folder, geodatabase, Feature Class Dataset, and Topology in ArcMap

Finally, in ensuring the data integrity for the parcels, the topology was inspected and a fixed result showing zero error was achieved as shown in the screenshot Figure 13.

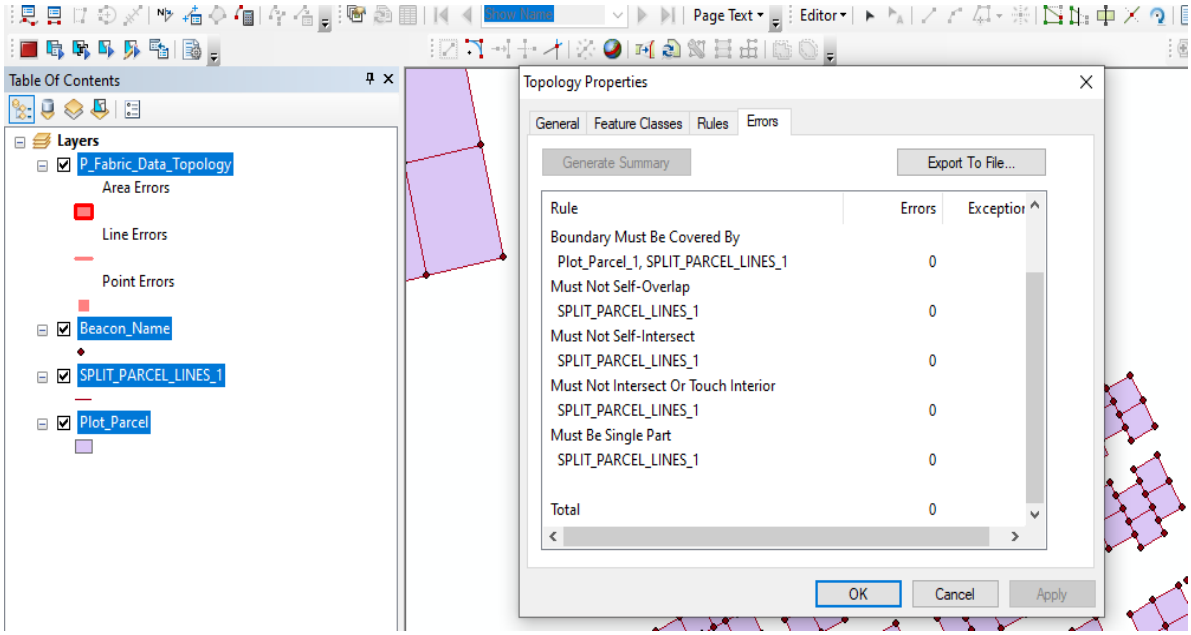


Figure 13: Result Showing Zero Error Topology used in the Data Processing

With the inspection of the topology error, the parcels were then migrated into the LUC_Fabric that was created previously. This allowed for the management and manipulation of the plots in a single geodatabase in which all forms of our LUC computations were made.

The algorithms (i)-(iv) were made and subsequently transformed into python programming codes.

LUC = GR+TR+PT+IMDC ……(i)

GR = Ground Rent = shape_Area(sqm) * Rate ……. (ii)

TR = Tenement Rate = Property Value * 0.12% …… (iii)

PT = Property Tax = Property Value * 0.15%.....(iv)

where;
LUC is the total land use Charge for a particular year
IMDC = Infrastructure Maintenance Charges are assigned fixed for residential areas, industries, and commercial land uses respectively.

It should be noted, however, that 0.12% for TR and 0.15% for PT were assigned for commercial and industrial land use types.

3. RESULTS AND ANALYSES

3.1 Results

The results achieved generating automated land use taxes in Kano State, Nigeria, using cadastral record and geospatial information system are as listed and illustrated below;

- Automated Land Use Charge Computation Template/Map
- Geospatial Database for Land-Related Taxes in Kano State
- Spatial Data Transformation/Conversion from Analogue to Digital Geospatial Information System for Cadastral Records.

The automated land use charge computation template/map consists of spatial information as well as attributes of the location together with the computation of land use charges as a medium for Land tax generation. See the Figures 14, 15, 16, and 17.

