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STREAMLINING LEGACY LAND LAYOUT PLAN USING COMPUTER-AIDED SURVEYING OF GUNKI LAYOUT IN NASARAWA LGA, NASARAWA STATE

Yusuf Umar[1]*, Musa Ibrahim[1], Waheed Adeyemi[1], Odo Ejike kizito[2]

[1]Department of Surveying and Geoinformatics, Federal Polytechnic Nasarawa, Nasarawa state Nigeria.
[2]Department of Geography, Federal University of Technology Minna, Niger State Nigeria.

*Corresponding author: *Email:* umaryusuf49@gmail.com, *Phone:* +2348039508010

ABSTRACT

The integration of computer technology and software in various aspects of land surveying provides surveyors with tools to enhance efficiency, accuracy, and productivity in their workflow. Land surveyors routinely engage in the complex process of managing land layouts, especially when traditional, non-digital methods are employed. This paper aims to streamlining the workflow for developing a legacy land layout using Computer-Aided Surveying (CAS) technologies. It demonstrates how CAS can be utilized for Site Selection, Layout Perimeter Plotting, Georeferencing, Parcel Digitization, Integration with GIS Database, Plot Area Calculation, Survey Data Extraction, and Topographic Map Generation. To realize this aim, the study utilized an old survey layout plan of Gunki that was manually produced in the 90s that covers an area of 185793.57m^2 (18.58 Ha). AutoCAD, QGIS and Surfer were the software used in preparing the survey data while ProMark™ 800 Differential Global Positioning System (DGPS) was used in staking out the layout plan. A total of one hundred and eighty-five (185) plots of land covering an area of 195260.26m^2 (19.53Ha) were identified and processed. 95% were identified as residential parcels/plots while the remaining 5% makes up of commercial, industrial and recreational plots. This paper establishes the effectiveness of CAS technology in modernizing and implementing a legacy layout plan for land development in Nasarawa LGA. The methodology outlined can be replicated across various regions facing similar challenges with outdated land-use plans.

Keywords: Computer-Aided Surveying, Land Layout, Land Development, Land Surveying, layout plan, Computer Technology.

INTRODUCTION

Land is the aspect which covers the totality of the environment and it's fundamental to man's survival (Oseni and Ebeh, 2020). Land is one of the most important possessions of mankind which a country could also use as its asset. Without land, there can be no place called Nasarawa. Then, the wealth of every nation and its economic development are dependent on the state of the land and its usage. The availability of this land in Nasarawa makes it possible for various layout to be executed for proper usage and generation of funds which may depends on sales of the land since it was planned and tax collection. It became apparent for us to develop our land using some lay down legacy to achieve valuable information concerning financial investment, trade, industry and agriculture.

Over the years, the manual or traditional surveying method of data handling has dominated land layout planning and management in a disordered manner among various land authorities within the state. Ajayi et al. (2021) stated that manual approach to cadastral survey data processing is not only rigid, cumbersome, and time consuming but also prone to computational errors. Obviously that traditional surveying method of handling information on land layout development can no longer cope with the increasing demand and requirements of users of such information. Hence there is a need for a contemporary system of managing land layout information typically used by local governments and even state governments. General and developmental project activity in particular, are associated with land and land transaction. Therefore, for planning purpose all land-associated information should be available in the form of a computer database, which can be easily accessed, manipulated by decision makers while formulating and executing a work.

Computer-aided surveying, also known as computer-aided design (CAD) surveying or digital surveying (Wang, 2020), is the use of computer software and technology to aid in the surveying process. This approach enhances the efficiency, accuracy, and visualization of survey data, allowing for electronic data collection and storage (Singh, 2019), automated calculations and analysis (Al-Bayari, 2017), creation of detailed digital maps and plans, 3D modeling and visualization, integration with Geographic Information Systems (GIS) and real-time data sharing and collaboration.

A "Legacy land layout plan" refers to a map or document outlining the existing layout and boundaries of a particular land area, often created in the past using traditional surveying methods (Lai and Davies, 2020). These plans are considered "legacy" because they represent the historical development or division of the land. Some key characteristics of legacy land layout plans are (1) Age; they are typically created many years ago. (2) Format; they might be hand-drawn paper documents or maps. (3) Accuracy; they might not have the same level of precision as modern computer-aided surveying (CAS) techniques. (4) Accessibility; they can be difficult to access or interpret due to their format or lack of digital copies. (5) Completeness; They might be missing details or have inconsistencies due to changes in ownership, development, or record-keeping practices over time.

We proposed the use of computer-aided surveying (CAS) to streamline the development of a legacy land layout plan for Gunki Layout in Nasarawa LGA, Nasarawa State. Legacy land layout plans, often created manually, can be outdated, inaccurate, or difficult to interpret. This can lead to inefficiencies and challenges in land management, development, and dispute resolution. Computer-aided surveying offers a solution by utilizing digital tools and technologies for surveying and map creation.

This paper establishes the effectiveness of CAS technology in modernizing and implementing a legacy layout plan for land development in Nasarawa LGA. The methodology outlined can be replicated across various regions facing similar challenges with outdated land-use plans. The developed layout can form a reform program for Nasarawa local government area and the entire country.

MATERIALS AND METHODS

Study Area

Geographic coordinates of Gunki are Latitude 08°35'01.6"N and Longitude 07°44'43.7"E. Gunki is a village located in the region of Nassarawa LGA in Nasarawa state. Nassarawa state's capital (Lafia) is approximately 85km away from Gunki (as the crow flies). The distance from Gunki to Nigeria's capital (Abuja) is approximately 59km (as the crow flies). Six prominent places found within 5 km around Gunki include Kemu, Tammah, Ugi Majowel, Marmara, Adakwu and Gidan-Biri.

