CADASTRAL MAPPING USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM IN BANJIRAM, ADAMAWA STATE, NIGERIA

BY

Wulga Yuwomgi BULUS
(MSC/SCIE/1013/2010-2011)

THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN GIS AND REMOTE SENSING

JUNE, 2014

DECLARATION

I declare that the work in this thesis entitled "CADASTRAL MAPPING USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (GIS) IN NEW BANJIRAM, ADAMAWA STATE, NIGERIA" was conducted by me, it has not been presented in the department or anywhere for a degree. All quotations and source of information are duly acknowledged by means of references.

_____ _____

_____

Wulga Yuwomgi BULUS. Sign Date

CERTIFICATION

This thesis entitled "CADASTRAL MAPPING USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (GIS) IN NEW BANJIRAM, ADAMAWA STATE, NIGERIA", by Wulga Yuwomgi Bulus meets the regulations governing the award of the degree of Master of Science (GIS and Remote Sensing) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

Chairman, Supervisory Committee _____

_____

Dr. I. J. Musa Sign Date

Member, Supervisory Committee _____ _____

Dr. D. N. Jeb Sign Date

Head of Department _____ _____

Dr. I. J. Musa Sign Date

Dean, Postgraduate Studies _____ _____

Prof. A. A. Joshua Sign Date

DEDICATION

This work is dedicated to the Almighty God.

ACKNOWLEDGEMENTS

Overall gratitude to The Most High God! My profound gratitude goes to my team of supervisors: Dr I.J. Musa God Dr D.N Jeb for their selfless commitment and sacrifices to making sure that this work is accomplished. To them am really grateful. My appreciation goes to my course mate (Remote Sensing and GIS, 2010-2011 Class). I also wish to extend my appreciation to all the lecturers and staff of Geography Department for their contributions in the course of this study.

I sincerely appreciate the support of my family members towards the actualization of this work. I also want to acknowledge the contributions of Mr Sanda Dogara Tah whose contributions are too much to be quantified. Also, to Mr Sunday Richard Thlakma and Makena Wusa, I am really grateful.

ABSTRACT

Banjiram is one of the communities resettled in the year 1980 to make room for the construction of Kiri dam to supply the Savannah Sugar Company with water for Irrigation. As part of the resettlement program, the Federal Government then, cleared and surveyed an alternative location (now New Banjiram). A cadastral survey was carried out and plots were physically delineated on the ground with beacons at the corners of each plot. Land right were orally transmitted and the evidence of such land rights has been based on the knowledge of community elders and village chiefs. With increasing population and consequent competition for land, there has been prevailing tenure insecurity with its associated conflicts and litigations over land ownership. One of the most important documents: paper-based cadastral layout of the area containing delineated parcels has been lying the cabinet of the Adamawa state Ministry of Lands and Survey in a decaying state. This research is aimed at carrying out a cadastral mapping of Banjirm using Remote Sensing and GIS with a view to developing digital cadastral Information System which has the ability to integrate the map and the record of ownership and use. To achieve this, the cadastral layout of the study area was scanned and georeferenced in ArcGIS 10.1. Parcels were then digitally delineated (digitized) and given unique identification numbers. To obtain the textual component of the cadastre (land ownership and use information), a fieldwork was carried out to determine the existing land rights through a participatory process of adjudication. The adjudication involved visits to each parcel by a team comprising the researcher, a representative of the traditional heads and member of the Land owners union. To ease the process, a remotely-sensed imagery (Google Earth image) upon which the digitized parcels with unique numbers was overlaid was presented to land owners and witnesses (adjoining land owners) to visually identify their parcels and present their claims. A questionnaire (adjudication form) was used to record information on land owners and their parcels. A digital camera was also used to capture the passport photograph of each land owner. After the fieldwork, a cadastral database (containing the digital record of land owners and their parcels) was then designed and built using the information gathered. Analysis and testing of the efficiency of the database was then performed and a variety of results were generated. Major findings of this research include: (i) there were 1278 parcel with 1166 owner; (ii) about 1086 (84.977%) parcels were allocated while192 (15.023%) parcels were not allocated; (iii) there were 865 (67.762%) parcels that were developed while 413 (32.238%) parcels were not developed; (iv) out of the 1278 parcels: 758 (31.91%) were found to be used for residential purpose; 32 (20.016%) for institutional purpose; 11 (2.431) for commercial purpose; 158 (14.2%) for agricultural purpose and 301 (31.408%) for mixed uses.

TABLE OF CONTENTS

Title Page

..... i

Declaration

.....ii

Certification.

..... iii

Dedication

……..……iv

Acknowledgement

.....v

Abstract

.....vi

Table of content

.....vi

List of Figures

.....xii

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

1.2 1

1.3 Statement of the Research Problem

1.4 3

1.5 Aim and Objectives of the Study

1.6 5

1.7 Scope of the Study

1.8 5

1.9 Limitations

1.10 ……..……..……6

1.11 Justification and Significance of the Study

1.12 6

CHAPTER TWO: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

.....8

2.2 Concept of Land and Land Registration

……8

2.2.1 Land

.....8

2.2.2 Land Registration

.....8

2.2.3 Adjudication

.....9

2.2.4 The concept of Cadastre

.....10

2.2.4.1 Textual and graphical component of a cadastre

.....10

2.2.5 Land Recording

.....11

2.6 Land Tenure

.....12

2.7 Cadastral Mapping and Land Right

.....12

2.8 Land administration and cadastre in Nigeria

.....13

2.8.1 Land Right Management in Nigeria

.....14

2.8.2 Cadastral mapping and land registration in Nigeria

.....13

2.8.3 Cadastral mapping and land registration in Adamawa state

.....15

2.8.4 Reforms in land registration and cadastral mapping in Nigeria

.....15

2.9.5 The National Cadastral Mapping Programme

.....16

2.9 Geographic Information System and Remote Sensing

.....16

2.9.1 Components of GIS

.....17

2.9.1.1 People

.....17

2.9.1.2 Data

.....18

2.9.1.3 Hardware

.....18

2.9.1.4 GIS software

.....17

2.9.1.5 Procedures/Methods

.....18

2.10 Geodatabase/Geo-Spatial Database

.....19

2.11 Geographic Information System and Remote Sensing in Cadastral Mapping

.....19

2.12 Method Cadastral Mapping using GIS

.....20

2.12.1 Preparation of Cadastral Base Map

.....20

2.12.1.1 Manual Digitizing from Analogue Maps

.....21

2.12.1.2 Scanning

.....21

2.12.1.3 Automatic Vectorization

.....22

2.12.1.4 Heads-up Digitizing

.....23

2.12.1.5 Coordinate Geometry (COGO)

.....23

2.12.1.6 Positioning Property Corners with GPS

.....23

2.3 Literature Review

…….24

CHAPTER THREE: THE STUDY AREA AND METHODOLOGY

3.1 Introduction

.....26

3.2 The Study Area

.....26

3.2.1 Location

.....26

3.2.2 Historical Overview

.....26

3.2.3 Climate

.....29

3.2.4 Vegetation

.....29

3.2.5 Drainage

.....29

3.2.6 Culture

……..……29

3.3 Methodology

……30

3.3.1 Data and Sources

.....30

3.3.2 Hardware and Software.

.....30

3.3.3 Adjudication Material

.....31

3.3.4 Methods and Techniques of Data Collection

.....31

3.3.4.1 Spatial data collection

.....31

3.3.4.2 Attribute data collection

.....31

3.3.5 Determination of Existing Land Rights (Fieldwork): Adjudication

.....32

3.3.6 Data Processing

.....34

3.3.6.1 Scanning

.....34

3.3.6.2 Georeferencing

.....35

3.3.6.3 Digitising

.....35

3.3.7 Designing and Building a Cadastral Geodatabase

.....36

3.3.7.1 Conceptual design

.....36

3.3.7.2 Logical design

.....38

3.3.7.3 Physical design

.....39

3.3.7.4 Creating and Building of the Cadastral Database

.....41

3.3.7.5 Creation Attribute field, Domains and Population of attribute fields
……41

3. 4 Data Analysis

……...……41

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 Introduction
.....43
4.2 Analysis and Testing the efficiency of the Cadastral Database
.....43
4.2.1 Searching and displaying parcel(s) belonging to a particular owner using the parcel owner name
.....44
4.2.2 Displaying the photograph of the owner of a selected parce
l.....44

4.2.3 Identifying and displaying the personal data of the owner of a particular parcel using the identity tool.
.....45
4.2.4 Finding out the land title information of a land owner
.....46
4.2.5 Finding out parcel that are owned by female
.....47
4.2.6 Finding out parcels that are owned by civil servants
.....48
4.2.7 Finding out parcels that have not been allocated
.....48
4.2.8 Finding located along a particular street
.....50
4.2.9 Finding out parcels that are not developed
.....51
4.2.10 Finding out parcels whose size is <= 600m square
.....53
4.2.11 Finding out parcels whose size is >= 1000m square.
.....53
4.2.12 Finding out parcels that are used for a particular purpose.
.....53
4.2.12.1 Selecting parcels used for residential purpose
.....54
4.2.12.2 Selecting parcels used for commercial purpose
.....55
4.2.12.3 Selecting parcels used for institutional purpose
.....55
4.2.12.4 Selecting parcels used for agricultural purpose
.....56
4.2.12.5 Selecting parcels used for mixed purpose
.....57
4.3 Land use statistic of parcels in Banjiram
……57

4.2 Report Creation
……..…….60

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

.....63
5.2 Summary of the Study
.....63
5.3 Summary of Findings
.....63
5.4 Conclusions
.....64
5.5 Recommendations
……64
5.6 Recommendations for Future Research
.....65
References
.....66
Appendix
.....70

LIST OF TABLES

1.Table 3.1: Types and Sources of Data
.....30
2. Table 3.2: The software (ArcGIS) dependent physical model of geodatabase
…….....40
3. Table 4.1: Land use statistic of parcels in Banjiram
.....58

LIST OF FIGURES

1. Figure 2.1: The Cadastral Concept……10
2. Figure 3.1 Map of Guyul L.G.A. showing Banjiram……..……27
3. Figure 3.2 Map of Banjiram showing Plots (Land parcels)…….....28
4. Figure 3.3: A subset (part) of the indexed map (imagery) used during adjudication…....35
5. Figure 3.4: Scanned Banjiram layout.....32
6. Figure 3.5: The conceptual model of geodatabase.....37
7. Figure 3.6: The logical model of geodatabase.....38
8. Figure 4.1: Query result showing parcels belonging to a particular owner after searching using the owner name.....44
9. Figure 4.2: Query result showing parcels belonging to a particular owner and displaying owner photograph after searching using the owner name.....45
10. Figure 4.3: Result of using identify tool to display personal data of a parcel owner.....46
11. Figure 4.4: Result of using identify tool to display land title information of a parcel owner…… 47
12. Figure 4.5: Query result showing parcels belonging to female owners.....47
13. Figure 4.6: Graph of male and female land owner (%)…….48
14. Figure 4.7: Query result showing parcels owned by civil servants.....49
15. Figure 4.8: Graph of land owners' occupation (%)……...49

16. Figure 4.10: Query result showing parcels that are not allocated.....50

17. Figure 4.10: Graph of Land parcel allocation status (%)……..….50

18. Figure 4.11: Query result showing parcels located along a particular street.....51

19. Figure 4.12: Query result showing parcels that are not developed.....52

20. Figure 4.13: Graph of land development status (%)…….52

21. Figure 4.14: Query result showing parcels whose size is <= 600m square.....53

22. Figure 4.15: Query result showing parcels whose size is >= 1000m square.....54

23. Figure 4.16: Query result showing parcels that are used for a residential purpose……..54

24. Figure 4.17: Query result showing parcels that are used for a commercial purpose.....55

25. Figure 4.18: Query result showing parcels that are used for institutional purpose.....56

26. Figure 4.19: Query result showing parcels that are used for agricultural purpose.....56

27. Figure 4.20: Query result showing parcels that are used for mixed purpose.....57

28. Figure 4.22: Bar Chart of Land Use Types and Number of Parcels……..……58

29. Figure 4.23: Land use Map of Banjiram.....59

30. Figure 4.24: Graph of Land Use Types and Number of Parcels.....60

31. Figure 4.25: Parcels table report.....61

32. Figure 4.26: Land Owner table report.....62

33. Figure 4.27: Parcel Beacons table report.....62

34. Figure 4.48: Land Title table report.....62

LIST OF PLATES

1.Plate I: Adjudication Team during Fieldwork.....34

APPENDIX

Appendix 1: Questionnaire/Adjudication Form
……...……..…71

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Land is a great resource and indeed, the backbone of wealth in many communities, whether urban or rural. People have depended on land for food, shelter, employment, resource, cultural and religious needs. Land is the foundation of all human activity. The relationship of people to land is fundamental to human existence (United Nations Economic Commission for Europe (UNECE), 2005). Issues of land have been identified to be a cause of civil and international wars and even genocide (Bell, 2011). Conflicts over ownership, land grabs, social disharmony, reductions in yields, diminished food security, weak land markets and negative impacts on the environment are associated with regions with poor system of land information management (McLaren, 2011). Current and reliable land information in terms of ownership, land use and value is necessary for: ensuring the security of property rights; reduction in litigation and less work for the courts; better land assessment and taxation; better information base for planning and administration; improving map production (such as base map, utility asset maps, zone maps and so on); easier transactions in land; establishing a transparent and operational land market; less corruption in land affairs and update the land information (Kabir, 2009). The cadastre is the core component of land information management (Andersson, 1986).

The International Federation of Surveyors (FIG, 1995) defines a cadastre as a parcel based and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). Williamson & Ting (1999) identified three forms of cadastre: the fiscal cadastre (used for generating revenue through taxation); legal or judicial cadastre (used for protecting property ownership rights) and; multi-purpose cadastre

(combining both functions of the fiscal and legal cadastres as well as being used for utility management, planning, environmental management, etc.). The core component of cadastres, Cadastral information system or Land Information System is the cadastral map obtained through cadastral mapping.

Synonymous with cadastre and cadastral mapping is land registration. According to McLaughlin & Nichols (1989) land registration is process of recording legally recognized interests in land. The overall aim of land registration is building a cadastre (Jing, 2011). Crucial to land registration is adjudication. The term adjudication was first used in 1950's to describe systematic ascertainment of rights in land (Lawrence, 1985). Adjudication is the first stage of land registration aimed at formalizing land through the procedure of land rights identification, demarcation cadastral surveying and mapping (Dale and McLaughlin, 1999). Adjudication occurs in two cases where no earlier register information is available or where the old information becomes obsolete with very bad quality (Jing, 2011).