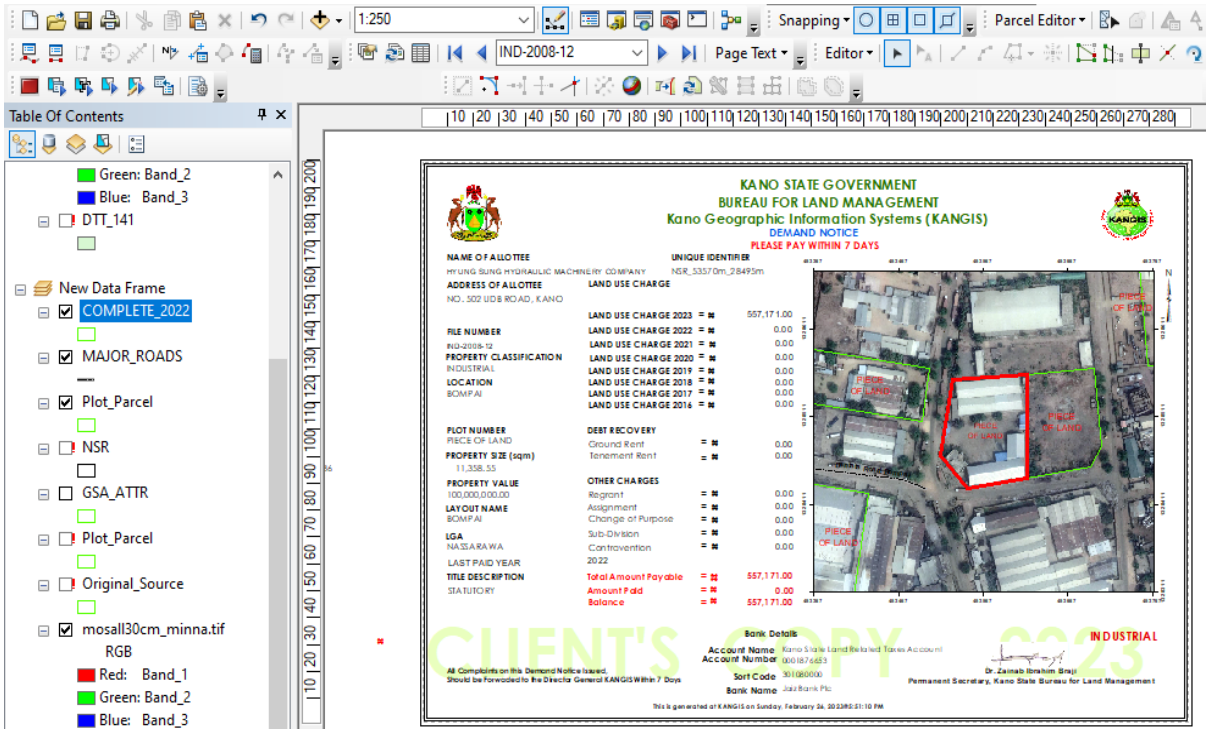
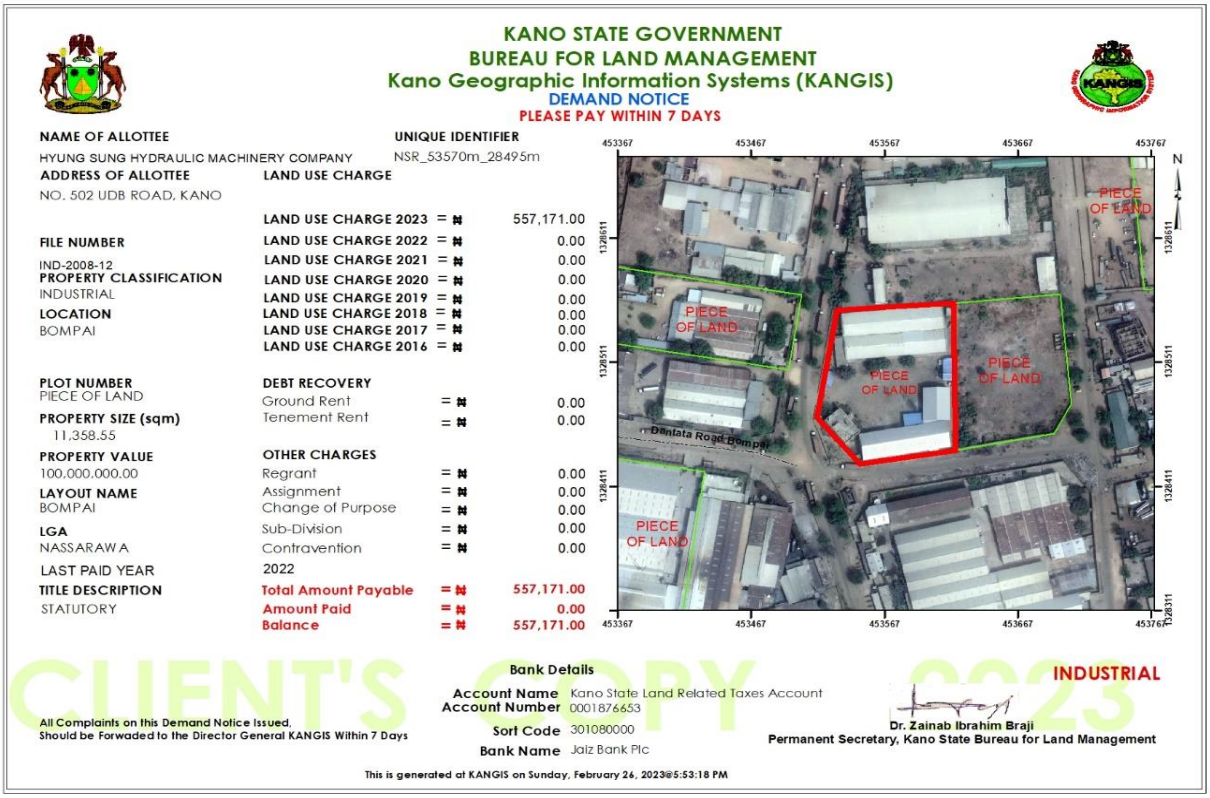