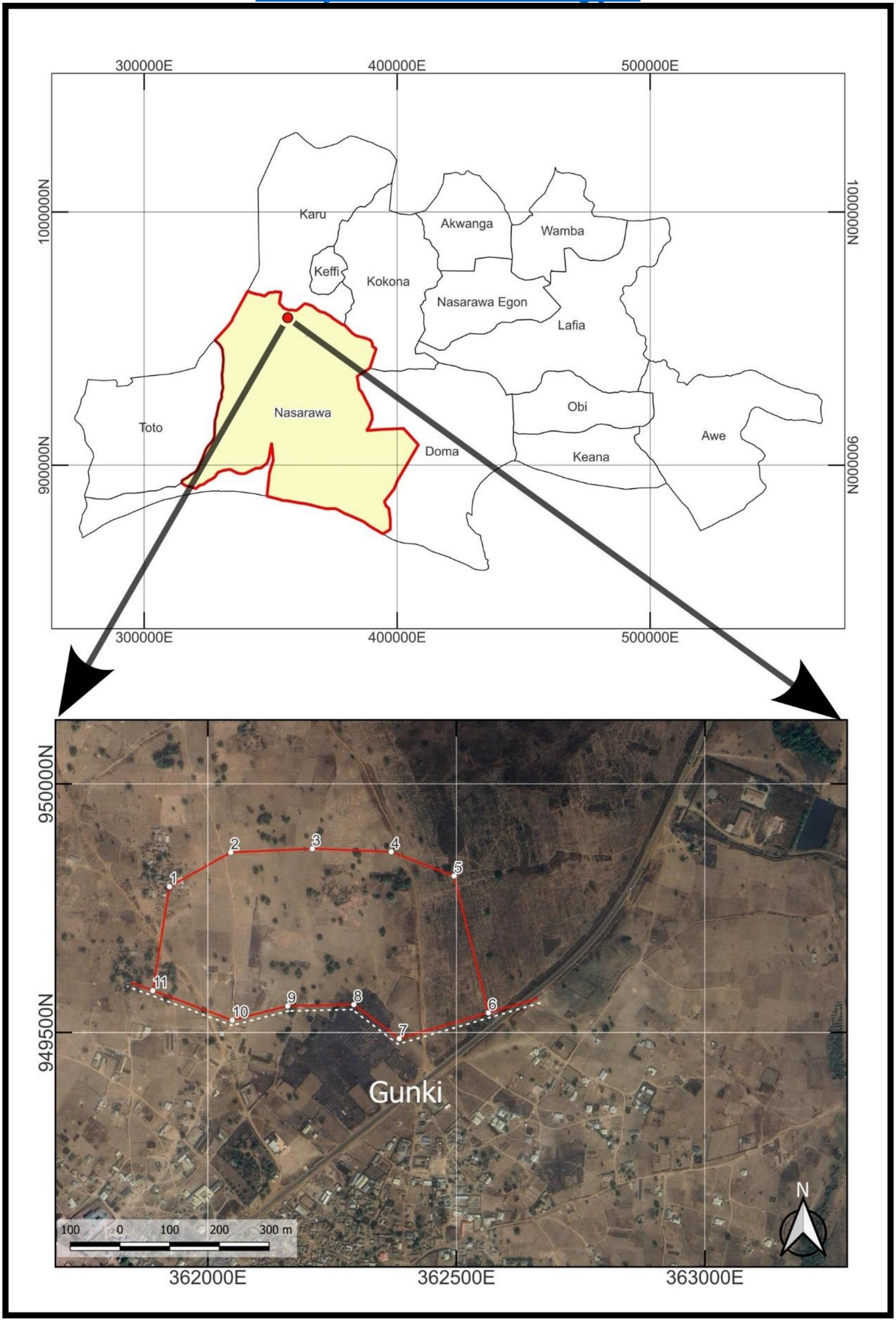

Figure 1: Map of the Study Area (Source: Authors' work)

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Data Acquisition

Data for this study were collected through secondary sources. The old layout plan was from the "Nasarawa Urban Development Board (NUDB)", Nasarawa LGA, Nasarawa state and the digital elevation model was sourced from OpenTopography.org.

The layout plan was produced in the early 1990s by NUDB. Upon requesting a copy, we were granted access to a scanned copy for utilization in this study (Figure 2). The plan has no georeferenced coordinates, so we relied on the bearings and distances for plotting, georeferencing and digitizing the layout plan.

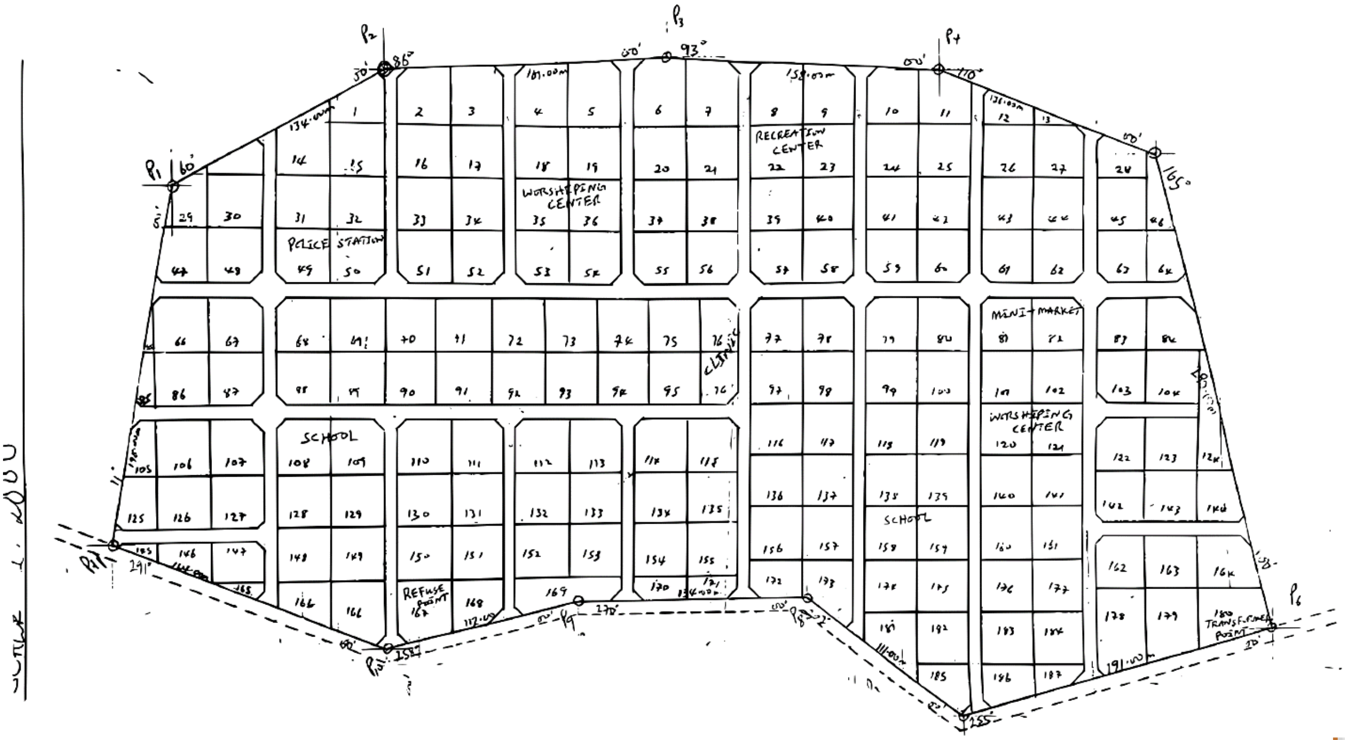

Figure 2: The legacy layout plan used for this study (Source: NUDB).

The layout consists of one hundred and eighty-five (185) plots with access roads within the layout and it covers an area of 195260.26m^2 (19.53Ha). Not all the land parcels/plots were meant for residential (Table 1), few percentages were air marked for other land uses.

Table 1: Percentage land use of the layout plots

S/N	Purpose	Number of Plots	%
1.	Clinic	2	0.5
2.	Market	2	0.5
3.	Police Station	2	0.5
4.	Recreation Center	2	0.5

5.	Refuse Point	2	0.5
6.	Residential	166	95
7.	School	4	1
8.	Transformer Point	1	0
9.	Worshiping Center	4	1

The software we used were AutoCAD, QGIS and Surfer. They all played different roles at different phases of the research work as detailed on 'Table 2' below. Though, some are capable of playing multiple roles depending on user's preference.

Table 2: List of software used in this study

S/N	Software	Version	Purpose/Role
1.	AutoCAD	2021	Layout Perimeter Plotting, Georeferencing Parcel, Digitization, Plot Area Calculation, Survey Data Extraction
2.	QGIS	3.36.3 'Maidenhead'	Site Selection, Georeferencing Parcel, Digitization, Integration with GIS Database, Plot Area Calculation, Survey Data Extraction
3.	Surfer	16	Topographic Map Generation

Data Processing Procedure

The workflow chart (Figure 3) shows the streamlined procedures we employed to realize the aim and objectives of this study.