Cadastral mapping could be described as the process and methods of building of information on land. Traditionally, cadastres and cadastral mapping systems have been manual and paper-based (Borzacchiello & Craglia, 2012). They contained a numerical/diagrammatic description (a graphical description of land parcels) and a separate list of land register (containing a list of names and rights of land holder) (Zevenbergen, 2002). Indexing schemes were used to link the map and the register.

Recent developments in the Remote Sensing and Geographic Information System (GIS) and web-based GIS, internet communications, band width and transmission speeds have necessitated and made possible the development of digital cadastres and cadastral mapping systems allowing the map and the register to be integrated into one single system (a digital cadastral map (database)) (Sutherland & Nichols, 2002). With the development of Geo-information technologies (GIT) adjudication of land rights benefits greatly from the use

of Remote Sensing/Photogrammetry (Jing, 2011). Remotely-sensed georeferenced orthophotos have been used for adjudication in various regions of the world (Meijs, Kapintango & Witmer (2009). Remote Sensing and Geographic information systems (GIS) have therefore become important geometric tools for building of digital cadastral systems (Albert, Edmund, Merem & Yaw, 2006). Elayachi & Semlali (2001) noted that a digital cadastral map is not a map in the traditional sense, but a map in which attributes (tabular) and map (graphic) data on cadastral unit are stored in the same database. They added that a digital cadastral map registers each parcel and its owners and describes all the spatial structures consisting of location, boundaries and contents.

While Western nations are advancing in the creation of multi-purpose cadastres that are aimed at supporting sustainable development, developing countries are only recently starting to establish more formal cadastral records for fiscal or other purpose.

In Nigerian, cadastral mapping land/registration and administration suffer from among others lack of use of appropriate technology in surveying and the mapping industry. Cadastral maps are worn out and outdated and modernization efforts are only made for urban lands and are still on pilot basis (Oboli & Akpoyoware, 2010). Only a few states including Lagos, Kano and the Federal Capital Territory have computerized land information (Bell, (2011). A greater part of land in Northern Nigeria is held under a customary system without being covered by cadastral mapping and land title registration (Usman, 2010).

1.2 STATEMENT OF THE RESEARCH PROBLEM

De Soto (2002) observe that two thirds of the worlds' land is characterized by bad titling, where titling is neither related to maps and registries, nor backed by the law or plugged into the financial system. According to the United Nations Economic Commission for Africa (2009), decision makers in Africa are not obtaining adequate information from

their present cadastral and Land Information Management Systems to make informed decisions as about 90% of land in Africa is not mapped with only less than 1 per cent of sub-Saharan Africa being covered by any kind of cadastral survey and mapping.

According to (Uluocha, 2012) “like most African countries, Nigeria still lacks basic maps needed for judicious resource planning, development, and management. Instability coupled with lack of a well-established mapping policy, shortage of funding, and successive governments' failure to integrate mapping into national development has affected mapping in the country”. Consequently, only about 3% of land is mapped, titled and registered (Ukaejiofo, 2009). This is supported by Adeniyi (2013) who stated that not more than 2.5% of the land in Nigeria has been registered since formal land registration and cadastrals mapping began in Nigeria in 1863. Cadastral mapping and land registration only covers a few urban area. Even in the few urban areas, records are mostly kept in a manual and analogue form. The existing analogue (paper) maps are unable to show more details and do not allow integration with other datasets which could be achieved by a GIS-Based Cadastral Map.

Over three decades after the re-settlement of Banjiram, apart from the cadastral survey carried out as part of the resettlement program, there has never been any effort to link the map with record of ownership and land use. Land right were orally transmitted and the evidence of land such rights is based on the knowledge of community elders and village chiefs. Decision makers and the public do not have sufficient land information to ensure security of land tenure and bring about sustainable development. Consequently, there have been prevailing ligations and disputes over land ownership as well as poor land development in the study area.

Based on the review of previous studies, the application of Remote Sensing and GIS in cadastral mapping in areas where land ownership records do not exists at all, particularly in Nigeria seems not to be well-researched. The uniqueness of this particular research is in the

fact that most researches in cadastral mapping using Remote Sensing and GIS such as, those of Orisakwe & Bakari (2012); Addai, Owusu, Poku – Gyamfi & Gyambibi (2011); and Lemmenet *al.* (2009) were involved in cadastral mapping in an areas where land records existed in an analogue format and just needed to be put on a cadastral database. Moreover, this type of study has never, ever been carried out in the study area. This is the gap in research and knowledge this research intends to bridge. It is against this background that this study intends to use Remote Sensing and GIS in carrying out cadastral mapping in the study area with a view to producing a land information system (a digital cadastral database) towards improving land tenure security in the study area and serving as a template for other areas.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of the research is to carry out cadastral mapping using Remote Sensing and GIS in Banjiram, Adamawa State. Specific objectives are to:

i. Determine the existing land right in the study area through an imagery-based adjudication.
ii. Design and build a GIS-based cadastral database of all parcels in the study area,
iii. Analyze the database and determine its efficiency.

1.4 SCOPE OF THE STUDY

The spatial scope of the study covers the New Banjiram (the resettlement area) that has been surveyed during the resettlement program. In content, the study is concerned with the application of Remote Sensing and GIS in cadastral mapping. The research was carried out within a period of three months.

1.5 LIMITATIONS

As with the general nature of any research especially in Nigeria, there are a number of limitations associated with this study. One of the major limitations of this study is the inaccessibly in terms of cost to very high resolution images. Another limitation was the incomplete information given by parcel owner. For instance, information on owner phone numbers and next of kin were not fully provided.

1.6 JUSTIFICATION OF THE STUDY

An efficient land tenure management requires an efficient system of cadastral mapping and land registration (United Nations, 1996). Manual land record keeping in Nigeria has been identified to be the major factor making land administration and management inefficient, daunting, time-consuming and prone to abuses. The present state of haphazard physical development, land tenure insecurity, conflicts and litigation over land in the study area is not unconnected to lack documented record of land ownership and use. Decision makers do not have adequate land information to make informed decisions in carrying out developmental projects and citing utilities. Courts and tradition authority do not have the necessary information to resolve conflicts arising from land ownership.

This study will help to provide a digital cadastral database which will record land ownership, land use and other related information which will help bring about security of tenure and in turn ensure social stability, economic development and environmental management. It will therefore provide the relevant ministries responsible for processing of land title documents with the necessary information that could lead to the formalization and issuance of land title documents (Certificate of Occupancy) to land owners in the study area

which will ensure the security and certainty of land rights. Moreover it will among others; reduce disputes on land ownership; form the basis for an efficient property tax system; support the effort of Presidential Technical Committee on Land Reform aimed at registering all rural lands in Nigeria and; support the achievement of the Millennium Development Goal 1: Eradicating Poverty and Hunger, through secured land in rural areas.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to review the literature related to the research. The chapter presents a brief description of the concept of cadastre, land registration, adjudication, cadaster, recording, land tenure, cadastral map and land title, land administration and cadastre in Nigeria. It again, looks at Remote Sensing and GIS, the application of Remote Sensing and GIS in cadastral mapping.

2.2 CONCEPT OF LAND AND LAND REGISTRATION

2.2.1 Land

Land as a word has a variety of meanings. It represents different things to different people, depending upon their outlook and their interest at a particular time. To the economist, for instance, it is a resource to achieve economic production and development while to the lawyer it is a volume of space from the centre of the earth to the infinite sky (carrot-theory) with a variety of rights for determining many objectives (Henssen, 1995). The United Nations Ad Hoc group of Experts on Cadastral Surveying and Land Information (1985), defined land as an area of the surface of the earth together with the water, soil, rocks, minerals and hydrocarbons beneath or upon it and the air above it. It added that land embraces all things which are related to a fixed area or point of the surface of the each, including the areas covered by water, including the sea.

2.2.2 Land Registration

Land registration is a process of official recording of rights in land through deeds or as title on properties (Williamson, 1986). It means that there is an official record (land

register) of rights on land or of deeds concerning changes in the legal situation of defined units of land. It gives an answer to the questions who and how (Henssen, 1995). There are two recognized systems of land registration, the deed and the title registration system

A deed registration system means that the deed itself, being a document which describes an isolated transaction, is registered. This deed is evidence that a particular transaction took place, but it is in principle not in itself proof of the legal rights of the involved parties and, consequently, it is not evidence of its legality (Henssen, 1995). Thus before any dealing can be safely effectuated, the ostensible owner must trace his ownership back to a good root of title.

A title registration system means that not the deed, describing e.g. the transfer of rights is registered but the legal consequence of that transaction i.e. the right itself (=title). So the right itself together with the name of the rightful claimant and the object of that right with its restrictions and charges are registered (Henssen, 1995). With this registration the title or right is created.

2.2.3 Adjudication

Adjudication is often referred to as first registration or land titling, involves the initial compilation of the land register. According to Dale & McLaughlin (1999) "Adjudication is the formalization of unwritten evidence of ownership into sworn written statement to be legally recognized as a documentary proof of ownership". Adjudication is a careful procedure for to investigate all relevant interests that exist on land when virtually no written document exists (Jing, 2011). It is the procedure to formalize land through land rights identification, demarcation, cadastral surveying and mapping (Zevenberngen, 2001).

Adjudication has been the most common method of determining land rights for registration purposes. Adjudication attempts to clarify all land interests, thus resulting in an

accurate land register (Hanstad, 1997). Adjudication precedes either sporadically or systematically. The sporadic approach is to adjudicate whenever or wherever there is a demand or other reason for determining the precise land rights concerning a particular parcel. The systematic approach is more methodical and rapid, and is typically compulsory. Adjudication proceeds one area at a time, and all parcels within a given area are entered into the land register at the same time. In the long term, the systematic approach is preferable because it is less expensive due to economies of scale (Hanstad, 1997). According to Jing (2011) adjudication involves both technical and legal perspectives. The technical perspective include the cadastral surveying and mapping while the legal perspective involves the land tenure and authorities as well as evidences of claim

2.2.4 The Concept of Cadastre

According to Stephen (1997) in typical context a cadastre can be described as a land ownership records. The International Federation of Surveyors (FIG) published statement specifically on the cadastre (FIG 1995) defines the cadastre as: "normally a parcel based and up-to-date land information system containing a record of interests in the land (e.g. rights, restriction and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and often the value of the parcel and its improvements."

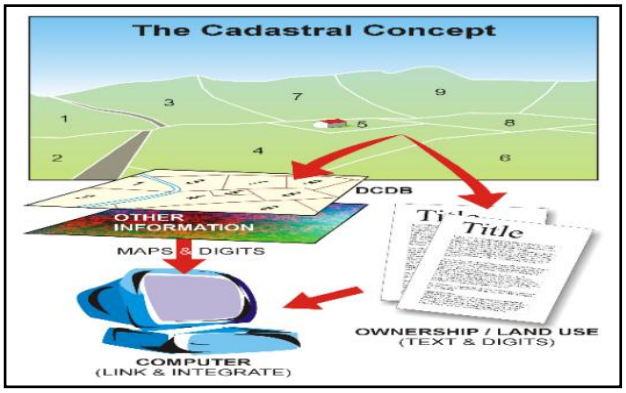


Figure 2.1: The Cadastral Concept
Source: Statement on the Cadastre (FIG, 1995)

There are two critically important components in any Cadastral System, namely the cadastral map and the title register (Williamson, 1996). The cadastral concept (shown in Figure 2.1) is very simple and clearly shows the attribute and spatial components of a cadastre.

2.2.4.1 Textual and graphical component of a cadastre

Traditional cadastral systems can be composed of two parts; a mapping (graphical) part and a textual part. The graphical component of cadastre include a series of large-scale maps showing property boundaries, all buildings and structures on the land and the major natural features (Williamson, 1996). According to Hespanha, Van Oosterom, Zevenbergen & Dias (2006) the mapping part of a cadastre is the result of a survey of the property boundaries and objects being part of the property (e.g. buildings, etc) according to the legal situation. The textual part consists in many cases of a register arranged according to parcels, a register according to proprietors and some auxiliary registers for easier handling (Williamson, 1996). Both textual data of cadastre and cadastral map (graphical data) are organized only in digital (vector) form, and connection is ensured between textual and graphical part.

2.2.5 Land Recording

Land registration and cadastre usually complement each other, they operate as interactive systems. According to Henssen, (1995) land registration puts in principle the accent on the relation subject-right, whereas cadastre puts the accent on the relation on right-object. In other words, the land registration answers the questions as to who and how, the cadastre answers the questions as to where how much. Because land registration and cadastre (who and how along with where and how much) complement each other, the terms "land

recording" or "land records" are usually used to indicate that these two components belong together as a whole Henssen, (1995).

2.6 LAND TENURE

Every well-organized form of a human society will define rights on the land (Harcombe, & Williamson, 2003). According to FIG Commission 7, (1998) the concept of land tenure can be defined as the "the act, right, manner or term of holding a landed property" or as "the nature of legal estate in land". If land tenure is related to the broad field of land use, it is more than the "man-land" relationship. Being able or not to exercise rights on the land can create deep emotions and often plays a vital role in the individual's feeling concerning the possibilities of participation in society (Harcombe & Williamson, 2003).

2.7 CADASTRAL MAP AND LAND RIGHTS

For land to effectively support the human existence, communities and individuals must have the rights to the use of the land and its yields, the rights to transfer and the rights to mortgage or lease. This bundle of rights is what is often referred to as a land title (Glaskin, 2003). Security of land right is critical to economic development, social stability and environmental management (Bell, 2009). In rural areas, security of land title or tenure rights is not only crucial to guaranteeing existing livelihoods, but also critical to active participation of local populations as stakeholders in rural development. The cadastral map records and preserves these rights. A cadastral map contains systematically arranged information on all properties (i.e. parcels) within a given village or district (Sengupta, Bandyopadhyay, Lemmen & van der Veen (2013). Both the maps and registers may be stored in computers, such as Cadastral Database Management System (CDMS) and Computerised Land Registration System (CLRS) (Choon & Hussin, 2013). UN-HABITAT (2008) noted that with

GIS in cadastral mapping legally secure rights can be provided to houses plots, farmland and natural resources.

2.8 LAND ADMINISTARTION AND CADASTRE IN NIGERIA

2.8.1 Land Right Management in Nigeria

Prior to the colonial invasion, land in Nigeria belongs to the community, village or family and there was no such thing as individual ownership. All members of the community, village or family have an equal right to the land but in general, the Chief or Headman of the village or the head of the family has responsibility for the land and is considered as the owner (The Government of the Federal Republic of Nigeria, 1970; Mabogunje, 2010). Formal recording of individual rights and interests in land started with the British Colonial Administration in 1863 (with the land registration law) based on European laws (Oboli & Akpoyoware, 2010). The former Capital city of Nigeria, Lagos with its environs was the first to be covered by the Land Registration Law, which was later extended to other parts of the country by the "Registration Ordinance" No. 2 of 1894. The currently, land administration in the Federal Republic of Nigeria is guided by The Land Use Act (Decree No.6 of 1978) (Oboli & Akpoyoware, 2010).