Figure 14: Automated Land Use Charge Computation Template/Map



KANO STATE GOVERNMENT
BUREAU FOR LAND MANAGEMENT
Kano Geographic Information Systems (KANGIS)
DEMAND NOTICE
PLEASE PAY WITHIN 7 DAYS

NAME OF ALLOTTEE
HYUNG SUNG HYDRAULIC MACHINERY COMPANY
ADDRESS OF ALLOTTEE
NO. 502 UDB ROAD, KANO

FILE NUMBER
IND-2008-12
PROPERTY CLASSIFICATION
INDUSTRIAL
LOCATION
BOMPAI

PLOT NUMBER
PIECE OF LAND
PROPERTY SIZE (sqm)
11,358.55
PROPERTY VALUE
100,000,000.00
LAYOUT NAME
BOMPAI
LGA
NASSARAWA
LAST PAID YEAR
2022
TITLE DESCRIPTION
STATUTORY

UNIQUE IDENTIFIER
NSR_53570m_28495m

LAND USE CHARGE

LAND USE CHARGE 2023	= ₦	557,171.00
LAND USE CHARGE 2022	= ₦	0.00
LAND USE CHARGE 2021	= ₦	0.00
LAND USE CHARGE 2020	= ₦	0.00
LAND USE CHARGE 2019	= ₦	0.00
LAND USE CHARGE 2018	= ₦	0.00
LAND USE CHARGE 2017	= ₦	0.00
LAND USE CHARGE 2016	= ₦	0.00

DEBT RECOVERY

Ground Rent	= ₦	0.00
Tenement Rent	= ₦	0.00

OTHER CHARGES

Regrant	= ₦	0.00
Assignment	= ₦	0.00
Change of Purpose	= ₦	0.00
Sub-Division	= ₦	0.00
Contravention	= ₦	0.00

Total Amount Payable	= ₦	557,171.00
Amount Paid	= ₦	0.00
Balance	= ₦	557,171.00

Bank Details
Account Name: Kano State Land Related Taxes Account
Account Number: 0001876653
Sort Code: 301080000
Bank Name: Jaiz Bank Plc

INDUSTRIAL

All Complaints on this Demand Notice Issued,
Should be Forwaded to the Director General KANGIS Within 7 Days

Dr. Zainab Ibrahim Braji
Permanent Secretary, Kano State Bureau for Land Management

This is generated at KANGIS on Sunday, February 26, 2023@5:53:18 PM

Figure 15: Sample of Demand Notice Generated for Industrial Property for the Year 2023