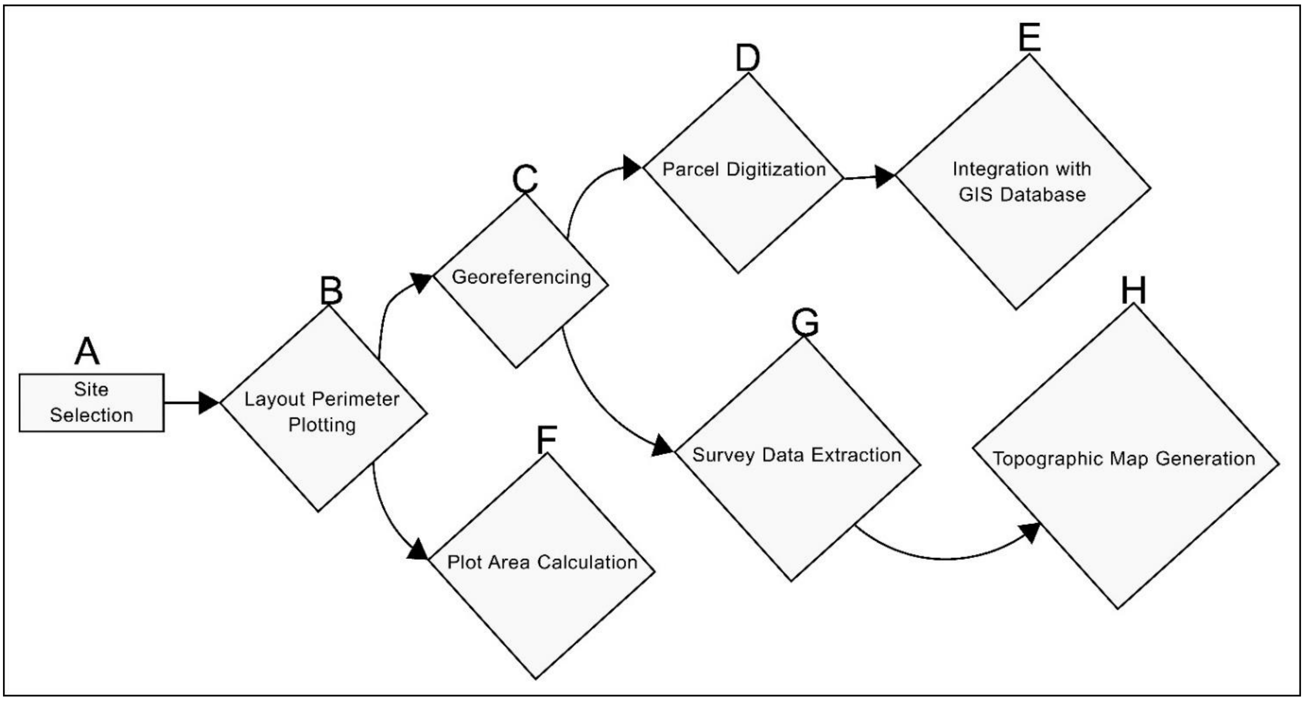

Figure 3: Flow chart methodology (Source: Authors' work)

The workflow starts with 'Site Selection' (A), where we located a suitable unallocated or vacant land to position the layout plan by considering accessibility to the express roadway as a paramount factor. This is followed by 'Layout Perimeter Plotting' (B), which defines the layout boundaries on the area of interest. 'Georeferencing' (C) is then performed to establish the precise location of the plotted perimeter on a real-world coordinate system. Based on the georeferenced data, we then carried out 'Parcel Digitization' (D) which involves creating digital representations of individual plots within the layout. The digitized parcels are then Integrated with a 'GIS Database' (E) for further analysis and management.

In parallel with georeferencing, 'Plot Area Calculation' (F) can be done to determine the size of each plot. 'Survey Data Extraction' (G) to retrieve additional survey information associated with the site was the next phase. Then finally, all the collected and processed information (parcel data, area calculations, potentially survey data) was used to generate a 'Topographic Map' (H) that visually represents the layout and its features.

Upon successful site selection, we obtained a coordinate for the first beacon point (location where we wanted use as starting point for the perimeter and subsequently the control point) then we used it to prepare an AutoCAD script that plots the perimeter of the layout plan as presented in the figure 4 below. The script is composed of AutoCAD commands and the bearings and distances extracted from the legacy layout plan obtained from NUDB.

Table 3: Survey data that makes the perimeter

S/N	Beacon From-To	Distance	Bearing
1	P1-P2	134.00m	60° 00' 00"
2	P2-P3	161.00m	86° 00' 00"
3	P3-P4	158.00m	93° 00' 00"
4	P4-P5	136.00m	110° 00' 00"
5	P5-P6	280.00m	165° 00' 00"
6	P6-P7	191.00m	255° 00' 00"
7	P7-P8	111.00m	302° 00' 00"
8	P8-P9	134.00m	270° 00' 00"
9	P9-P10	112.00m	258° 00' 00"
10	P10-P11	164.00m	291° 00' 00"
11	P11-P1	198.00m	11° 00' 00"

```
LINE
361922.77,949793.27
@134.00<60d00'00"
@161.00<86d00'00"
@158.00<93d00'00"
```

```
@136.00<110d00'00"
@280.00<165d00'00"
@191.00<255d00'00"
@111.00<302d00'00"
@134.00<270d00'00"
@112.00<258d00'00"
@164.00<291d00'00"
@198.00<11d00'00"
CLOSE
```

Figure 4: AutoCAD Script to plot the layout perimeter (Source: Authors' work)

The perimeter was composed of eleven (11) points. We re-established the first two to serve as the layout's control points.

Furthermore, the coordinates of other beacon points that makes up the boundary were extracted using AutoCAD 'LIST' command (Figure 5). The coordinates were then prepared in a script (.src extension) file to label the points in this format "*_Text Eastings,Northings TextSize, TextOrientation (90°), and PillarNo*" (Chiemelu and Onwumere, 2013).

```
Command: LIST
11 found

                  POINT     Layer: "Perimeter"
                            Space: Model space
                   Handle = 7ed
                at point, X=361922.77  Y=949793.27  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
                   Handle = 7ee
                at point, X=362045.99  Y=949862.03  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
Press ENTER to continue:
                   Handle = 7ef
                at point, X=362210.17  Y=949869.63  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
                   Handle = 7f0
                at point, X=362369.01  Y=949863.28  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
                   Handle = 7f1
                at point, X=362495.35  Y=949814.73  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
                   Handle = 7f2
                at point, X=362564.40  Y=949539.63  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
                   Handle = 7f3
                at point, X=362385.03  Y=949487.61  Z=     0.00

                  POINT     Layer: "Perimeter"
                            Space: Model space
```

```
                  Handle = 7f4
               at point, X=362293.61  Y=949556.11  Z=     0.00

Press ENTER to continue:
                 POINT     Layer: "Perimeter"
                           Space: Model space
                  Handle = 7f5
               at point, X=362160.59  Y=949553.22  Z=     0.00

                 POINT     Layer: "Perimeter"
                           Space: Model space
                  Handle = 7f6
               at point, X=362049.01  Y=949524.81  Z=     0.00

                 POINT     Layer: "Perimeter"
                           Space: Model space
                  Handle = 7f7
               at point, X=361889.22  Y=949584.26  Z=     0.00
```

```
PointLabel.scr - Notepad
File  Edit  Format  View  Help
_TEXT 361922.77,949793.27 10 90 PA1
_TEXT 362045.99,949862.03 10 90 PA2
_TEXT 362210.17,949869.63 10 90 PA3
_TEXT 362369.01,949863.28 10 90 PA4
_TEXT 362495.35,949814.73 10 90 PA5
_TEXT 362564.40,949539.63 10 90 PA6
_TEXT 362385.03,949487.61 10 90 PA7
_TEXT 362293.61,949556.11 10 90 PA8
_TEXT 362160.59,949553.22 10 90 PA9
_TEXT 362049.01,949524.81 10 90 PA10
_TEXT 361889.22,949584.26 10 90 PA11
```

Figure 5: AutoCAD 'LIST' command that displays the boundary coordinates (Source: Authors' work)

The scanned layout plan (Figure 2) was then georeferenced and all its feature were digitized in AutoCAD. Then the final digitized layout plan (Figure 6) was then exported into DXF file format for import into QGIS environment so it can be integrated with a spatial database.