Before The Land Use Act, there were two systems of land ownership in the Northern and Southern parts of the country. Land in the Northern Nigeria were held and administered by the emirs while land in the Southern part was own and held by communities, clans and families (Oboli & Akpoyoware, 2010). It was intended to usher in land reforms in Nigeria, through comprehensive tackling of four major challenges of land management: lack of uniformity in the laws governing land use and ownership; uncontrolled speculation in urban land; the question of access to land rights by Nigerians on equal basis; and the issue of

fragmentation of rural lands arising from application of traditional tenets of inheritance or population growth and increasing land uses which exert tremendous pressure on available land (Edmead, 2010).

2.8.2 Cadastral mapping and land registration in Nigeria

Land registration and cadastral recording was introduced in Nigeria during colonial rule which led to the establishment of a Land Registry in Lagos in 1863. This operated for some time and later land registration laws were based on regional basis until 1915 when the Land Registration Ordinance No.12 was enacted and unified the Systems of Land Registration in the colony of Southern and Northern protectorates (Nuhu, 2009). There was only one Survey Department in the country with branch offices in Lagos, Ibadan, Kaduna and Enugu. It was vested with the responsibilities of execution of geodetic, topographical and cadastral surveying throughout the country.

Following regionalisation in 1951, the Survey Departments in Ibadan, Kaduna and Enugu became the Regional Survey Headquarters for the Western, Northern and Eastern Regions respectively, and they were then to provide essential cadastral survey services for the Regions in which they were situated (Birner & Okumo, 2011). The Federal Survey Department was then charged with the responsibility of providing cadastral survey services for the Federal Territory of Lagos executing all geodetic and topographical survey in the country, and for the profession of surveying (Birner & Okumo, 2011).

The Office of the Surveyor General of the Federation (OSGOF) is now an institution that provides the much needed control over survey and mapping in Nigeria. OSGOF is recently into development of a Cadastral Geographical Information System (GIS) that would

allow defining land parcel data of Federal Lands that can seamlessly integrate with FELIS for effective management and Administration of Federal Lands in Nigeria (Nuhu, 2009).

A striking feature of the current land registration system in Nigeria is the fact that specific procedures for registering rural land through the local governments do not exist; even many decades after the LUA established provisions for this purpose (Edmead, 2010). At the demand side, rural land users may not be aware of the possibility of such a mechanism and they may, therefore, not demand this local service (Edmead, 2010).

2.8.3 Cadastral Mapping and Land Registration in Adamawa State

Orisakwe & Bakari (2012) noted that problems of survey and mapping practice in the Adamawa State include: lack of independent practicing surveyors, proliferation of quacks, non-charllant attitude of government surveyors to issues relating to modern practice, non-attendance to AGM and SURCON activities nation-wide, lack of adequate man power and, non-adherence to current survey rules and regulations.

The current process of land allocation and administration in Adamawa state is bedevilled with a lot of inadequacies. Some of the problems include: forgeries of land documents, encroachment onto right of ways, multiple allocations of parcels and overlapping allocations, inefficient system of revenue generation, obsolete hardware for data collection and management system is vulnerable to alterations, theft, and substitution, encouraging corruption, paper based records are difficult to preserve and irreplaceable, duplication on similar media is cumbersome and will result in similar problems of maintenance after a few years (Orisakwe & Bakari, 2012).

2.8.4 Reforms in land registration and cadastral mapping in Nigeria

Oboli & Akpoyoware (2010) noted that there are efforts at improving the Cadastre and modernising land administration in some parts of the country which include: Lagos, Kano and Enugu states as well as FCT Abuja. In Lagos State the Electronic Document Management Systems (EDMS) was launched to provide services in the improved land registry. Most of the records pertaining to titles on landed property for urban lands where documentation exists have been converted to digital format and the Land Registry has completed computerization of its records. In the Federal Capital Territory (FCT) the Abuja Geographic Information System, AGIS was set up in 2004 to serve as a Spatial Data Infrastructure for Abuja (Oboli & Akpoyoware, 2010). Thus AGIS is expected to assist in conflict resolution in plot allocation and innovation in land registration. On 25th May, 2006 Enugu State commissioned the State's computerized land registry called Enugu State Land Information Management Service (ESLIMS).

2.8.5 The National Cadastral Mapping Programme

The Survey Unit of the defunct Federal Ministry of Housing and Urban Development in collaboration with the Office of the Surveyor General of the Federation (OSGOF) proposed a Large Scale Cadastral and Township Mapping Programme for Nigeria in 2005 (Oboli & Akpoyoware, 2010). The Minister of Housing and Urban Development at the time made a presentation on the progress of FELIS in year 2006 to the Federal Executive Council (FEC) which resulted in Mr President setting up a Cabinet committee. The Cabinet Committeee was assigned the task of proposing a programme for the implementation of a Comprehensive Computerisation and Modernisation of Land Administration in Nigeria as well as a National Cadastral and Township Mapping Programme. The programme still remains in the planning stage due to funding constraints.

2.9 GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING

GIS is acronym for Geographic Information System. It is an organized collection of computer hardware, software, geographic data, procedures, and personnel designed to capture, store, analyze, query and display of all forms of geographic data.

Remote Sensing is the science and an art of acquiring spectral, spatial and temporal information of material objects, areas, or phenomena without coming into physical contact with the object, area, or phenomena under investigation (Jain, 2009). More commonly, the term remote sensing refers to imagery and image information derived by both airborne and satellite platforms that house sensor equipment. Remote sensing is a science which involves the acquisition of information about the earth's surface without coming into a physical contact with it. It provides data in form of satellite images and aerial photos which could been used to build cadastral base maps (Bekure, Abegaz, Frej, & Abebe (2006).

2.9.1 Components of GIS

The components of GIS include: People, Data, Software, Hardware, Procedures/Methods.

2.9.1.1 People

People are the most essential component of a GIS. They set the procedure and methods that are used by a GIS and carry out all operations such as ground truthing data collection, data storing, processing and analysis (Guanfu & Ershun, 1998). People include surveyor, software user and GIS analyst, etc.

2.9.1.2 Data

Data is the core of any GIS. The availability and accuracy of data will affect the results of any analysis. A GIS can integrate data from a number of different sources and store in a database management system. There are two types of data used in a GIS - spatial and Attribute/non-spatial/aspatial.

Spatial data: Spatial data consist of the location of objects on the surface of the earth. An example of spatial data might be the location of houses or the delineation of a road. This locational information is stored using a series of x, y-coordinates based on a map projection (i.e., a method to transpose data from the earth's curved surface to a flat map with minimal distortion).

Attribute/nonspatial/aspatial data: Attribute data are the information linked to the geographic features (spatial data) that describes the features (Phadke, 2006). The associated attribute data, however, does not tell where the object is on the earth, but it contains other important information about the object. An example of attribute data might include the date of construction of a building, the owner of a parcel, area of a parcel etc. The power of GIS is in its ability to link the spatial and attribute which allows complex analyses to be performed.

2.9.1.3 Hardware

The type of hardware determines, to an extent, the speed at which a GIS will operate. Additionally, it may influence the type of software used. To a small degree, it may influence the types/ personalities of the people working with the GIS. Hardware types, range from desktop computers to large computer servers. Other hardware components include graphics devices, plotters, printers and scanners (Star & Estes, 1990).

2.9.1.4 GIS software

Software tools provide the functions and tools required to store analyse and display the spatial data. This includes the GIS software, database and drawing software (Tomlinson, 2007). It encompasses not only to the GIS package, but all the software used for databases, drawings, statistics, and imaging. Popular GIS Software include: ArcGIS (ESRI), ArcView, MapInfo (vector-based GIS); Erdas Imagine (Leica), ENVI (RSI), ILWIS (ITC), IDRISI (Clark Univ.) (Raster-based GIS).

2.9.1.5 Procedures/Methods

The procedures used to input, analyse, and query data determine the quality and validity of the final product. The procedures used are simple the steps taken in a well-defined and consistent method to produce correct and reproducible results from the GIS system (Tomlinson, 2007).

2.10 GEODATABASE/GEO-SPATIAL DATABASE

Data mean representations that can be operated upon by a computer. More specifically, spatial data means data that contains positional values. Geospatial data is a further refinement, which then means spatial data that is georeferenced. Spatial databases are a specific type of database. They store representations of geographic phenomena in the real world to be used in a GIS. They are special in the sense that they use other techniques than tables to store these representations. The GIS does not store data as maps but as GIS database, also referred to as spatial database, geodatabase or geo-spatial database (Goodchild, 1991). Spatial database is based on Relation Database Management System (RDBMS) which store information in tables that relate to each other through common fields and are generally queried through the Structured Query Language or SQL. With GIS, cadastral maps will be

built and stored as geo-database could be systematically be developed containing land records.

2.11 GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING IN CADASTRAL MAPPING

Remote Sensing and Geographic information systems (GIS) have been instrumental in cadastral mapping (Albert, Edmund, Merem, & Yaw, 2006). Remotely-sensed high resolution satellite images are effective in carrying out adjudication of rights in land (Delville, 2006). High Resolution Satellite imagery (HRSI) has been successfully used in some African countries, like Ethiopia (Lemmen, Zevenbergen, Lengoiboni, Deiniger, & Burns, 2009). Lemmen *et al.* (2009) argued that almost without exception, local people could easily recognize the area and building where they are living land on the imagery during an imagery base adjudication. Jing (2011) in a study to assess Larsi-Integrated Participation Procedure for Urban Adjudication in China stated that the new procedure will contribute to improving efficiency, saving labour and reducing cost of adjudication.

In Kenya, high resolution images (QuickBird and Ikonos) have been used for general boundary surveying in rural areas (Kenya, & O, 2006). In Thailand, aerial photos have been used for urban adjudication where cadastral maps where directly delineated form orthophotos (Jing, 2011). Georefenced orthophotos have been used in Namibia for rural adjudication (Meijs, Kapintango & Witmer (2009).

Mapping components of cadastres can be improved significantly through the use of Geographical Information System (Adeel, 2010). GIS has been used for cadastral mapping in different parts of the world. According to (Gavish & Ester, 2009) by the year 2000 the Survey of Israel (SOI) had accomplished the building of a GIS driven cadastral database and the main efforts were turned to updating and maintenance. GIS has revolutionize cadastral data

management in the Nigerian FCT Abuja. It has greatly reduce corrupt practices in land administration in the Federal Capital Territory of Nigeria (Akingbade, Navarra & Georgiadou, 2010).

2.12 METHOD CADASTRAL MAPPING USING GIS

Technically, cadastral mapping methods may involve the preparation of a base map, georeferencing, vectorization.

2.12.1 Preparation of Cadastral Base Map

According to Goodwin (1994) a base map is the graphic representation at a specified scale of selected fundamental map information that provides a primary medium by which the locations of cadastral parcels can be related to. Several types of sources may be used as a base map. This includes orthophotographs, and already existing maps, such as road network maps, and topographic maps.

One of the important steps in creating digital cadastral maps is conversion of traditional paper maps (or analogue maps) into digital GIS data layers as well as the vectorization of the data so that GIS software would be able to distinguish between individual elements such as lines, points, and polygons.

Massachusetts Geographic Information System (MASSGIS, 1999) has identified several ways of preparing a cadastral base map. This are discussed below.

a) Manual digitizing from analogue maps;

b) Scanning with further “heads-up” digitizing or automatic vectorization;

c) Coordinate Geometry conversion (COGO);

d) Positioning property corners with GPS.

2.12.1.1 Manual Digitizing from Analogue Maps

This is the most basic method of transferring hardcopy maps into a digital format. Manual digitizing is done by attaching a paper map to a digitizing tablet, registering the corners of the map to real world coordinates, and then tracing the map features with a mouse-like device (Sugumaran & Degroote, 2011). Manual digitizing is slow, expensive and difficult to process as such leads to many errors (Ablameyko, 1997).

2.12.1.2 Scanning

The second method of parcel data conversion is scanning. In order to obtain better result, a parcel map should be in a very good condition with minimum text on it. Hardcopy parcel maps are converted to digital form using an electronic device (scanner). In order to be able to edit or update the map features, are converted from the raster format to a vector format. There are two methods that could be used for this purpose: automatic vectorization and heads-up digitizing (MASSGIS, 1999).

2.12.1.3 Automatic Vectorization

This method could be used only if a map is in a very good condition – all lines are clear, have similar thickness, and clear intersections, and if there is no annotation or unnecessary features on the map. In this method, the software can trace all the lines on the map. This is the easiest and quickest method of parcel data conversion, but, unfortunately, parcel maps are usually not in pristine condition and have all types of different features and text on them (MassGIS, 2002).

2.12.1.4 Heads-up Digitizing

This method is usually used when the analogue map is in a very bad condition and when the digitizing board is not available. Heads-up digitizing involves manually tracing the lines on a computer screen over the top of the scanned raster image Goodwin (1994). The raster image is used as a background image. Everything that was said about on board digitizing could be applied to on screen digitizing as well.

2.12.1.5 Coordinate Geometry (COGO)

This is a more accurate method of parcel data conversion to a digital form than any of the methods mentioned above. COGO uses a completely different approach to the process of data conversion compared to digitizing or scanning. The difference is that the analogue map is not involved, but land surveys and deeds are used instead (Levachkine & Guzmán-Arenas 2004). Land surveyors' record information about each individual parcel in terms of geometric distances and angles from control points (benchmarks) (Haunold & Kuhn, 1994). The COGO procedure involves entering into computer such information as a precise starting coordinate, the direction and distances of each side of the parcel (MassGIS, 2002). After that, the computer performs some calculations to create a geometrically accurate parcel polygon. Unfortunately, not all parcels have property boundary descriptions or the information could be wrong. Therefore, it is often necessary to go out in the field and collect the missing information or verify the existing documentation.

2.12.1.6 Positioning Property Corners with GPS

Another method of creating digital spatial data is by carrying out field surveys using Global Positioning Systems (GPS). The GPS was developed by the United States military. Originally, it was for defence applications but has grown over time in a wide range of private

and government sectors (Sugumaran & Degroote, 2011). In parcel mapping, it involves the survey of the property boundary and obtaining the coordinates of corners. The coordinates of these markers are then input into GIS software and the dots are connected to have a very accurate parcel map. The resulting accuracy could surpass even that of COGO (Struck, 1998). The rapid development of the Global Positioning System (GPS) has made it easier to get coordinates for the property corners.