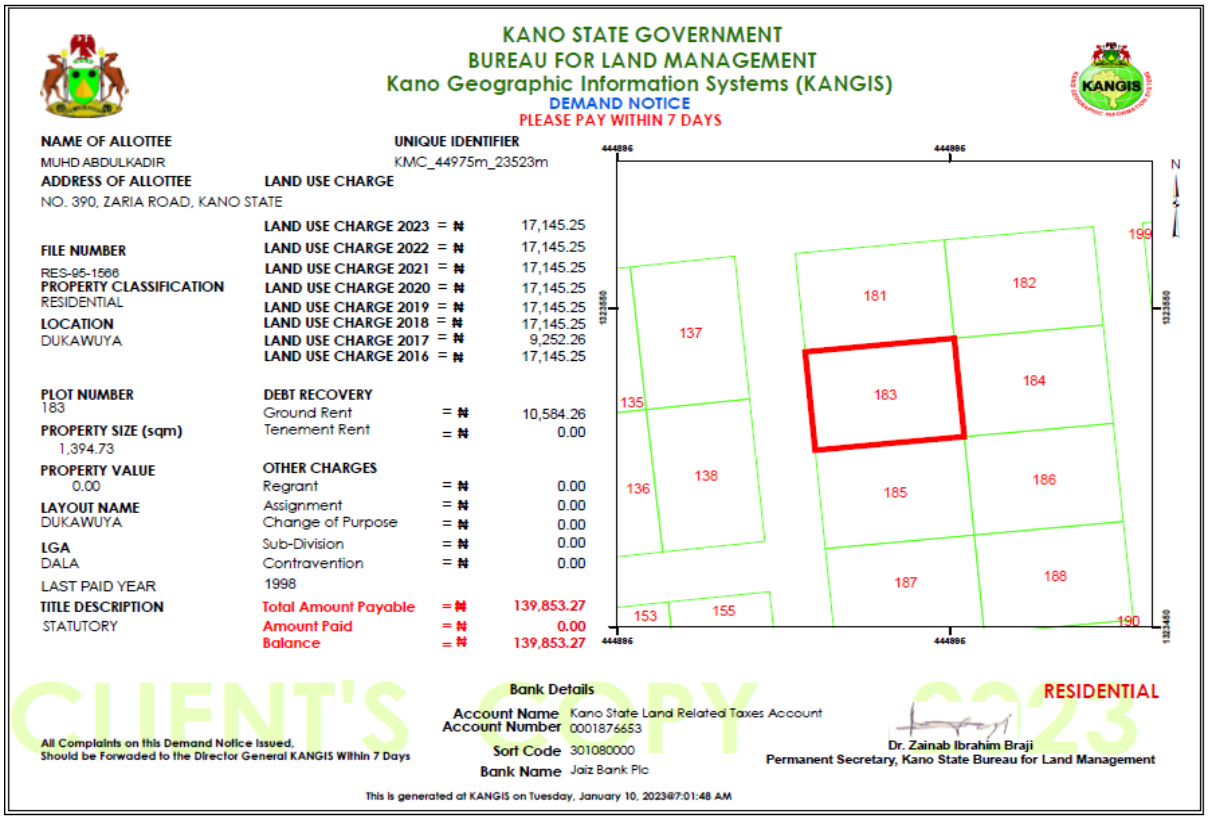


Figure 16: Sample of Demand Notice Generated for Residential Property Recovery for Several Years.