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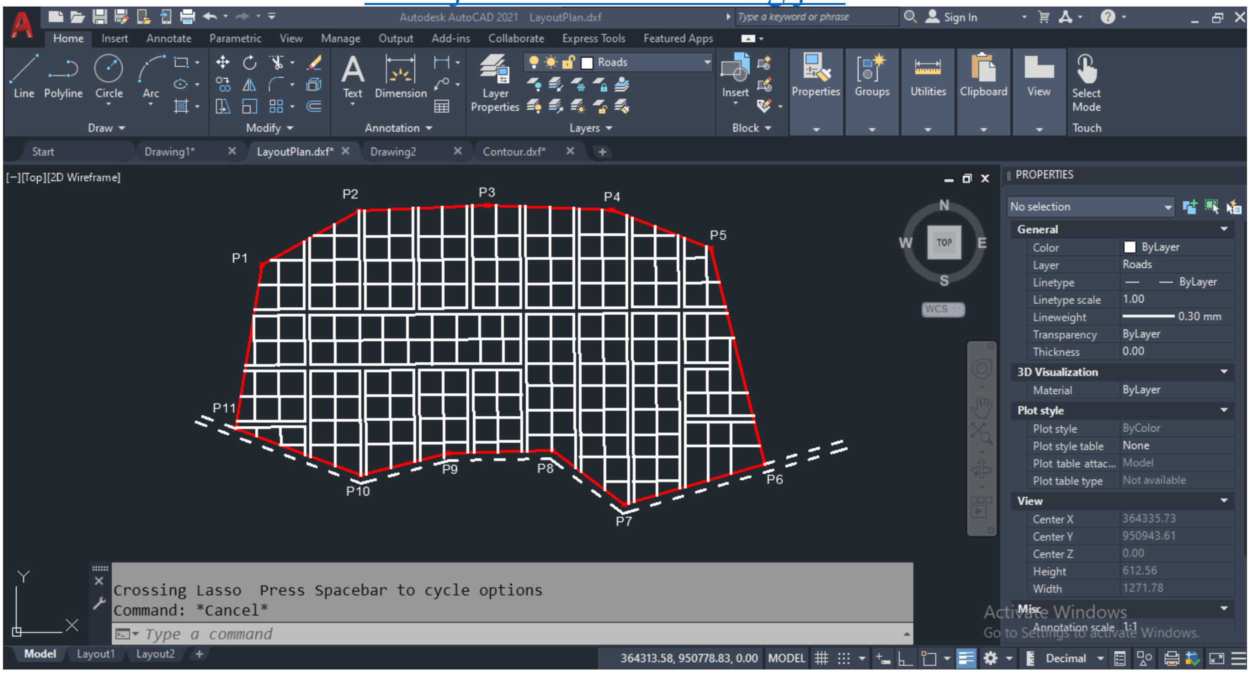


Figure 5: Final digitized layout in AutoCAD (Source: Authors' work)

Next, we used QGIS to integrate the resulting AutoCAD drawing into SQLite/Spatial Lite database where an attribute field for area calculation was created and other parcel data where extracted (Raza et al., 2017). On the database we were able to perform several attributes and spatial queries.

With the layout integrated into a database, we used the area function to calculate the area of each plot. The plot with the least (minimum) area size was 409.045m^2 (0.041Ha) and the maximum area was 1520.409m^2 (0.152Ha).

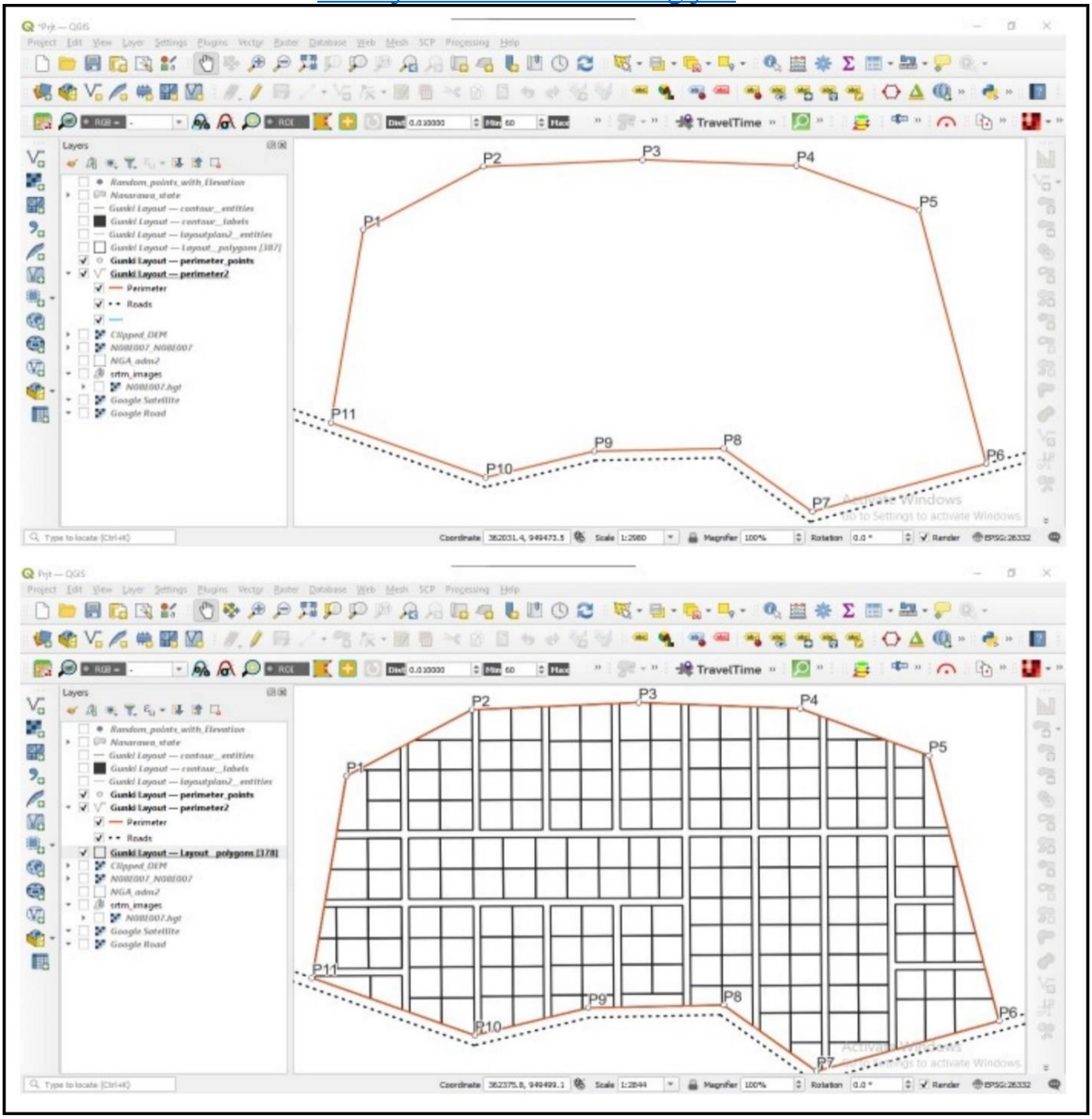


Figure 5: Layout Perimeter and parcels in QGIS Spatial Database (Source: Authors' work)

To generate the topographical map of that area, we downloaded a 30m resolution digital elevation model (DEM) that covers the area. Then generated 500 random spot point that covers the layout area to extract elevation values from the DEM. From the extracted elevations, Surfer software was then used to generate the contour lines at one meter (1m) interval (Figure 5). Ali, (2024) reviewed that a topographic map is one of the most often utilized maps and accurately depicts the geographical characteristics of an area, such as rivers, lakes, paths, railways, power lines, elevations, and contours. A topographic survey is the means of producing a topographic map and the preparation of topographic map can be done by means of theodolite, aerial photography, Total Station, GNSS etcetera (Okwuenu et al., 2024).