2.3 LITRATURE REVIEW

Bell (2011) observed that imperial researches based on carefully evaluated pilots are necessary for addressing complex issues of land. A couple of researches have been carried out on the land registration and the application of Remote Sensing and GIS in cadastral mapping.

Lemmen, Zevenbergen, Lengoiboni, Deiniger & Burns (2009) studied the use of High Resolution Imagery Based Adjudication Approach for Social Tenure Domain Model in Ethiopia. Their methodology was based on: Informing Local Communities, Fieldwork and processing and building a digital land register. They found that High Resolution Imagery-based adjudication is an effective tool in determining land right as local people can read images plotted on paper and recognize the boundaries of their plots.

Addai, Owusu, Poku – Gyamfi & Gyambibi (2011) studied systematic land title registration using GIS using the Ghana Land Administrative Project (LAP). Their methodology was based on: reconnaissance survey; public announcement; questionnaire administration; spatial data capturing using the Global Positioning System (GPS) and digital camera and; collection of photocopies of existing documents on parcels of land. They found

that the process of land registration can quickly and speedily be carried out at a much reduced cost with the help of GIS.

Orisakwe & Bakari (2012) studied the development of Cadastral Information System for part of Kofare Government Residential Area of Jimeta-Yola in Adamawa State. Their methodology involved: the acquisition of spatial and attribute data from the ministry of lands and survey, scanning and importing into AutoCAD, georeferencing, creation of layers and building a cadastral database. The research concluded that GIS is capable of building editing and analyzing of a cadastral information system.

Babalola & Kardam (2012) studied the development of a digital land register (Cadastral Information System) for Part of Fadaman-Mada Area of Bauchi Metropolis. The methodology was based on: the collection of secondary data (cadastral layout blocks survey plan and the record of ownership) from the Ministry of Lands and Survey; updating the record with field survey; building a spatial database of all parcels and; determining the efficiency of the GIS by issuing queries and observing how the system responds. They found that land registeres and cadasters can efficiently be built and managed using GIS

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This chapter describes the geographic variables of the study area, the data types and sources, tools and procedures for data collection and methods and techniques of data processing.

3.2 THE STUDY AREA

3.2.1 Location

The study area is located between latitudes 9°47'12.86"N to 9°48'24.73"N and longitudes 11°57'13.33"E to 11°57'50.06"E. It has a total land area of approximately 1,700 Acres. It is located along the Numan-Biu Federal Highway, 11 Km south of Guyuk- the local government headquarters and 80 Km south-east of Yola- the state capital (as a crow flies). See figures 3.1 and 3.2.

3.2.2 Historical overview

Banjiram is the Headquarters Banjiram District in Guyuk L.G.A. of Adamawa State. The study area was resettled in 1980 from its old location (along River Gongola) to make room for the construction of Kiri dam to irrigate the sugar cane plantations of the Savannah Sugar Company and projects of the Upper Benue River Basin and Rural. The study area was planned by the Upper Benue Development Authority as part of the resettlement. Plots are well demarcated with concrete monuments containing labels placed on parcel corners. See plate 1 and figure 1.0.

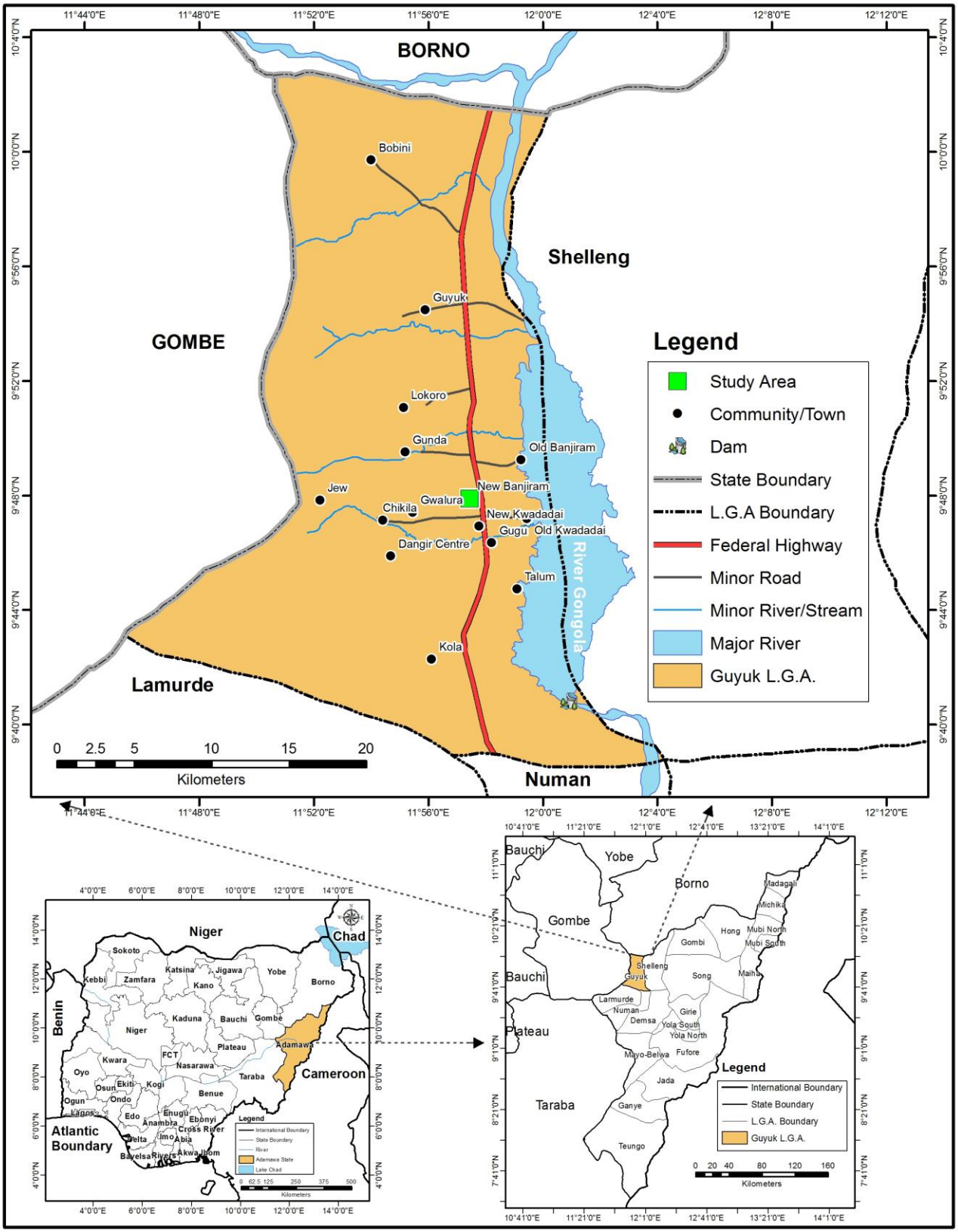


Figure 3.1 Map of Banjiram showing Plots (Land parcels)
Source: Adapted and modified from the Banjiram layout plan

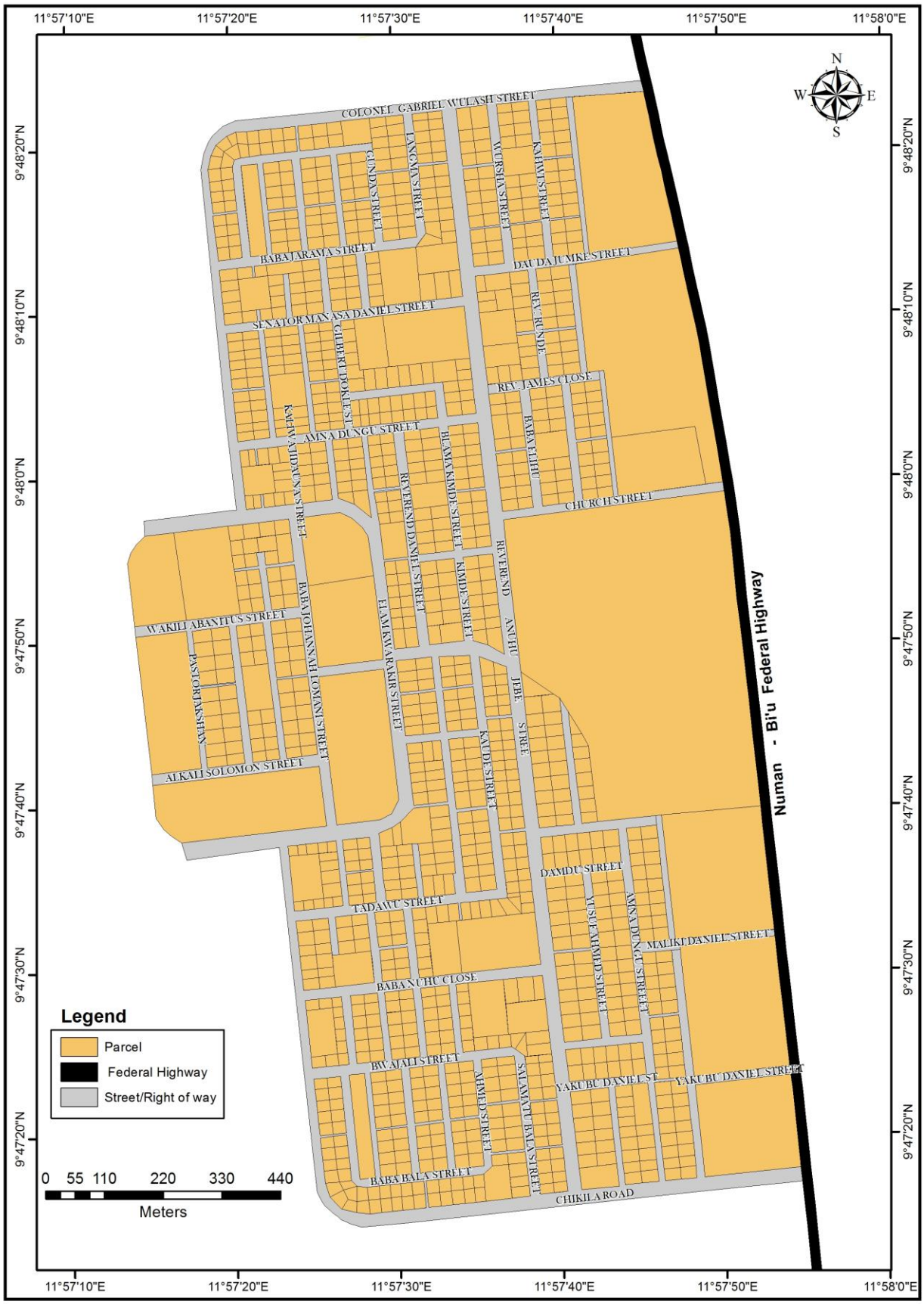


Figure 3.2 Map of Banjiram showing Plots (Land parcels)
Source: Adapted and modified from the Banjiram layout plan

3.2.3 Climate

The climate of the study area is typical of the West African Savanna climate. However, there is usually a seasonal change in the temperature; there is gradual increase in temperature from January to April. There is also a distinct drop in temperature at the onset of rains due to the effect of cloudiness. A slight increase after the cessation of rain (October to November) is experienced before the onset of harmattan in December when the temperature in the study area reaches 31^{o}C. In April while minimum temperature can be as low as 18^{o}C to 27.8^{o}C (Adebayo & Tukur, 1999).

3.2.4 Vegetation

Banjiram is located within the savanna vegetation zone which is transitionally in between northern guinea savanna and Sudan savanna with pockets of woodland vegetation along river basins and is covered by more or less continuous grass cover, but in some parts tree growth suppresses the grass growth.

3.2.5 Drainage

Banjiram is traversed by two stream- the Kwasalda and the Kwamajuwe streams located at the Northern and the Southern parts respectively. These streams got their source from the Lunguda plateau (located west of the area) and drain into the River Gongola (located at the eastern side) which carries water throughout the year. Both streams get flooded during a heavy downpour. The Kwasalda stream which a little lager than Kwamajuwe flows relatively continuously on the onset of the rainy season (in April) till January and February.

3.2.6 Culture

Banjiram is dominated by Lunguda tribe, a tribe that is said to have come from "Gimai" which was the way they called east. History had it that they settle in different places before finally settling along the banks of River Gongola. The community is said to had contained the Lunguda War shrine where the gun of the colonial master refuse to fire when they came to fight with Banjiram people following a dispute. Other tribes include Hausa, Kanakuru and Waja.

3.3 METHODOLOGY

3.3.1 Data and Sources

As shown on table 3.1, four types of data were used in this research. A layout plan of the study area obtained from Adamawa state Ministry of Land and Survey serves as the cadastral base map from which individual parcels, and beacons were digitized and also used in the preparation of an index map that was used in the field for determination of land rights. A satellite imagery obtained online from Google Earth Pro was used to develop an indexed map which enabled land owners to identify their parcel by themselves during fieldwork. Attribute data which was obtained through fieldwork provided attribute information on land owners and ownership information used in building the cadastral database. GPS data which was obtained through field work was used to georeferecing the layout plan.

Table 3.1: Types and Sources of Data

Data required	Sources
Layout plan/Map (Spatial data)	Ministry of lands and survey, Yola.
Satellite data: Spot 5 (2011) at scale: 1 m (spatial data)	Google Earth
List of land owners and ownership information (Attribute data)	Field work (adjudication)
GPS Data (Spatial data)	Field work

3.3.2 Hardware and Software

A. Hardware:
   i. A HP DV6 digital electronic laptop was used for data input, storage, processing and analysis.
   ii. A hand held global positioning system (GPS) was used during fieldwork to pick coordinates of selected beacon.
   iii. An A0 scanner was used to scan the hardcopy layout plan of the study area.
   iv. A digital camera was used to capture the photographs of parcel owners.

B. Software:
   i. ArcGIS 10.1 was the major software used for: georeferencing the layout plan, spatial database creation and analysing the database.

3.3.3 Adjudication Materials

A. Index map /Imagery containing delineated parcels with unique identification numbers was taken to the field to enable land owners identify their parcel by themselves.

B. Adjudication forms were used to collect the record of parcels and owners during field work.

3.3.4 Methods and Techniques of Data Collection

3.3.4.1 Spatial data collection

The layout plan of the study area containing surveyed parcel boundaries, corners and (beacons) monument was obtained from Ministry of lands and survey, Yola. It was scanned and converted into a raster format and individual parcels and beacons were vectorized. Moreover, GPS-based field work was carried out to capture the coordinates of some selected control points for georeferencing and updating the cadastral layout plan.