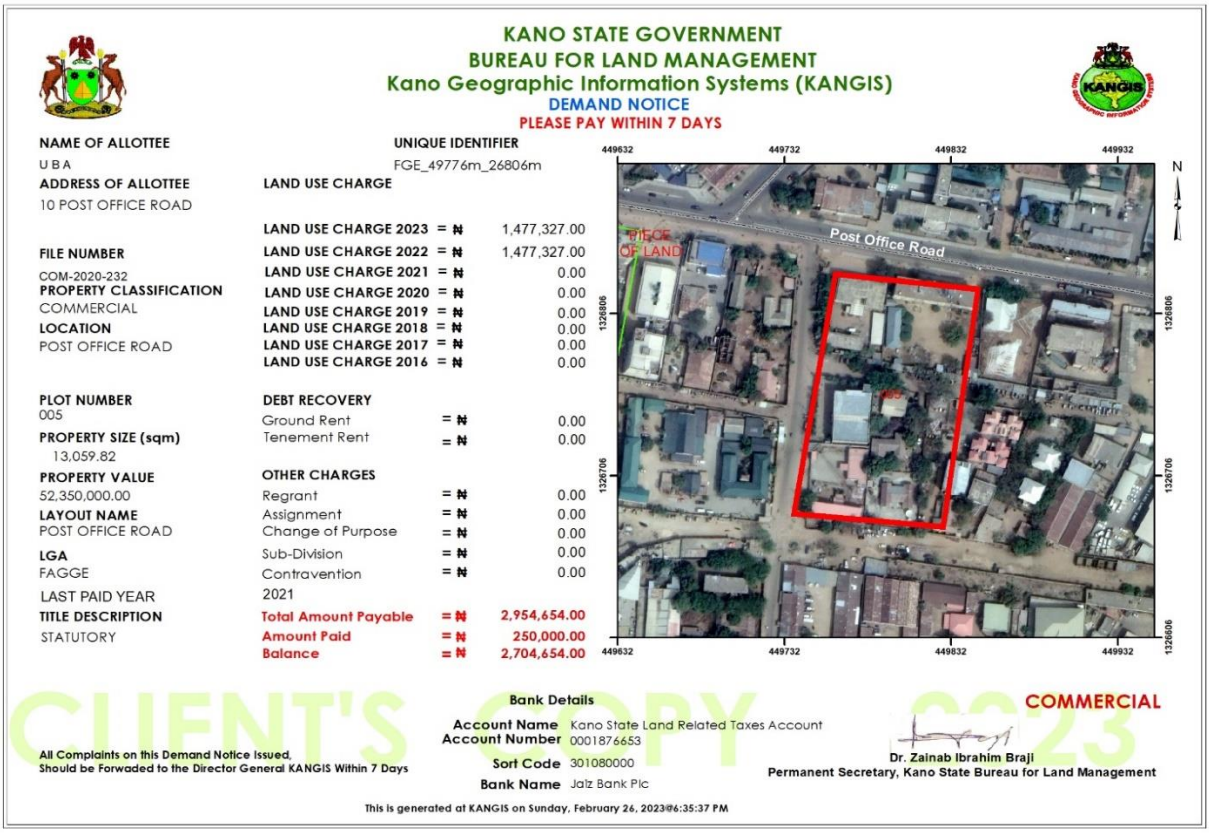
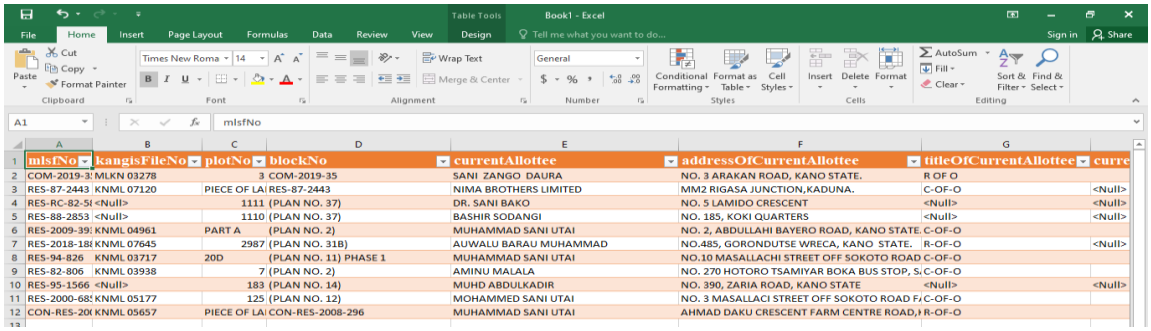


Figure 17: Sample of Demand Notice Generated for commercial Property Recovery from 2022-2023 Years.

The geospatial database for land-related taxes in Kano state was created from the GIS-driven database, this serves as a medium for checking and verification of defaulting payments and underpayments of land use charges in the entire Kano state and it supports updates, queries, displays, and its contents can be flexibly converted to many other database management systems such as ms-excel, access, oracle, Dbase MySQL, etc. See Figure 18.