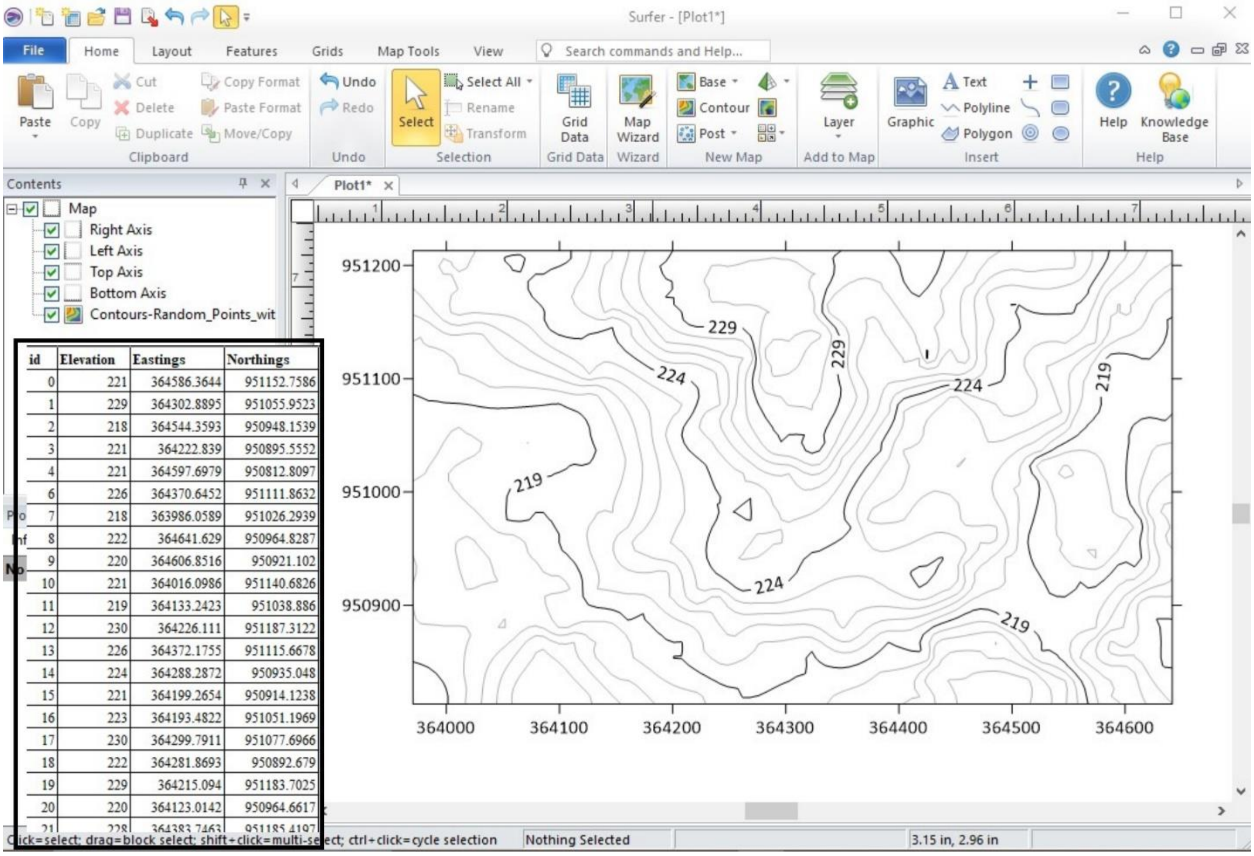


Figure 5: Surfer software showing the worksheet and the contour plot (Source: Authors' work)

The resulting contour map in Surfer software was imported back into AutoCAD and QGIS for further analysis and integration.

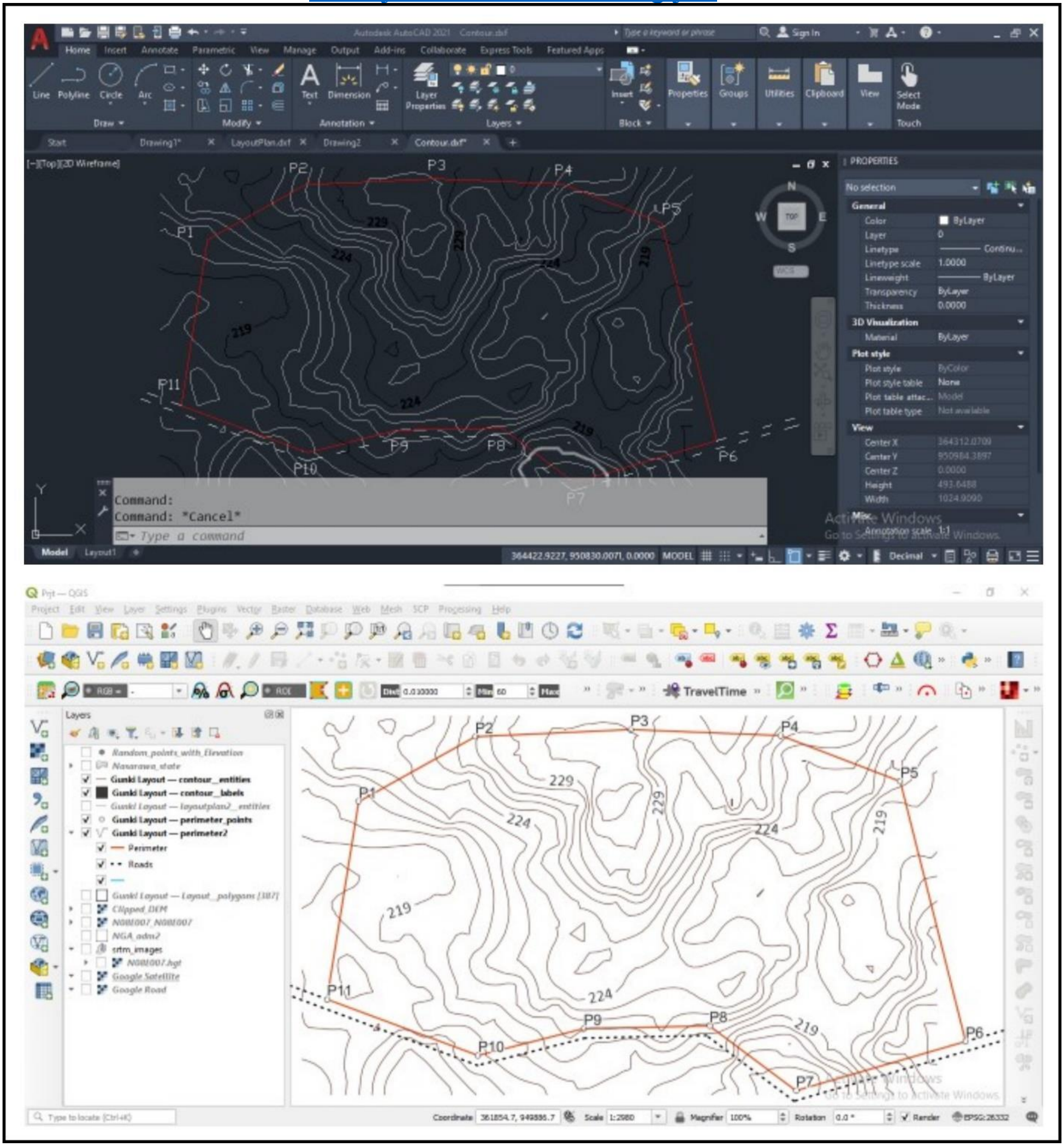


Figure 6: Contour lines integrated into AutoCAD and QGIS (Source: Authors' work)

RESULTS AND DISCUSSION

This study demonstrated the effectiveness of CAS technology in modernizing and implementing the Gunki layout plan.

Digital layout plan

The legacy analogue layout was finally converted into a digital layout plan (Figure 7). Everything about the layout plan is in a GIS database which offers several benefits to surveyors, improving efficiency, accuracy, and productivity in various aspects of surveying work.

Land uses of the layout

On the old layout plan, some plots where air marked for different land uses including residential, clinic, market, police station, recreation center, refuse point, school, transformer point and worshiping center. Our result clearly captured all the land uses in the CAD workflow (Figure 8).