3.3.4.2 Attribute data collection

Attribute data of spatial features: parcels' area, beacons labels and beacon coordinate were obtained directly from the layout plan. However, attribute data of land owners: names, sex, occupation, address and phone numbers were collected through field work involving adjudication.

3.3.5 Determination of Existing Land Rights: (Adjudication)

Adjudication (Objective I) was achieved through field work (adjudication) to determine existing land rights in the study area. Prior to the process, announcements were made in the whole community and in mosques and churches to sensitize land owners on the exercise and the criteria used to adjudicate land rights. The exercise was carried out in a participatory manner by an adjudication team comprising the researcher, a member of the Village Land Owners Union (VLOU), and a representative of the village head. See plate 1.

The adjudication form in on appendix 1.1 and a hardcopy indexed satellite image/map containing digitized parcels with unique identification numbers was used for ease of identification of parcels by owners. The adjudication exercise in operation, involved visits to each parcel by the adjudication team where land owners were required to identify their plot on the satellite image and on the ground as well, in the presence of adjoining plot owners (neighbours) and the adjudication team. See figure 3.2 for a sample subset of the indexed image/map. As land owners identified their parcels and their claims of ownership get verified and authenticated by traditional authorities and adjoining land owners, they were required to provide the necessary details to fill the adjudication form which was later signed by the village head. To ensure complete coverage, each of the 18 village units (Unguwani) was

covered one after the other until all the parcels in the study area were registered. Each of the eighteen village units was covered in one day.

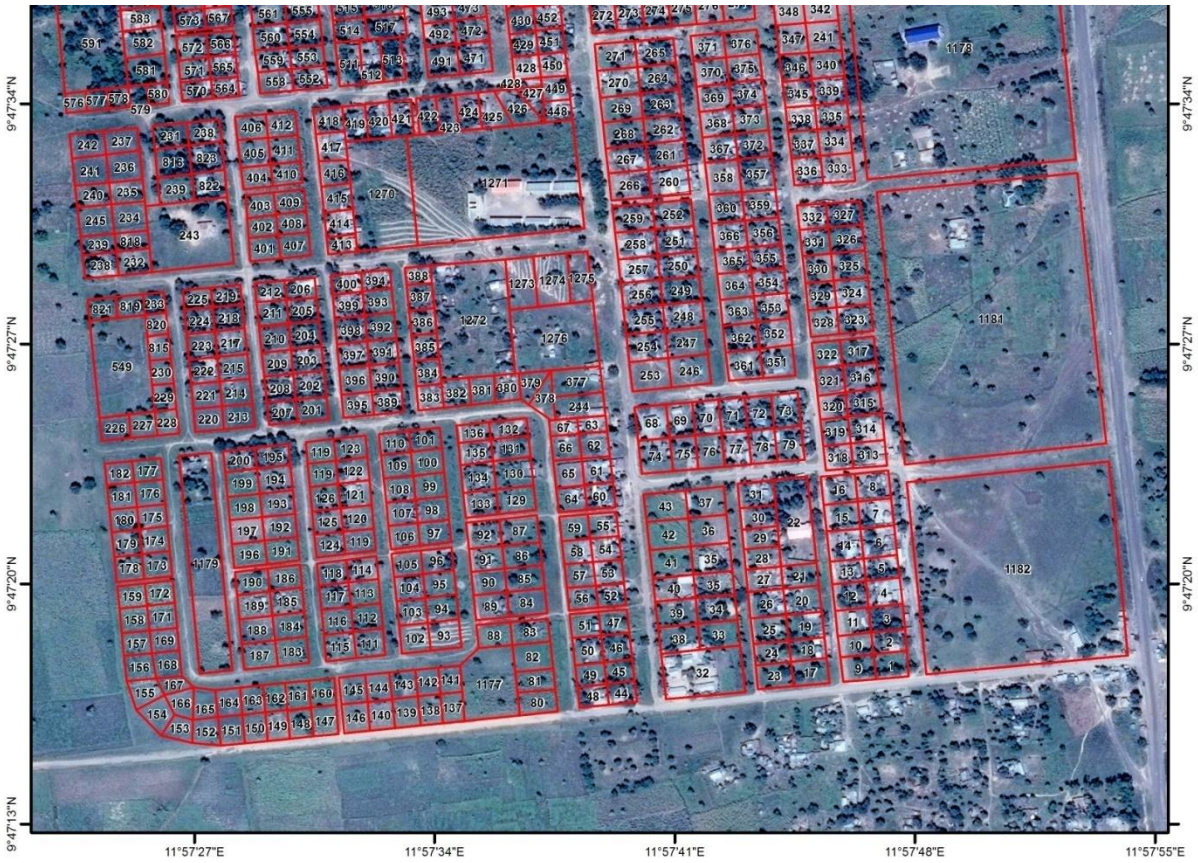


Figure 3.2: A subset (part) of the indexed map (imagery) used during adjudication
Source: Researcher



Plate I: Adjudication Team during Fieldwork
Source: Researcher

3.3.6 Data Processing

Processing of the data involved, scanning; geo-referencing; digitizing; and feeding the fieldwork attribute data to the digitized parcels.

3.3.6.1 Scanning

The layout plan of the study area containing the identified boundaries was scanned using Cougar 36 scanner with 350dpi resolution. Scanning resulted in raster data sets in .JPEG format. See figure 3.4. Appropriate geo-correction were carried out.

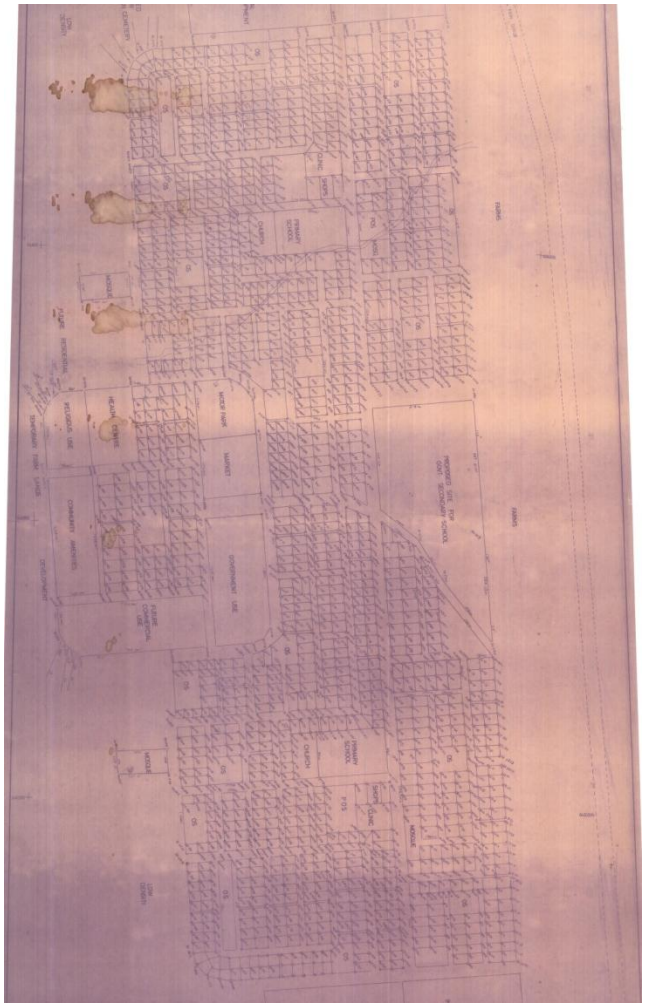


Figure 3.4: Scanned Banjiram layout
Source: Adamawa state ministry of lands and survey

3.3.6.2 Georeferencing

The scanned layout plan (raster datasets) containing undefined spatial reference was imported in ArcMap. The Universal Travers Mercator (UTM) projection system was used. After defining the spatial reference system, geo-referencing was then performed through the use of the coordinates of selected beacons obtain from the field using GPS.

3.3.6.3 Digitising

After the image was geo-referenced, on-screen digitizing was performed in ArcGIS. Parcel boundaries were extracted by pointing and tracing the cursor along parcel boundaries.

Each parcel was created as a closed polygon. Beacons were also digitized as points. Resultant features were parcel boundaries and beacons in feature class format.

3.3.7 Designing and Building a Cadastral Geodatabase (Objective II)

This involved the three stages of building and designing a geodatabase; conceptual, logical and physical stages.

3.3.7.1 Conceptual design

The Entity Relation (E-R) model was used for the conceptual design. This involved the identification of entities, identification of attributes, determination of relationships and the drawing of an E-R diagram. Four entities were identified in the design. These include; parcels, owners, land titles, and beacon. Figure 3.5 shows the proposed conceptual model of the geodatabase.

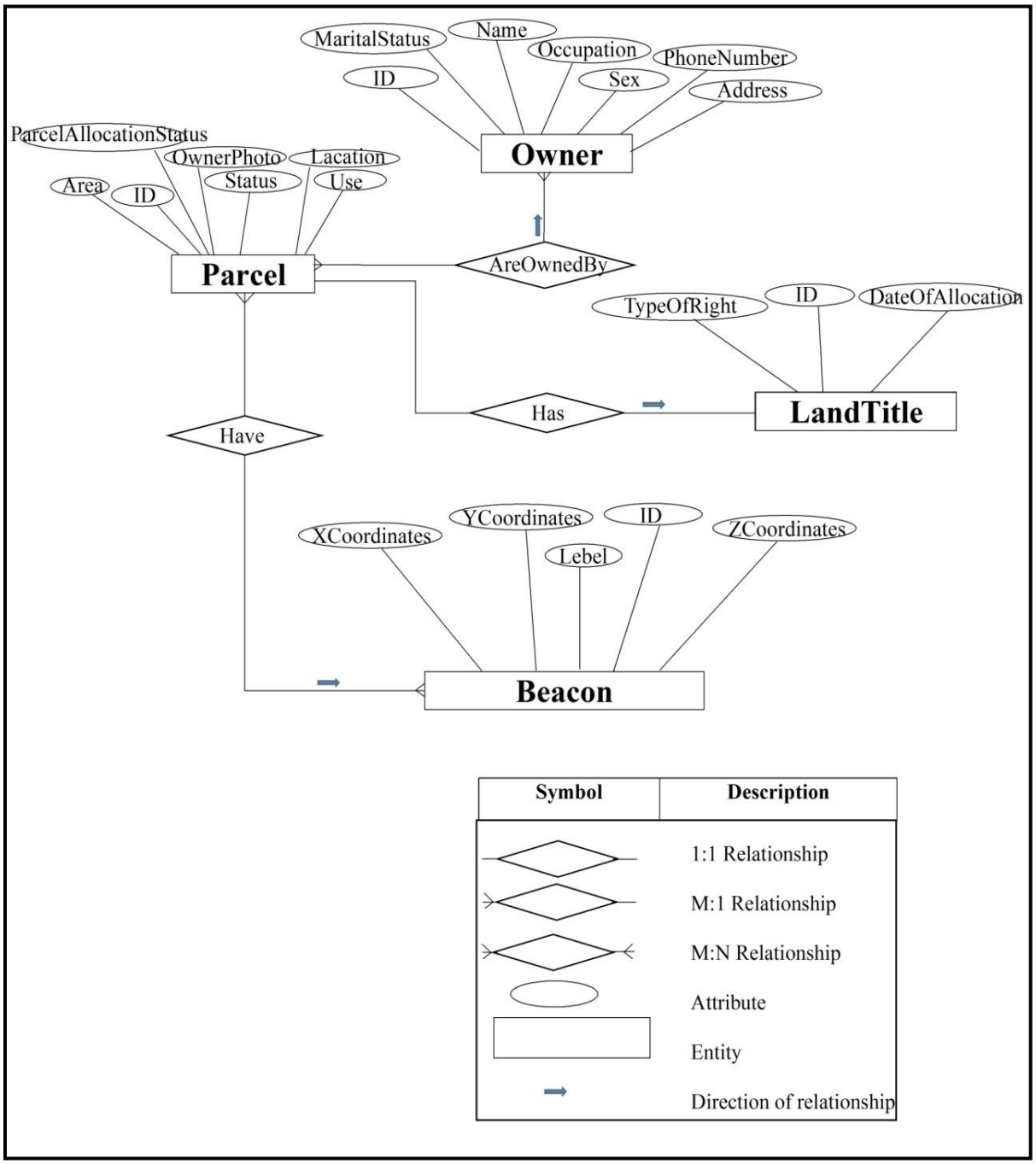


Figure 3.5 The Conceptual model of Geodatabase
Source: Researcher's Analysis

3.3.7.2 Logical design

The logical design involved mapping the conceptual E-R diagram into a logical schema, identification of primary and foreign keys and normalizing attribute table. The Relational Database Management System (RDMS) model was used for the logical design. The Parcel ID and Owner ID were identified as primary keys in the parcel and owner a tables, respectively. The Beacon ID was identified as the primary key in the beacon table while, the Land Title ID was identified as the primary key in the land tile table.