mlsfNo	kangisFileNo	plotNo	blockNo	currentAllottee	addressOfCurrentAllottee	titleOfCurrentAllottee	curre
COM-2019-3	MLKN 03278	3	COM-2019-35	SANI ZANGO DAURA	NO. 3 ARAKAN ROAD, KANO STATE.	R OF O	
RES-87-2443	KNML 07120	PIECE OF LA	RES-87-2443	NIMA BROTHERS LIMITED	MM2 RIGASA JUNCTION,KADUNA.	C-OF-O	<Null>
RES-RC-82-5	<Null>	1111	(PLAN NO. 37)	DR. SANI BAKO	NO. 5 LAMIDO CRESCENT	<Null>	<Null>
RES-88-2853	<Null>	1110	(PLAN NO. 37)	BASHIR SODANGI	NO. 185, KOKI QUARTERS	<Null>	<Null>
RES-2009-39	KNML 04961	PART A	(PLAN NO. 2)	MUHAMMAD SANI UTAI	NO. 2, ABDULLAHI BAYERO ROAD, KANO STATE.	C-OF-O	
RES-2018-18	KNML 07645	2987	(PLAN NO. 31B)	AUWALU BARAU MUHAMMAD	NO.485, GORONDUTSE WRECA, KANO STATE.	R-OF-O	<Null>
RES-94-826	KNML 03717	20D	(PLAN NO. 11) PHASE 1	MUHAMMAD SANI UTAI	NO.10 MASALLACHI STREET OFF SOKOTO ROAD	C-OF-O	
RES-82-806	KNML 03938	7	(PLAN NO. 2)	AMINU MALALA	NO. 270 HOTORO TSAMIYAR BOKA BUS STOP, S	C-OF-O	
RES-95-1566	<Null>	183	(PLAN NO. 14)	MUHD ABDULKADIR	NO. 390, ZARIA ROAD, KANO STATE	<Null>	<Null>
RES-2000-68	KNML 05177	125	(PLAN NO. 12)	MOHAMMED SANI UTAI	NO. 3 MASALLACI STREET OFF SOKOTO ROAD F	C-OF-O	
CON-RES-20	KNML 05657	PIECE OF LA	CON-RES-2008-296	MUHAMMAD SANI UTAI	AHMAD DAKU CRESCENT FARM CENTRE ROAD,	R-OF-O	

Figure 18: A Sample of GIS Attribute Data Converted to Excel Format.

3.2 Analysis

The analyses made herein are per the interpretation of results generated from the methodologies adopted in processing the geospatial data which was digitally enhanced to automate the generation of land use charge taxes using cadastral survey records. The analyses show an upward flow of land uses revenue from the year 2016 to 2022.

The year 2017 marked the beginning of the increase, which significantly increased from ₦513,261,462.93 to ₦1,615,456,611.75, three times as much as the year 2016. This accounted for the land use charge tax in the state counting in ten digits' significant figures (billion nairas).

Furthermore, the year 2017 witnessed a further increase in land use tax generation from ₦1,615,456,611.75 recorded in 2017 to ₦2,041,798,850.04 in 2018. This accounted for the land use charge tax in the state counting in multiples of billions of naira.

Moreover, the land use charge tax generated in the year 2019 still counted in billions but with a slight decrease in the total amount generated for the year, it decreased from ₦2,041,798,850.04 In 2018 to ₦2,001,412,435.80 in 2019. This accounted for a deficit of ₦40,386,414.24, however, it was an excellent result.

However, the year 2020 recorded an all-time low amount of land use tax generation in comparison with the year of automation, (2017), the amount generated was ₦1,438,315,330.09. this low revenue generation was of course due to the covid-19 pandemic and subsequent lockdown of all activities in the state and all over the nation and the entire globe at large. Interestingly, the first quarter of the year 2020 started very well as depicted in the table and the chart below. Importantly, with the declaration of ease on the lockdown in the state and the nation, the figures rose from September to December of the same year 2020.

More so, in the year 2021, the figures in land use tax revenue generation returned to billions of naira to the exact figure of ₦ 2,008,518,674.98, this must have included some land use tax recovery that was defaulted in the previous year, 2020.

Finally, in the year 2022, the land use tax charges were reduced to less than two billion nairas to about ₦1,791,344,552.48. Despite this drop in the figures generated for the year 2022, it was very significant as most of the payments made were only for the current year 2022 with less recovery of the previous years' land use charges. The year 2023 was just beginning and therefore, fewer data were available, just for January and February, which is statistically inadequate for any inference. It should be noted that enforcement for land use tax generation was not initiated in the year 2023 and this was due to proximity to the election period and the government was most probably avoiding the public threat of losing votes and so the police enforcement team was avoided for the time being.

The total amount so far generated for February 2023 was just ₦255,852,653.51. The chart in figure 21 below showed the annual distribution of land use tax generated from the years 2016-2023, with the year 2023 being available for only two months (January and February) respectively.