Area variation of the layout

A choropleth plan of the layout area was presented with five categories as follows 0.041Ha to 0.0632Ha as Extra Small, 0.0632Ha to 0.0854Ha as Small, 0.0854Ha to 0.1076Ha as Medium, 0.1076Ha to 0.1298Ha as Large, and 0.1298Ha to 0.152Ha Extra Large. The result indicates that the plots with larger areas (Figure 8) are those that boarders the layout perimeter due to the irregular shape of the boundaries.

Parcel Site Plan and Survey Data

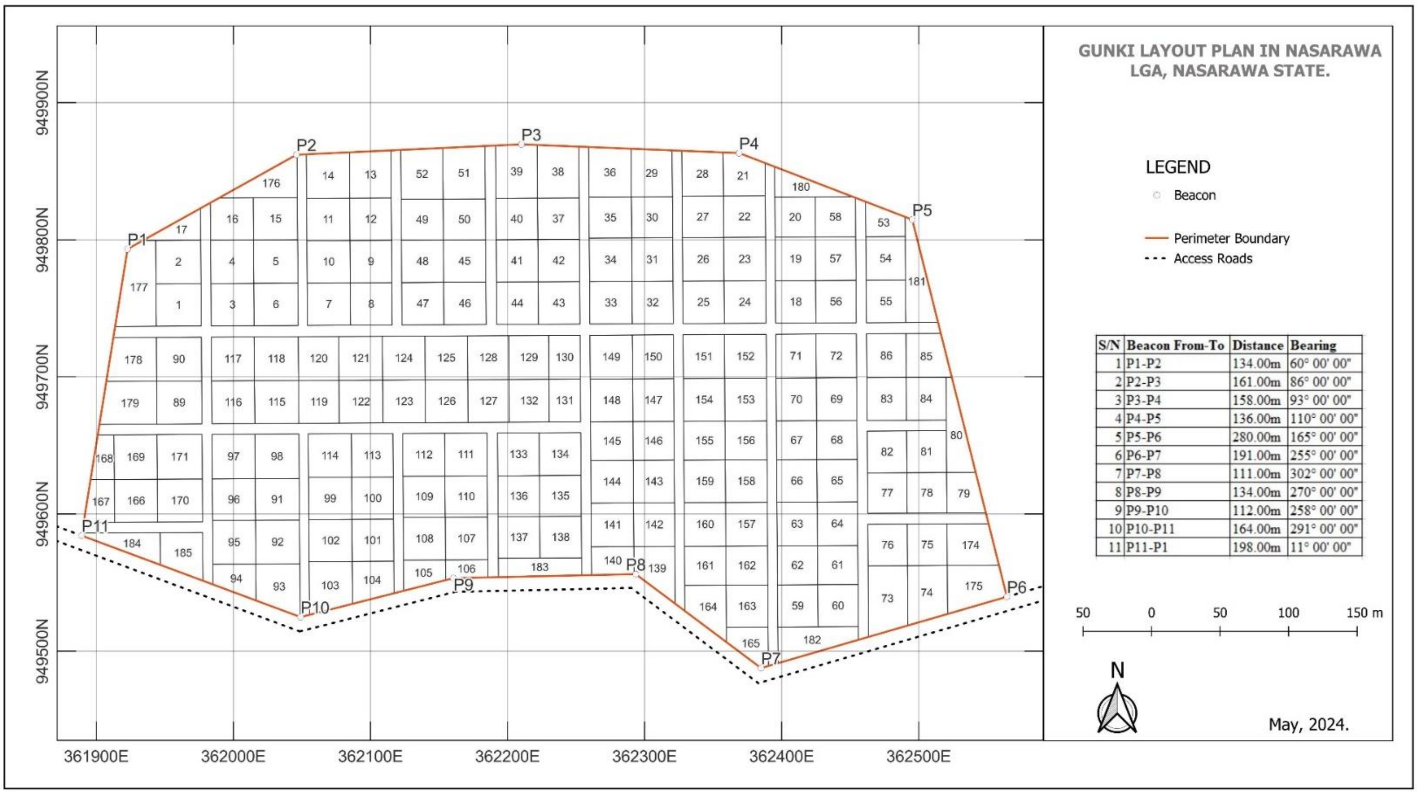
Each of the plots will have its site plan and survey data (Figure 10). Adopted from Tereşneu and Tereşneu, (2023), table 4 below shows the survey data for plot number one. This data can be used together with a digital Differential Global Positioning System (DGPS) instrument such as ProMark™ 800 to establish the position of the parcel/plot on the ground.

Table 4: Survey data for plot with ID number one

fid	Purpose	Area (Ha)	Area (Sq M)	Plot_IDs	Easting	Northing	Distance (m)	Bearing
1	Residential	0.102	1016.251	1	361976.346	949768.077	0	314° 39' 40.43"
2	Residential	0.102	1016.251	1	361943.518	949767.913	32.829	224° 39' 40.43"
3	Residential	0.102	1016.251	1	361943.729	949736.967	63.775	134° 39' 40.43"
4	Residential	0.102	1016.251	1	361976.557	949737.132	96.603	44° 39' 40.43"
5	Residential	0.102	1016.251	1	361976.346	949768.077	127.55	314° 39' 40.43"

The site plan of plot one and some selected others are presented in figure 11 to figure 14.

Figure 7: Gunki Digital Layout Plan (Source: Authors' work)



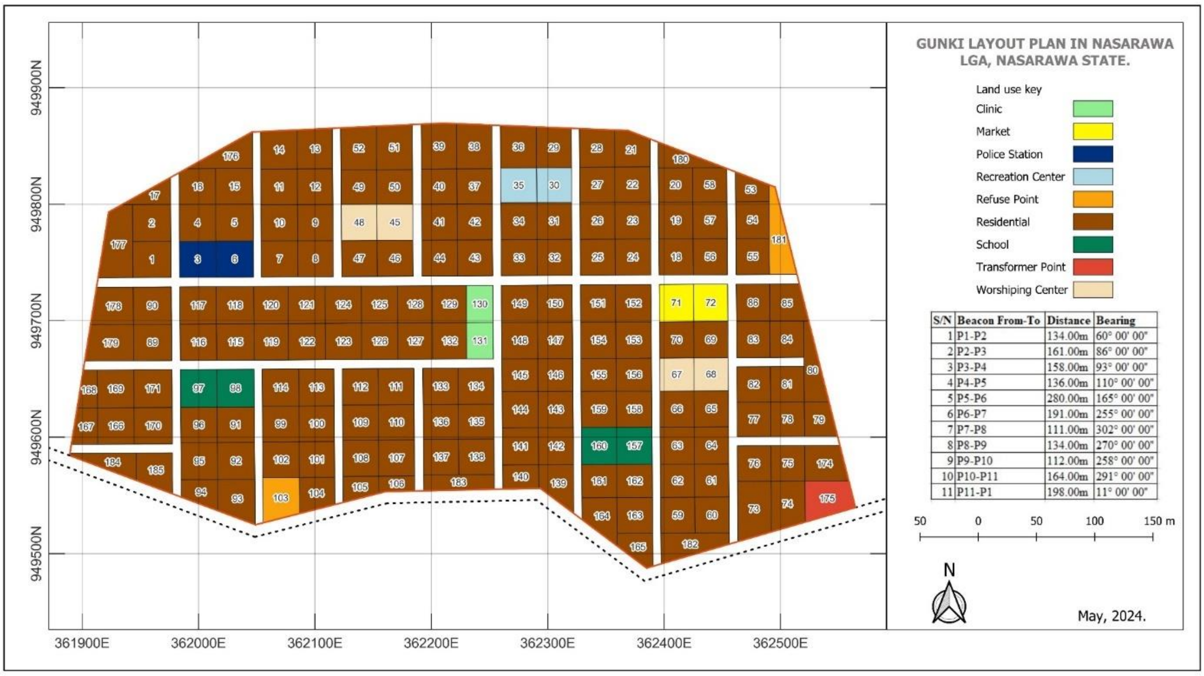


Figure 8: Land use plan of the layout (Source: Authors' work)