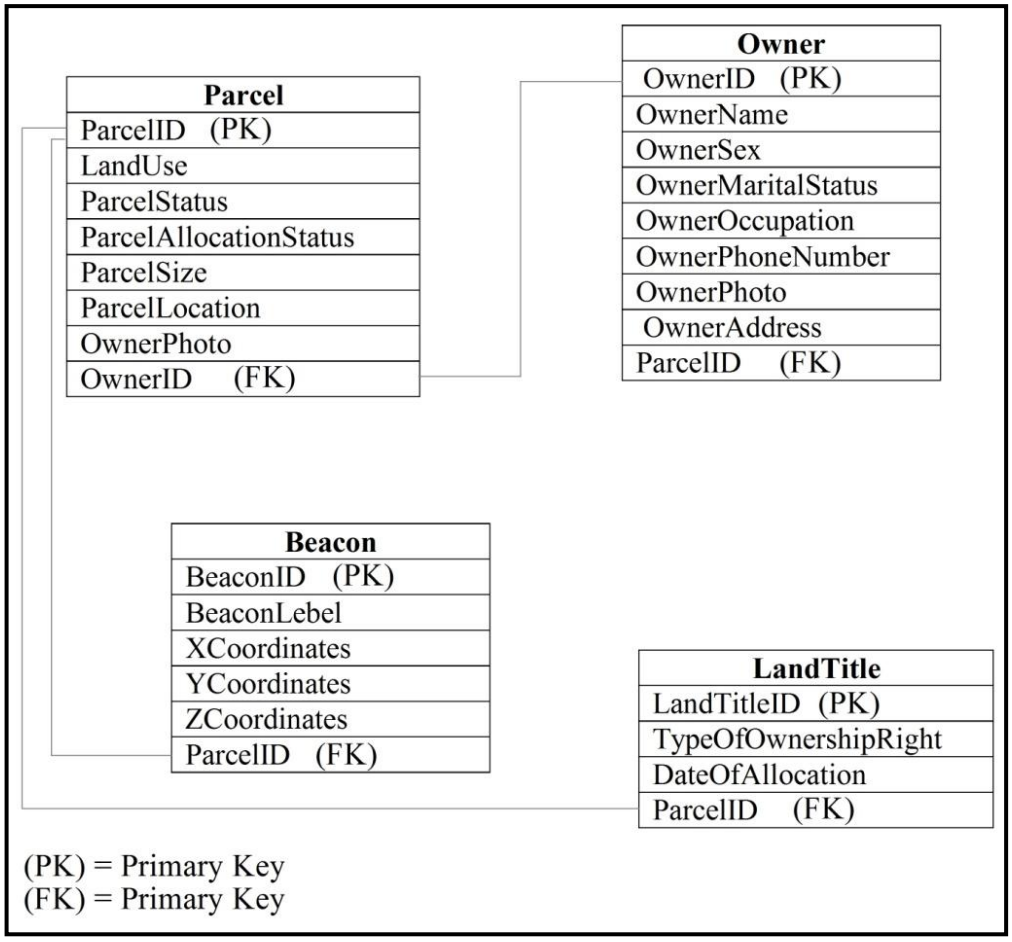


Table 3.6: The logical Model of Geodatabase

3.3.7.3 Physical design

The two steps of physical spatial database design involved determining the characteristics of attributes in the logical schema and the creation of new feature attribute table for each of the spatial layers identified in the spatial database will be followed. ArcGIS 10.1 version will be used for the physical design. Feature classes will be created in ArcCatalog for spatial entities- parcels and beacons. Tables will be creation for non-spatial entities - owners and land titles. Table 3.2 below shows a summary of the physical designed based on the ArcGIS data storage structure.

Table 3.2: The Software (ArcGIS) Dependent Physical Model of Geodatabase

Attribute	Field Name	Field Description	Field Type	Field Width
Parcel (Feature class): Polylgon fature type				
Parcel ID	P_ID	A unique parcel identification number of the parcel	Double	10
Parcel Use	P_USE	Residential, Agricultural, Commercial, Institutional..	Text	1
Parcel Status	P_STATUS	Developed or Not Developed	Text	1
ParcelAllocationStatus	P_ALLC_STAT	Allocated Not Allocated	Text	1
Parcel Area (Sqm)	P_SIZE	Parcel size (metre square)	Numeric	12
Parcel Location	P_LOC	Street along which the parcel located		100
Owner Photo	OWN_PHOTO	A Pasport photographs of the owner	Text	50
Owner (Object class): Table				
Owner ID	OWN_ID	A unique identification number of the owner	Short Integers	4
Owner Name	OWN_NAME	Full name of the owner (surname first)	Text	100
Owner Sex	OWNER_SEX	Gender of land owner: Male, Female	Text	1
Owner Occupation	OWN_OCCUP	Subtypes: Farming, Civil Service or Others	Text	1
Owner Next of kin	OWN_NXT_KIN	Next of kin of land owner	Text	100
Owner Address	OWN_ADDR	Contact address of the owner	Text	150
Owner Phone Number	OWN_PHON	Telephone Number of the owner	Text	11
Beacon (Feature class): Point feature type				
Beacon ID	BEACON_ID	A unique identification number of the beacon (Monument)	Short Integers	4
Beacon Lebe	BEACON_LEB	A label (written) on the beacon		12
XCoordinates	X_COORD	X Coordinates of the corner point	Text	12
YCoordinates	Y_COORD	Y Coordinates of the corner point	Text	12
ZCoordinates	Z_COORD	Z Coordinates of the beacon	Text	12
LandTitle (Object class): Table				
Land title ID	LT_ID	A unique identification number of the title	Short Integers	4
Ownership right type	RIGHT_TYPE	Subtypes: Customary or Statutory	Text	1
Year of Acquisition	YEAR_ACQ	The year the land was acquired	Date	1

3.3.7.4 Creating a Geodatabase and Building of the Cadastral Database

A file geodatabase was created in ArcCatalogue. This was carried out by right clicking on the project folder on C-Drive and selceting file geodatabase. The shapefile of parcels and beacon were imported into the geodatabase and converted to feature classes. The layout plan (in a raster format) of the study area was also migrated into the geodatabase. In the geodatabase, geodatabase tables created in ArcGIS for owners and land title information.

3.3.7.5 Creation Attribute field, Domains and Population of attribute fields

Fields for feature classes and tables were created based on the design in the physical geodatabase design on figure. This was carried out in ArcMap. Some special fields which had domain include: Owner occupation, Owner sex (Owners table); Parcel use, Parcel status, Parcel allocation status and Parcel location (Parcels featureclass); Ownership right type (Land title table). All fields were populated using some of the information obtained from the field and the information derived from the layout plan.

3.4 DATA ANALYSIS

Data analysis involved the used of query selection, report creation, identifications and simple percentages as well as pie and bar charts. Analysis carried out include: searching and displaying parcel(s) belonging to a particular owner using the parcel owner name; displaying the photograph of the owner of a selected parcel; identifying the owner of a particular parcel using the identity tool; finding out the land title information of a land owner using the identify tool; finding out parcel that are owned by female; finding out parcels that are owned by civil servants; finding out parcels that have not been allocated; finding out parcels located along a particular street; finding out parcels that are not developed; finding out parcels whose

size is <= 600m square; finding out parcels whose size is greater that than 600m square; finding out parcels that are used for a particular purpose.

Simple percentages were used to analyse the percentages of parcels: allocated and not allocated; parcels developed and not developed; parcels used for residential, agricultural, institutional, mixed and commercial uses.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results of the analysis and its discussion. It presents the processes involved in using GIS in analyzing and testing the efficiency of the cadastral geodatabase. The processes involved queries, searches, report creation and identifications among others.

4.2 Testing the Effeciency of the Cadastral Database (Objective III)

Analysing and testing the efficiency of the cadastral database was achieved using various capabilities and analytical tools provided in the ARCGIS 10.1. These tools include: select, find, identify, hyperlink among other. A few of the operations performed include: report creation, viewing hyperlinked documents, graph creation, map production and queries. Analysis that was carried out are listed below.

i. Searching and displaying parcel(s) belonging to a particular owner using the parcel owner name.
ii. Displaying the photograph of the owner of a selected parcel.
iii. Identifying the owner of a particular parcel using the identity tool.
iv. Finding out the land title information of a land owner using the identify tool.
v. Finding out parcel that are owned by female.
vi. Finding out parcels that are owned by civil servants.
vii. Finding out parcels that have not been allocated.
viii. Finding out parcels located along a particular street.
ix. Finding out parcels that are not developed.

x. Finding out parcels whose size is <= 600m square.

xi. Finding out parcels whose size is greater that than 600m square.

xii. Finding out parcels that are used for a particular purpose.

The methods and results of the above analysis are displayed below.

4.2.1 Searching and Displaying Parcel(S) Belonging to a Particular Owner Using the Parcel Owner Name

QUERY: SELECT* FROM PARCEL WHERE: "OWN_NAME" = 'Mohammed Ma'aru'. See figure 4.1 below show a result of a query of find a parcel owner using his name. After the query, the parcels belonging to the owner are accessed and viewed by using the 'Tables Options' and selecting 'Related Tables'.

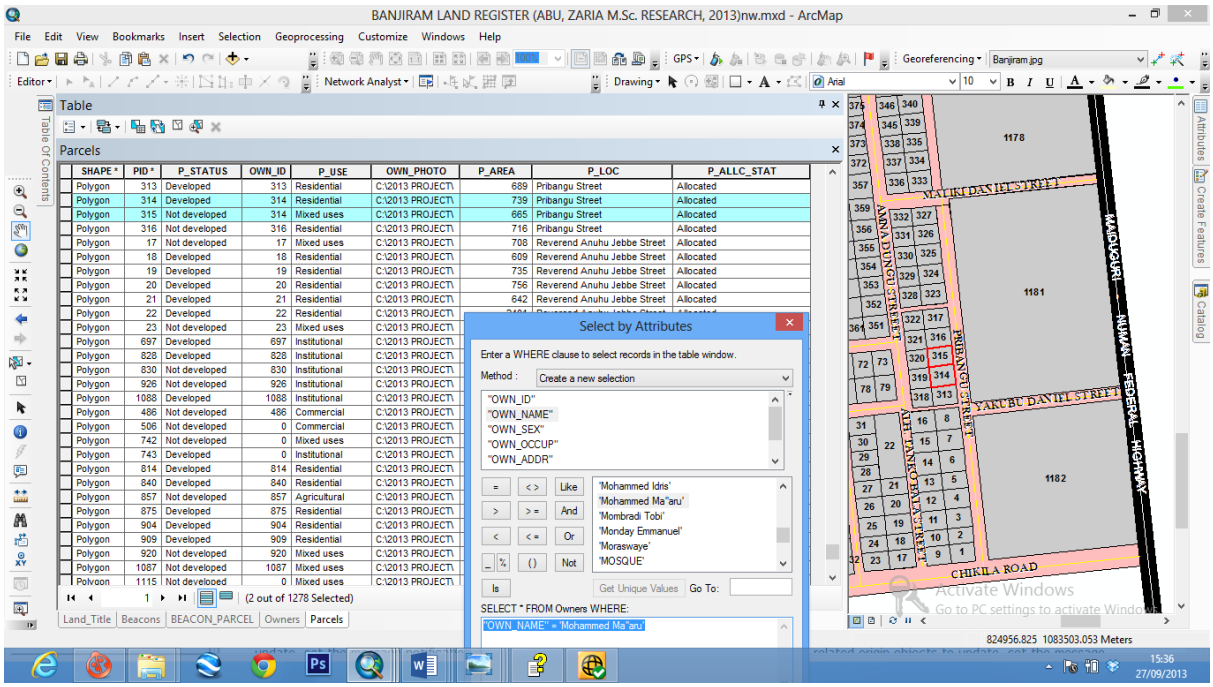


Figure 4.1: Query result showing parcels belonging to a particular owner after searching using the owner name.
Source: Author's Analysis

The selected parcels are shown on the map with a red out while the attributes are highlighted in the attribute table in Blue colour

4.2.2 Displaying the Photograph of the Owner of a Selected Parcel

After carrying out the query and process in figure 4.1, the photograph of a selected parcel was displayed by picking the hyperlink tool and clicking the parcel of interest. See figure 4.2 below.

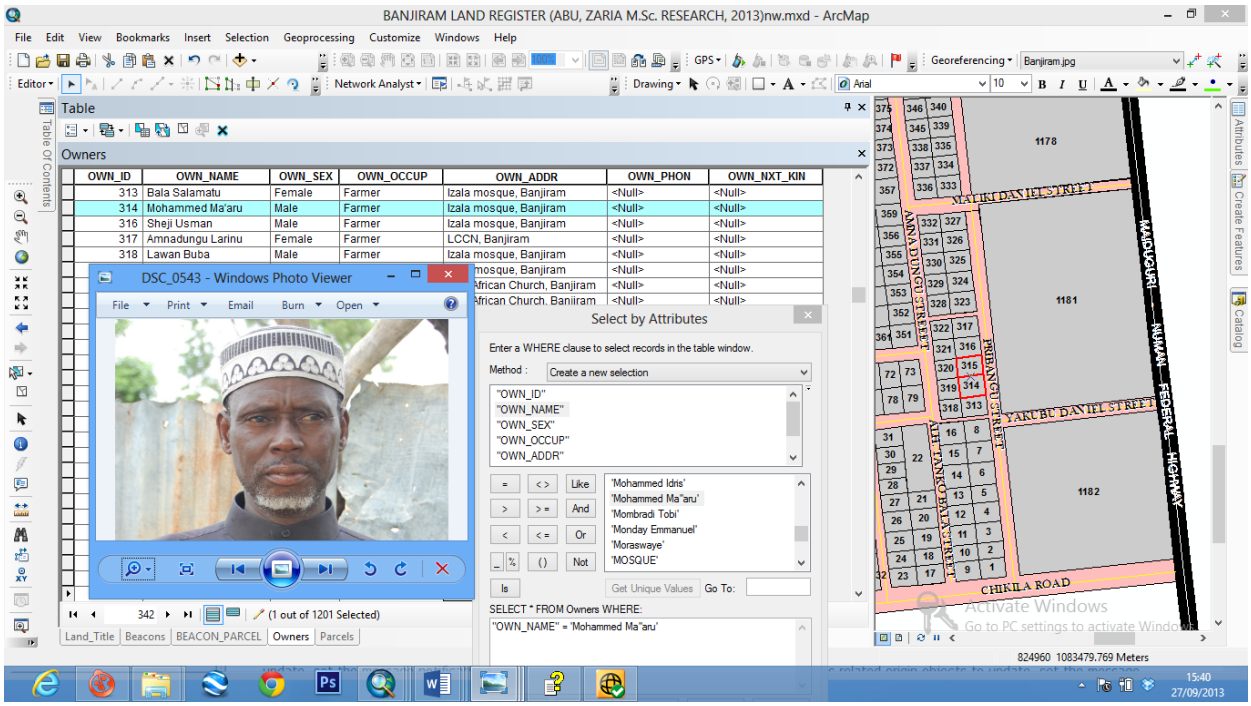


Figure 4.2: Query result showing parcels belonging to a particular owner and displaying owner photograph after searching using the owner name
Source: Author's Analysis

4.2.3 Identifying and Displaying the Personal Data of the Owner of a Particular Parcel Using the Identity Tool

This was achieved by selecting a parcel using the select tool picking the identify tool and clicking the selected parcel. In the identify window, the owner details is accessed by clicking the plus sign and navigating to the owner name and double clicking on it.