Year	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
2016	42,125,253.25	47,258,129.35	47,584,365.27	11,232,522.55	52,954,354.26	64,157,369.60	53,512,324.27	41,825,821.32	43,254,125.35	42,546,198.23	35,456,874.25	31,354,125.24	513,261,462.93
2017	103,258,124.26	133,158,369.21	121,258,124.25	101,965,253.32	111,145,354.32	135,425,432.21	122,148,365.29	163,396,357.12	175,125,369.32	176,128,365.25	157,125,842.36	115,321,654.84	1,615,456,611.75
2018	162,543,252.15	172,358,125.32	185,353,655.23	169,354,663.15	149,326,523.25	171,235,254.36	168,369,654.13	169,253,215.23	174,257,258.36	192,125,425.39	159,252,365.12	168,369,458.35	2,041,798,850.04
2019	201,565,321.32	221,369,547.25	213,258,658.21	199,853,325.19	164,235,974.25	161,587,369.25	156,789,412.36	147,258,456.21	124555369.14	184258147.36	112,425,981.25	114254874.01	2,001,412,435.80
2020	149,857,354.25	168,258,456.32	108,023,254.21	72,129,354.27	56,542,542.36	51,973,652.14	49,727,233.93	69,158,355.12	166,354,268.97	141,465,298.57	195,367,194.81	209,458,365.14	1,438,315,330.09
2021	201,435,932.35	221,152,323.25	207,369,789.25	214,125,987.36	200,158,978.84	190,000,789.27	177,259,374.69	174,597,125.28	102,654,369.21	101,141,125.39	106,021,215.02	112,601,665.07	2,008,518,674.98
2022	125,963,125.24	198,528,325.14	156,235,321.14	139,325,125.01	137,325,241.20	151,252,369.21	158,255,245.21	145,085,243.22	124,758,369.21	119,842,365.24	177,185,369.31	157,588,453.35	1,791,344,552.48
2023	135,369,125.24	120483528.27											255,852,653.51

Figure 19: Table of Land Use Charge Tax from the Year 2016 To 2023 (Source: Account Department, KSBLM).