Figure 9: Area variability of the layout plan (Source: Authors' work)

Gunki Layout — Survey__Data — Features Total: 993, Filtered: 993, Selected: 0

	fid	fidnew	Purpose	Area (Ha)	Area (Sq M)	Purpose_2	Plot_IDs	distance	angle	easting	northing	distance (m)	bearing
1	1	1	Residential	0.102	1016.251	Residential	1	0	314.66122966...	361976.346	949768.077	0	314° 39' 40.43"
2	2	1	Residential	0.102	1016.251	Residential	1	32.82853340517596	224.66122966...	361943.518	949767.913	32.829	224° 39' 40.43"
3	3	1	Residential	0.102	1016.251	Residential	1	63.77475153487866	134.66122966...	361943.729	949736.967	63.775	134° 39' 40.43"
4	4	1	Residential	0.102	1016.251	Residential	1	96.6032849402886	44.661229668...	361976.557	949737.132	96.603	44° 39' 40.43"
5	5	1	Residential	0.102	1016.251	Residential	1	127.54950306976004	314.66122966...	361976.346	949768.077	127.55	314° 39' 40.43"
6	6	2	Residential	0.104	1040.746	Residential	2	0	314.66122966...	361976.13	949799.769	0	314° 39' 40.43"
7	7	2	Residential	0.104	1040.746	Residential	2	32.82853340517713	224.66122966...	361943.302	949799.604	32.829	224° 39' 40.43"
8	8	2	Residential	0.104	1040.746	Residential	2	64.52066993972642	134.66122966...	361943.518	949767.913	64.521	134° 39' 40.43"
9	9	2	Residential	0.104	1040.746	Residential	2	97.34920334490238	44.661229669...	361976.346	949768.077	97.349	44° 39' 40.43"
10	10	2	Residential	0.104	1040.746	Residential	2	129.0413398796845	314.66122966...	361976.13	949799.769	129.041	314° 39' 40.43"
11	11	3	Police Station	0.097	968.413	Police Station	3	0	314.66122966...	362014.907	949768.271	0	314° 39' 40.43"
12	12	3	Police Station	0.097	968.413	Police Station	3	31.28318528879698	224.66122966...	361983.624	949768.114	31.283	224° 39' 40.43"
13	13	3	Police Station	0.097	968.413	Police Station	3	62.22940341849968	134.66122966...	361983.835	949737.168	62.229	134° 39' 40.43"
14	14	3	Police Station	0.097	968.413	Police Station	3	93.51258870741422	44.661229669...	362015.118	949737.325	93.513	44° 39' 40.43"
15	15	3	Police Station	0.097	968.413	Police Station	3	124.45880683688488	314.66122966...	362014.907	949768.271	124.459	314° 39' 40.43"
16	16	4	Residential	0.099	991.755	Residential	4	0	314.66122966...	362014.691	949799.962	0	314° 39' 40.43"
17	17	4	Residential	0.099	991.755	Residential	4	31.28318528891514	224.66122966...	361983.408	949799.805	31.283	224° 39' 40.43"
18	18	4	Residential	0.099	991.755	Residential	4	62.97532182323242	134.66122966...	361983.624	949768.114	62.975	134° 39' 40.43"
19	19	4	Residential	0.099	991.755	Residential	4	94.25850711202938	44.661229669...	362014.907	949768.271	94.259	44° 39' 40.43"
20	20	4	Residential	0.099	991.755	Residential	4	125.95064364669508	314.66122966...	362014.691	949799.962	125.951	314° 39' 40.43"

Show All Features

Figure 10: Layout Survey Data (Source: Authors' work)