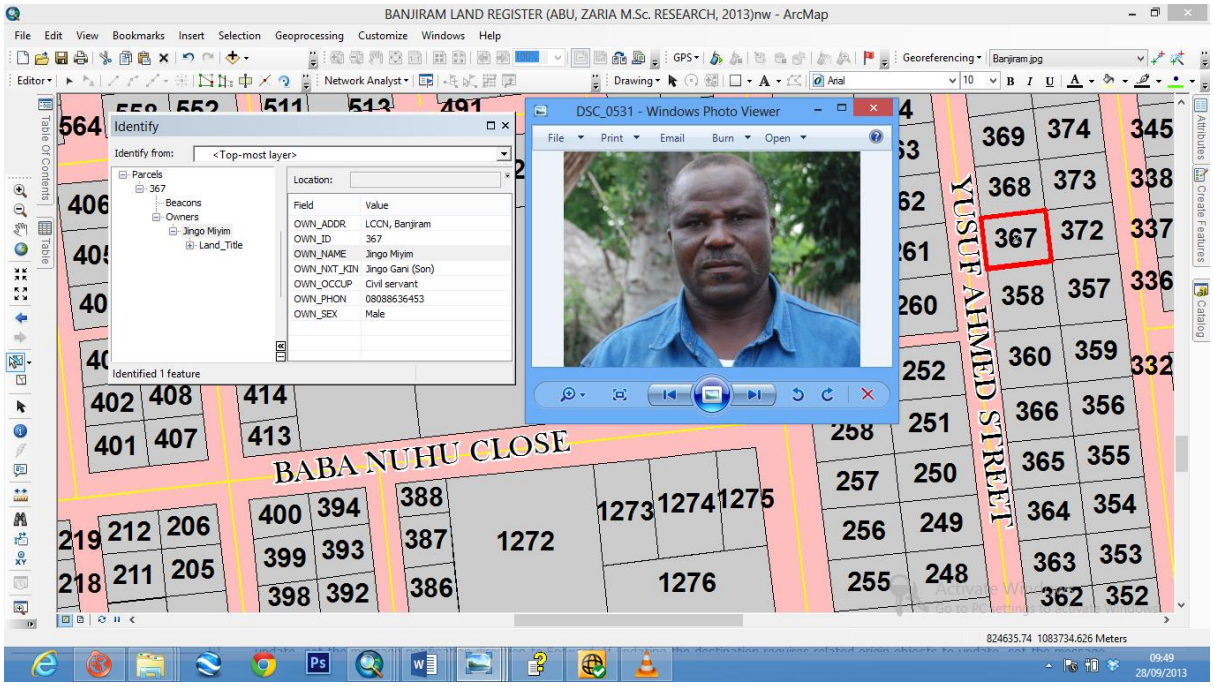


Figure 4.3: Result of using identify tool to display personal data of a parcel owner
Source: Author's Analysis

Figure 4.3 shows the personal details of a land owner displayed in the identify dialogue box and his parcel (with red outline). The photograph was displayed by the use of the hyperlink tool.

4.2.4 Finding out The Land Title Information of a Land Owner

This was achieved by selecting a parcel using the select tool picking the identify tool and clicking the selected parcel. In the identify window, the owner details is accessed by clicking the plus sign and navigating to the land title and double clicking it. See figure 4.4 for result.

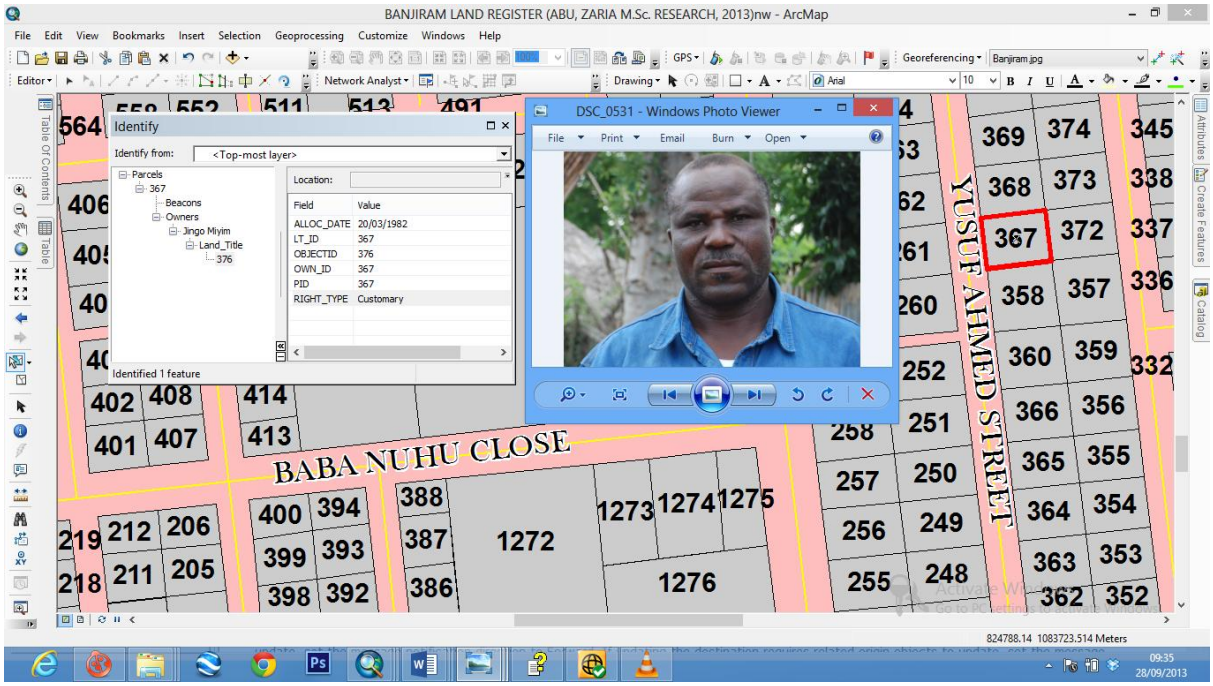


Figure 4.4: Result of using identify tool to display land title information of a parcel owner

Source: Author's Analysis

4.2.5 Finding out Parcel that are Owned by Female

QUERY: SELECT* FROM Owners WHERE "OWN_SEX" = 'F'

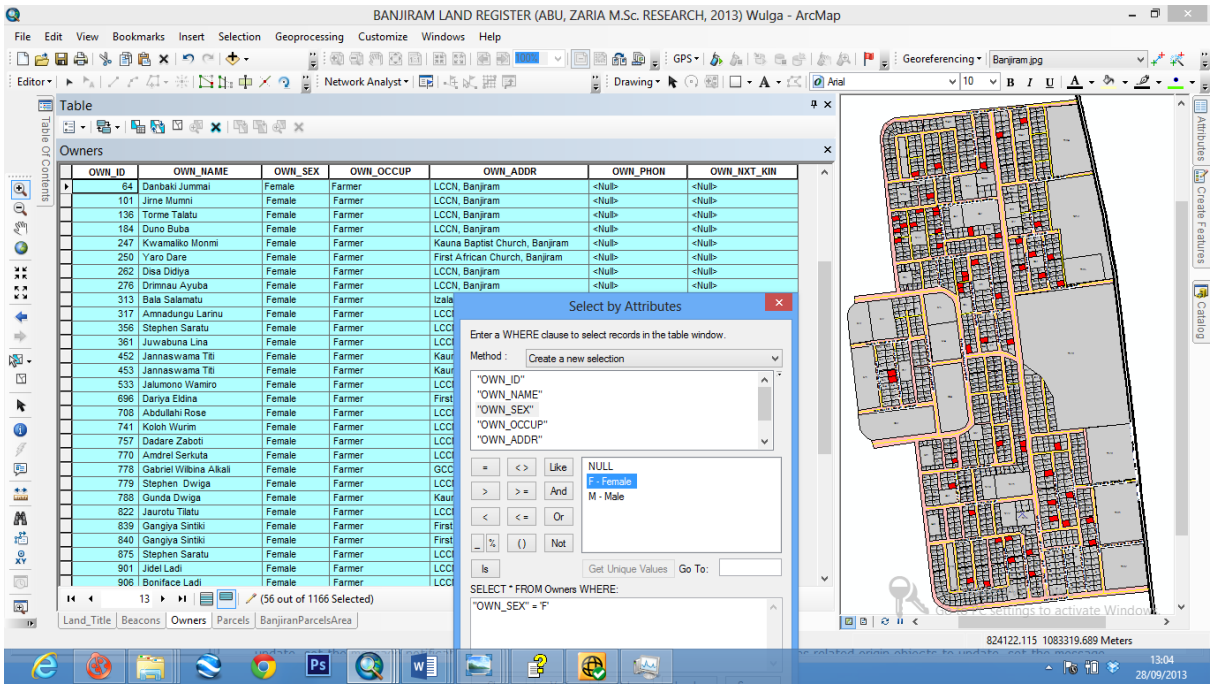


Figure 4.5: Query result showing parcels belonging to female owners

Source: Author's Analysis

Figure 4.5 shows the result of a query to select parcels belongs to female owners. Selected parcels are displayed in red and the details of owner in the attribute table are shown in blue. It showed that 56 out of the1166 land owners in the study area are females. As shown in the figure 4.6 below this represent 4.803% of land owners while male owners represent the rest of the 95.197%.

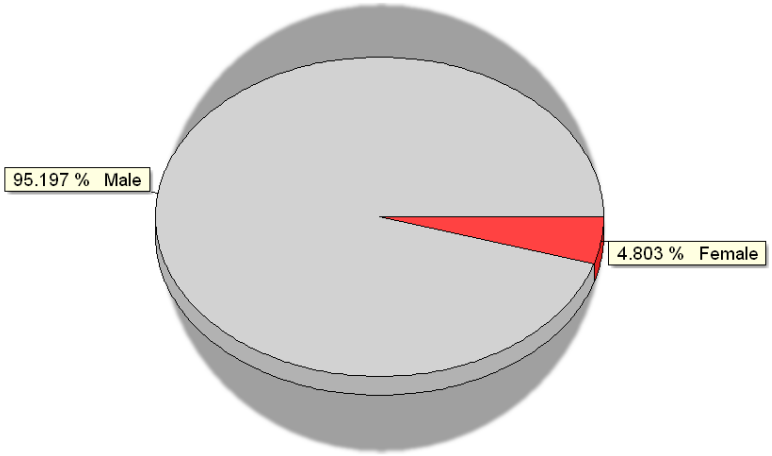


Figure 4.6: Graph of male and female land owner (%)
Source: Author's Analysis

4.2.6 Finding out Parcels that are Owned by Civil Servants

QUERY: SELECT* FROM Owners "OWN_OCCUP" = 'CVS'

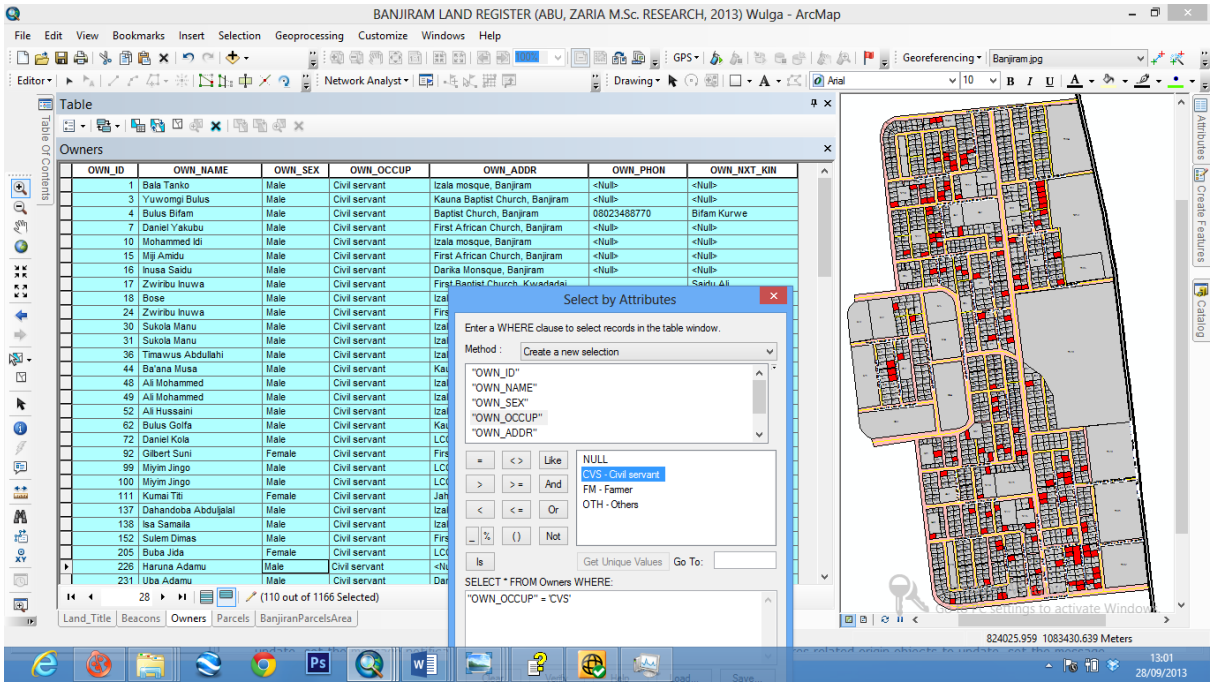


Figure 4.7: Query result showing parcels owned by civil servants.
Source: Author's Analysis

Figure 4.7 shows a query of parcels belonging to civil servants. Selected parcels are shown in red and their details are shown in the attribute table (in blue). It showed that out of the 1166 of the parcel owners, 110 are civil servants representing 9.434 for civil servants and 90.556 for farmer as shown on the figure 4.8 below.

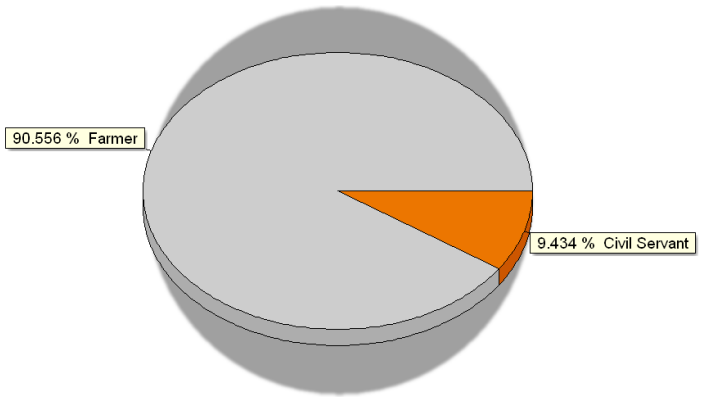


Figure 4.8: Graph of land owners' occupation (%)
Source: Author's Analysis.