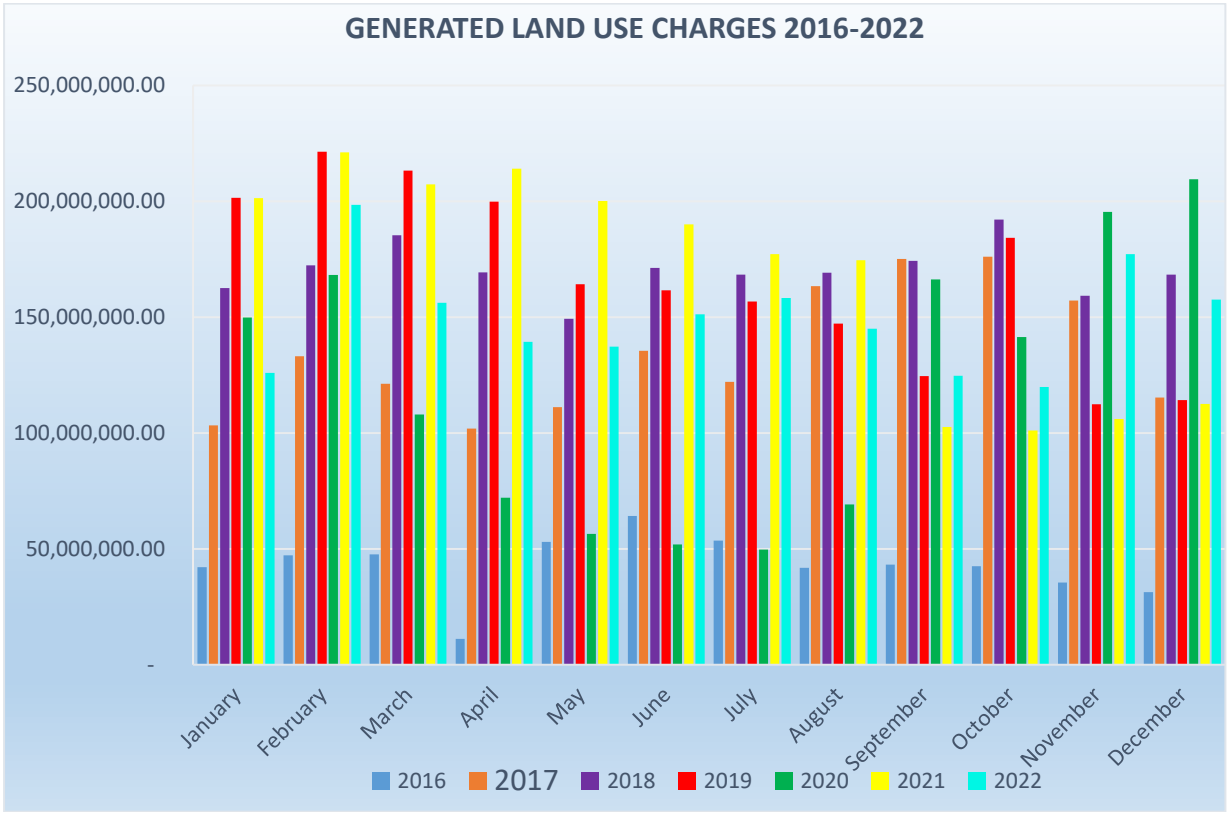


Figure 20: Statistical Chart of Monthly Land Use Charge Tax from the Year 2016 to 2022.

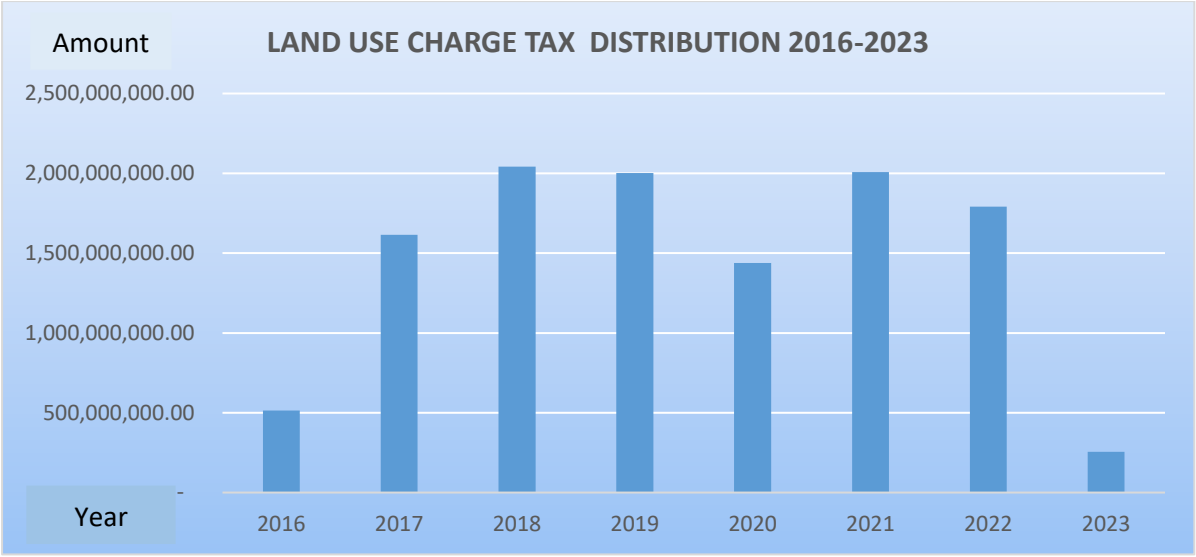


Figure 31: Statistical Chart of Annual Land Use Charge Tax from the Year 2016 to 2023.

4. CONCLUSIONS

This paper has significantly demonstrated the digital power of geospatial tools in the conversion and processing of cadastral survey records for the automation of Land use tax generation in Kano state, Nigeria, and the same technique can be applied anywhere as far land use tax generation is concerned. The technology shows an upward inflow of land revenue generation from the year 2017 to 2023 while the year 2016 was used as a benchmark to show the magnitude of revenue generation before the start of this automation technique. This also shows the rise in revenue generation from five hundred million nairas to about two billion naira which represents a 400% increment from 2016 to 2023 respectively. The technique has proven to be a very fast, efficient, and reliable method for the computation of all land-related taxes using complex mathematical algorithms embedded in the python programming language. It provided a mechanism for updates as well as storage of land use rates as domain attributes in the ArcGIS platform. The technology also eliminated the difficulty in the identification of properties at their various locations for issuance of demand notices via the map/template.

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