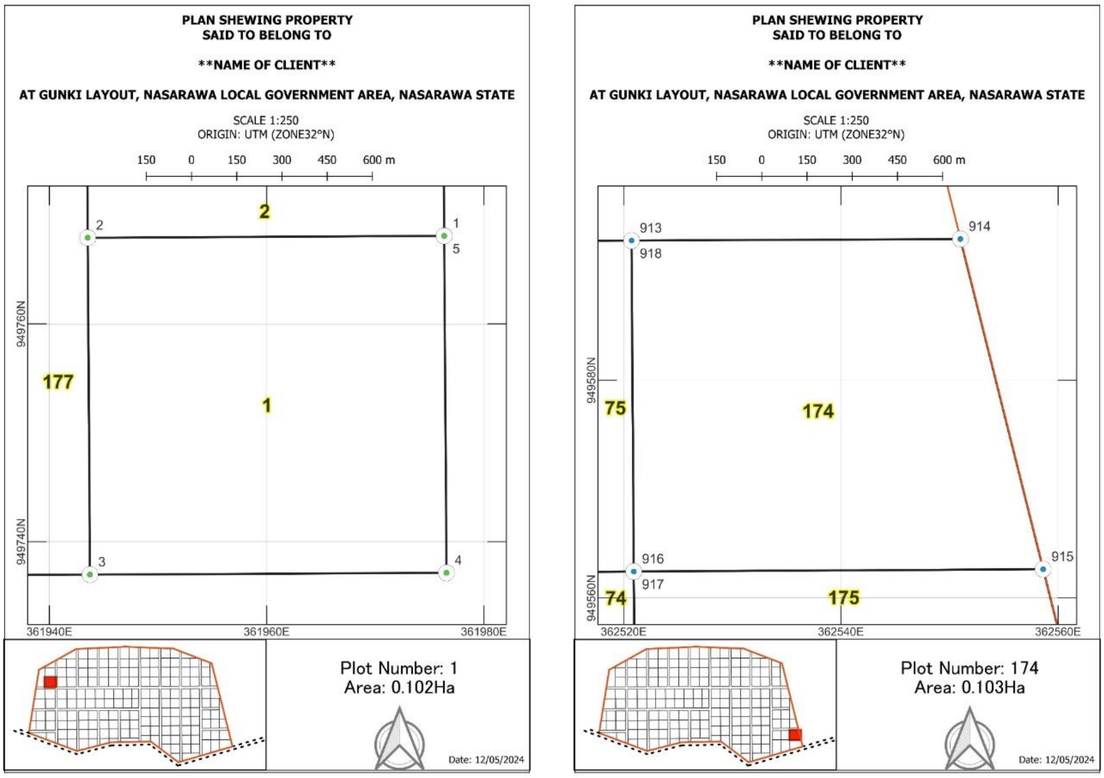


Figure 11: Site Plan of plot number 1 and 174

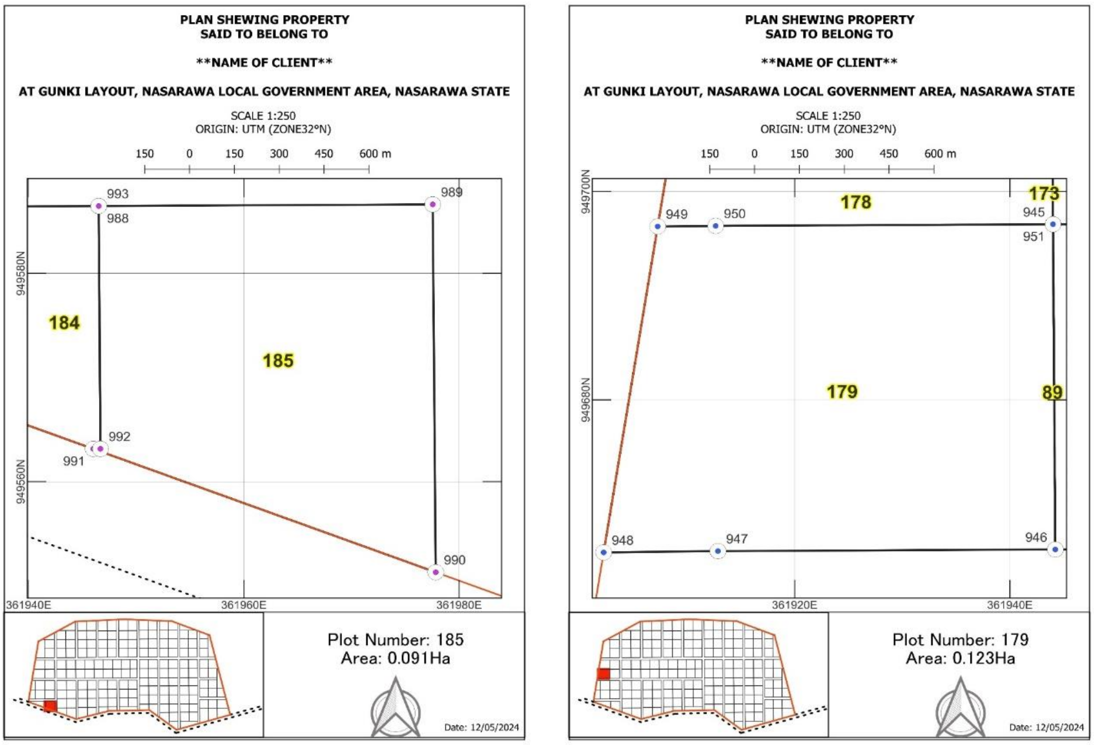


Figure 12: Site Plan of plot number 185 and 179

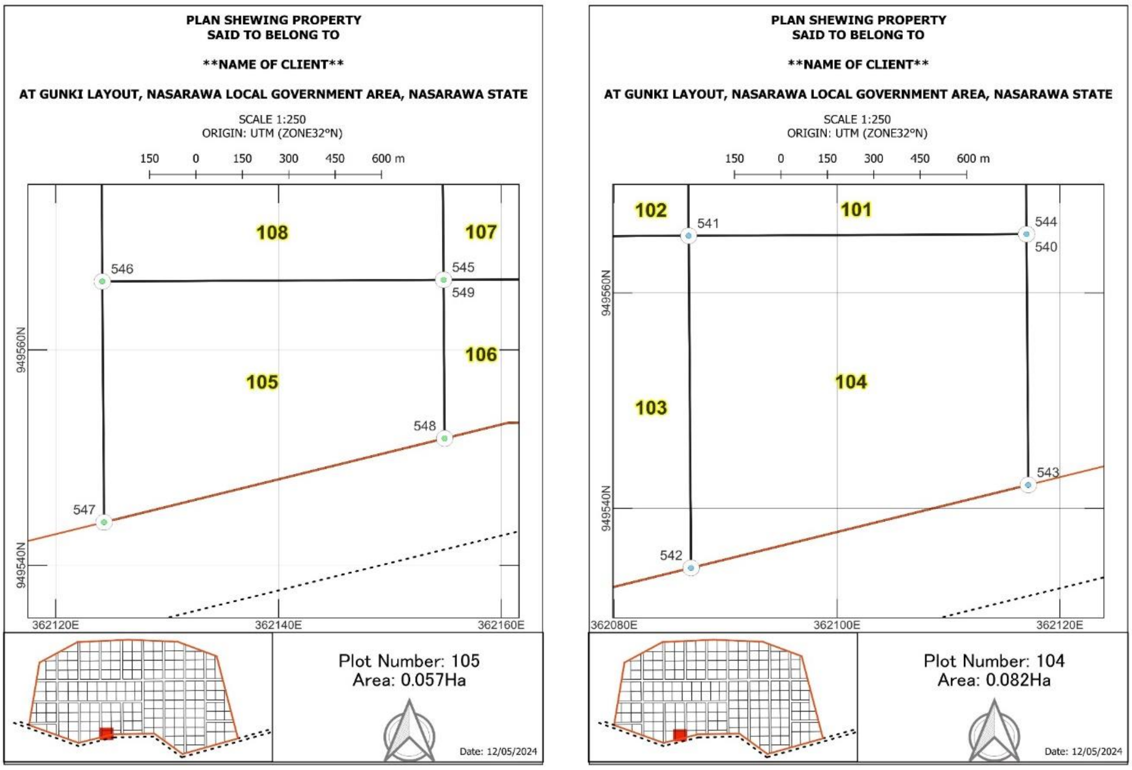


Figure 13: Site Plan of plot number 105 and 104

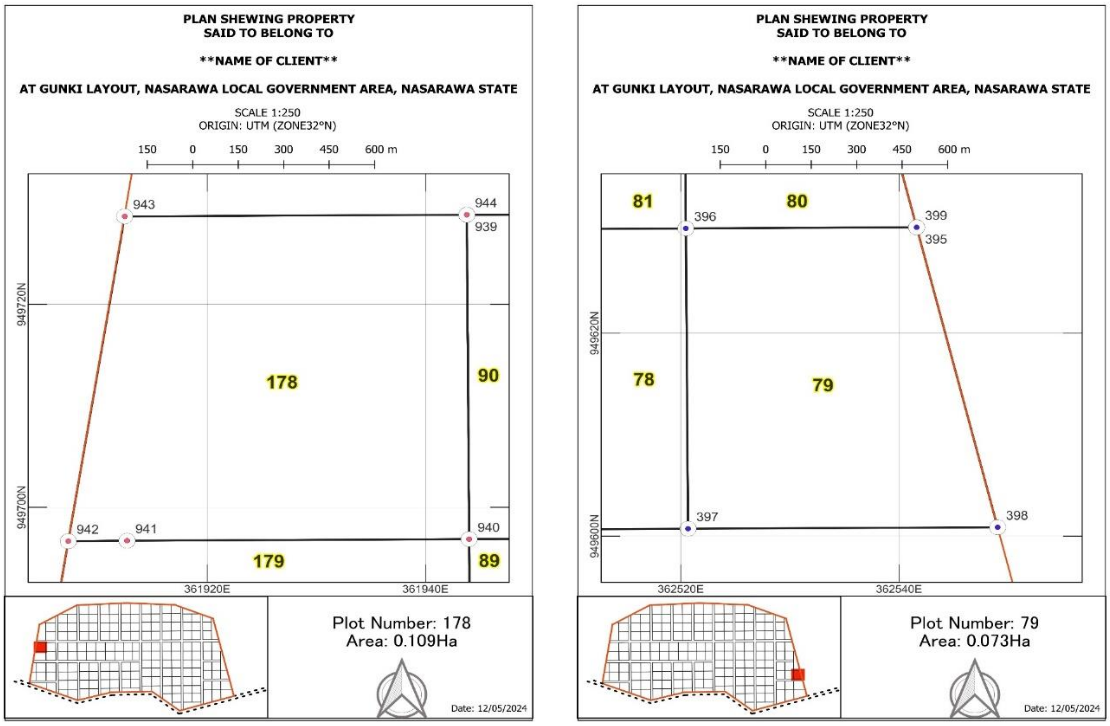


Figure 14: Site Plan of plot number 178 and 79

CONCLUSION

Using Gunki Layout, Nasarawa LGA, Nasarawa State, as the study area, the paper implemented computer-aided surveying (CAS) techniques to develop a digital land layout plan. The traditional manual surveying methods were compared with the CAS approach, highlighting the significant advantages offered by CAS.

Based on the successful application of CAS in Gunki Layout, the following recommendations are made for wider adoption:

a) Training programs and workshops should be organized to equip surveyors and land management professionals with the necessary skills and knowledge to utilize CAS effectively.
b) Standardized data collection and file formats for CAS-generated land layout plans should be established to ensure seamless integration with existing land management systems.
c) Collaboration between government agencies, professional surveying bodies, and private sector stakeholders is crucial to facilitate the widespread adoption of CAS and create a comprehensive digital land registry system.

Further research is recommended in the following areas:

a) Investigating the feasibility and benefits of cloud-based CAS solutions for increased accessibility and collaboration.
b) Researching the potential for automating repetitive tasks within the CAS workflow to further streamline the land layout plan development process.

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