4.2.7 Finding out parcels that have not been allocated

QUERY: SELECT* FROM Parcels WHERE "P_ALLC_STAT" = 'NT_ALLCTD'

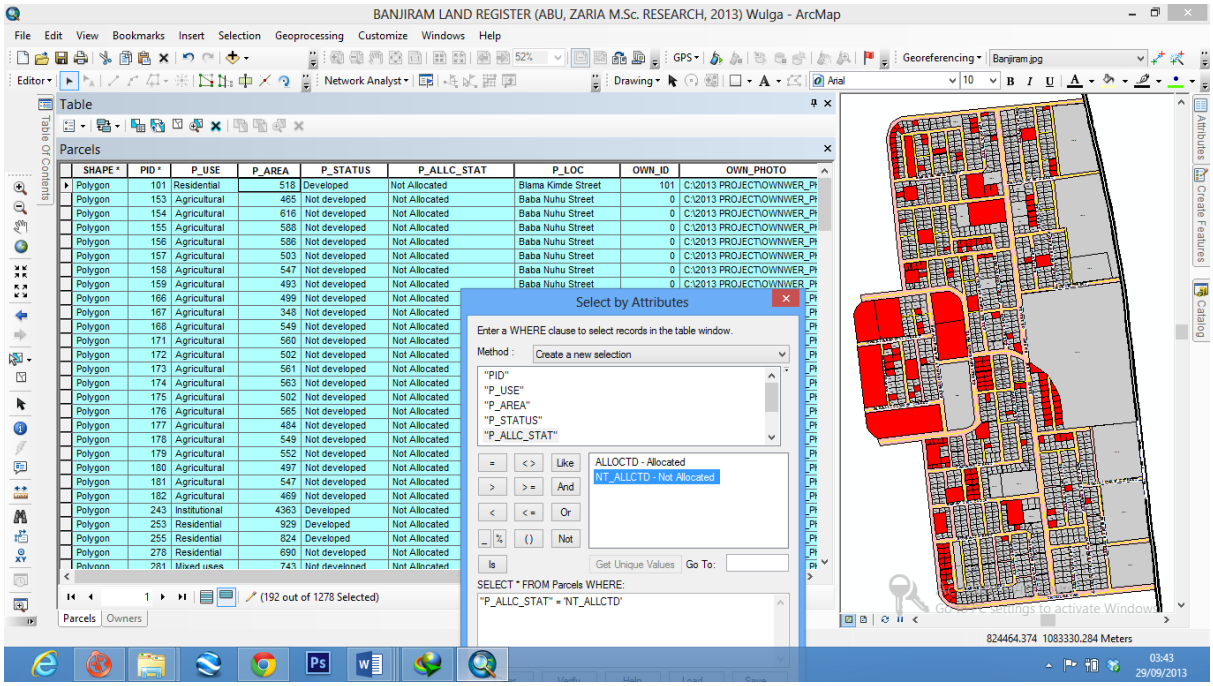


Figure 4.9: Query result showing parcels that are not allocated
Source: Author's Analysis

Figure 4.9 above shows the result of a query to select parcels that are not allocated. Selected parcels are shown in red and their attributes are shown in the attribute table. It showed that 192 out of the 1278 are not allocated. This represents 15.023%. See figure 4.10 below.

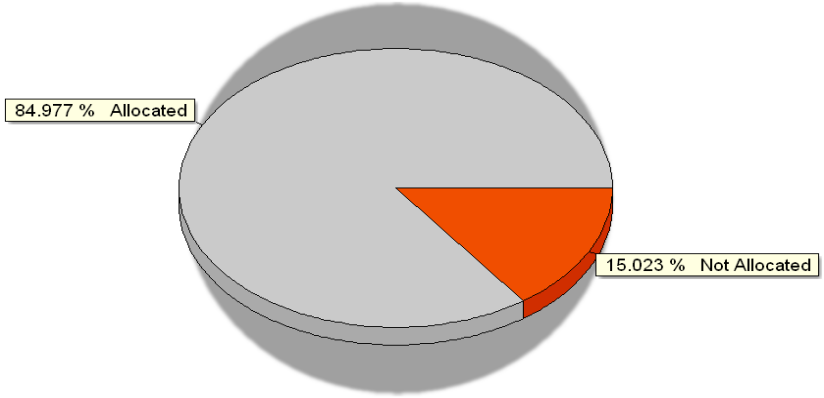


Figure 4.10: Graph of Land parcel allocation status (%).
Source: Author's Analysis.

4.2.8 Finding located along a particular street

QUERY: SELECT* FROM Parcels WHERE "P_LOC" = 'Senator Manasa Daniel Street'

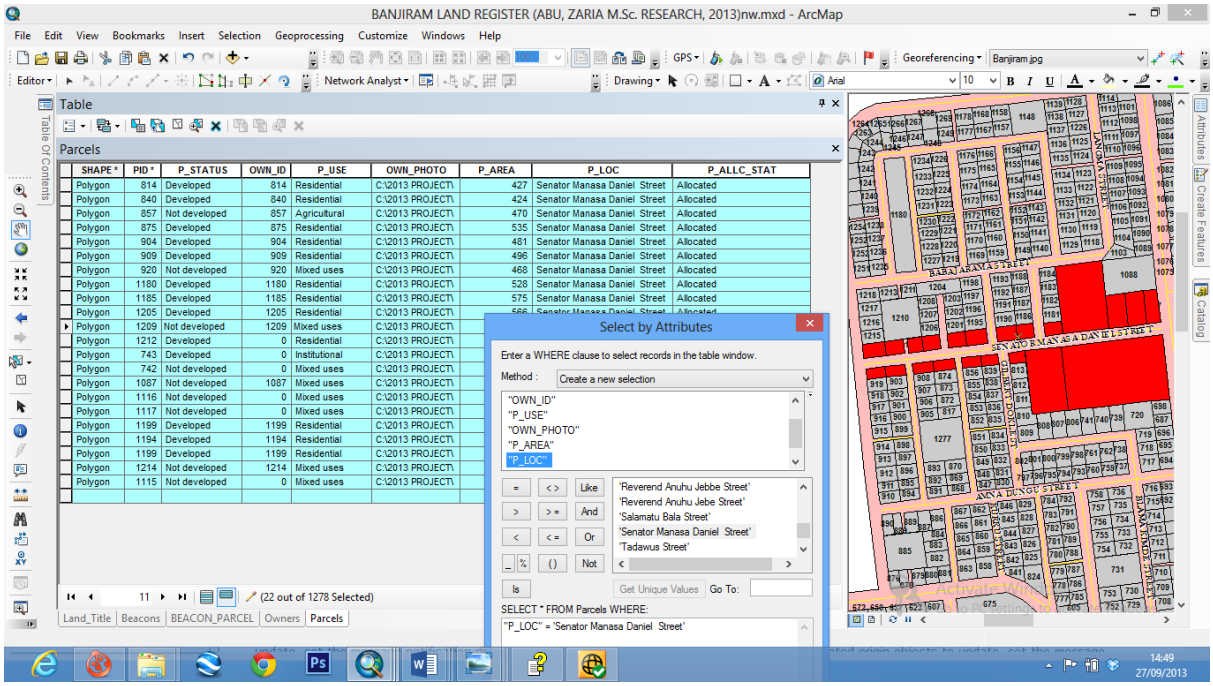


Figure 4.11: Query result showing parcels located along a particular street
Source: Author's Analysis.

Figure 4.11 above shows the result of a query to select parcels that are located along Senator Manasa Daniel Street. Selected parcels are shown in red and their attributes are shown in the attribute table.

4.2.9 Finding out parcels that are not developed

QUERY: SELECT* FROM Parcels WHERE "P_STATUS" = 'NOT_DDVP'

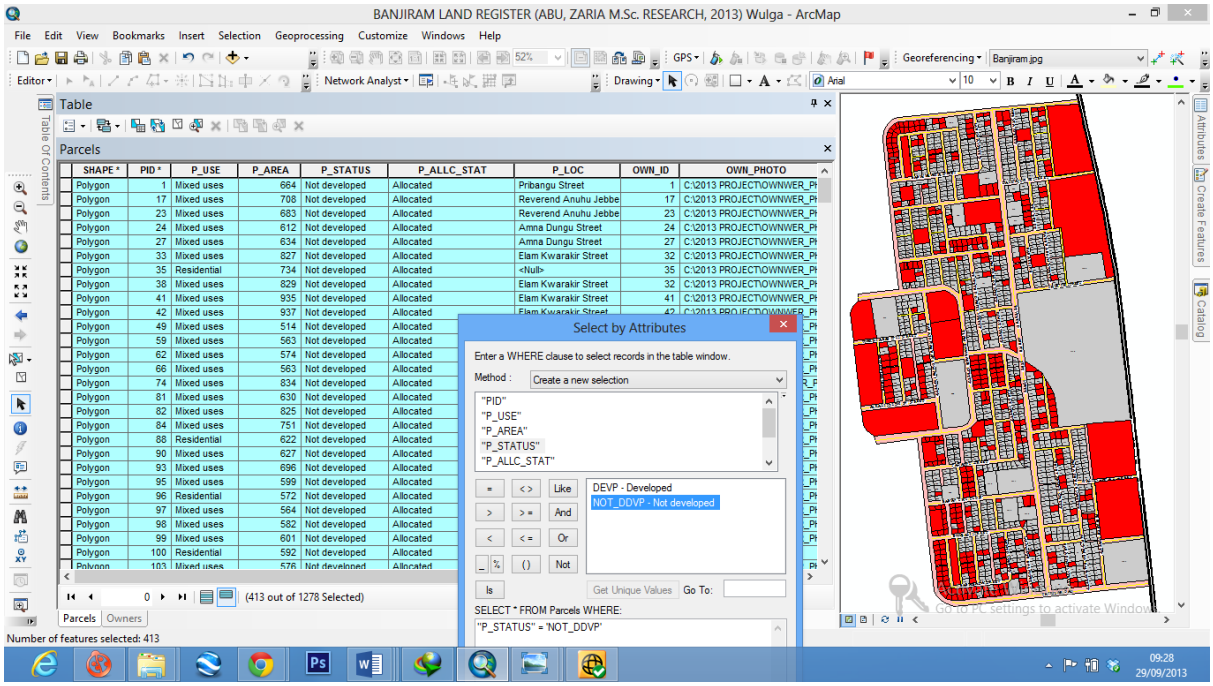


Figure 4.12: Query result showing parcels that are not developed

Source: Author's Analysis

Figure 4.12 shows a result of query to select parcels that are not developed. It showed that 413 out of the 1278 parcels are not developed. This represents 32.238% as shown on figure 4.13 below.

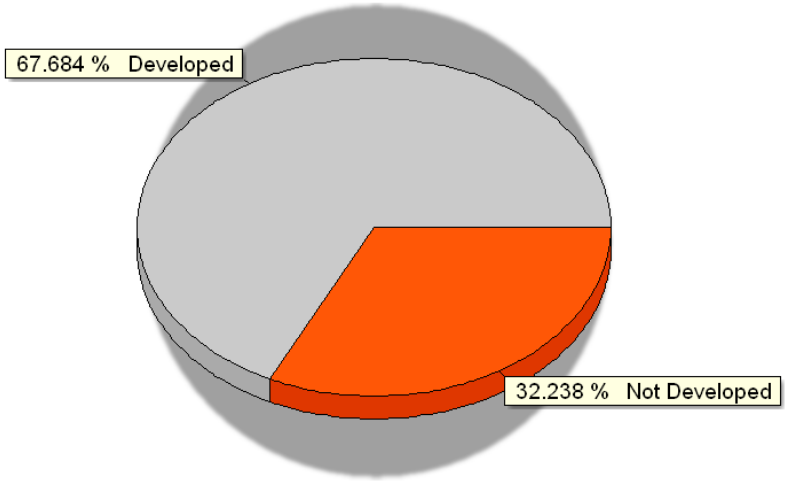


Figure 4.13: Graph of land development status (%).
Source: Author's Analysis.

4.2.10 Finding out parcels whose size is <= 600m square

QUERY: SELECT* FROM Parcels WHERE "P_AREA" <= ‘600’

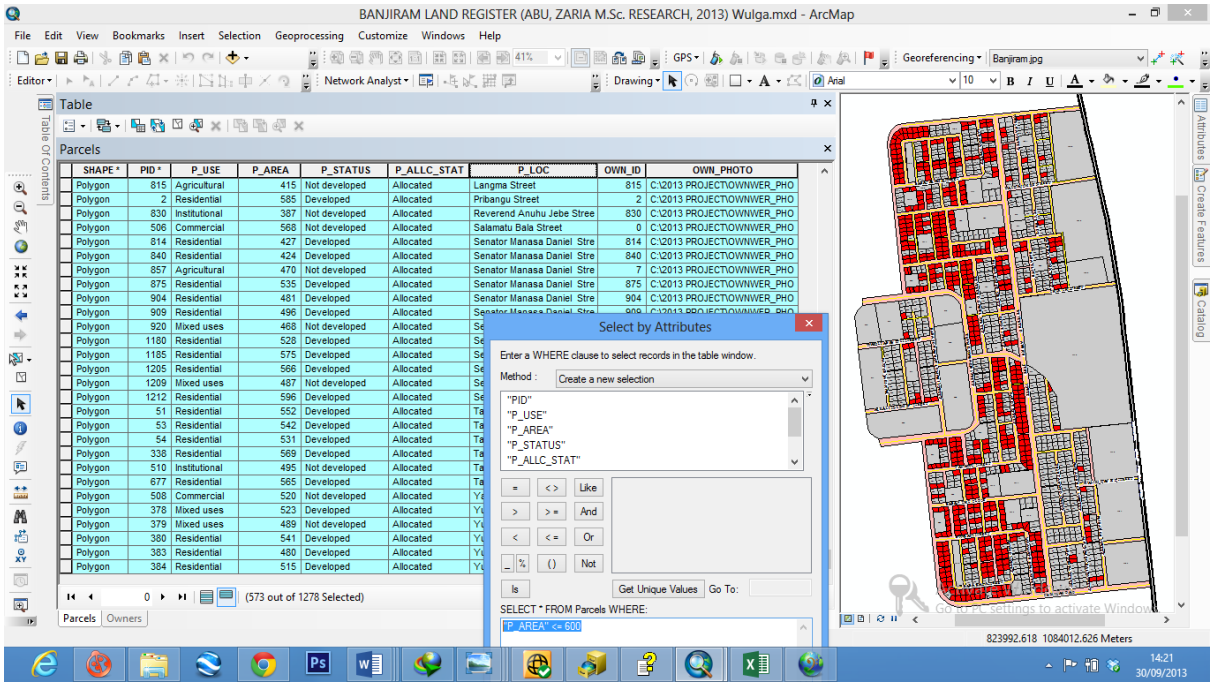


Figure 4.14: Query result showing parcels whose size is <= 600m square
Source: Author’s Analysis

Figure 4.14 show a result of a query to show parcels that are <= 600m square. 537 parcels out of the 1278 parcels were found.

4.2.11 Finding out parcels whose size is >= 1000m square

QUERY: SELECT* FROM Parcels WHERE "P_AREA" <= 1000’.

Figure 4.15 shows a result of a query to show parcels that are >= 1000m square. 64 parcels out of the 1278 parcels were found.

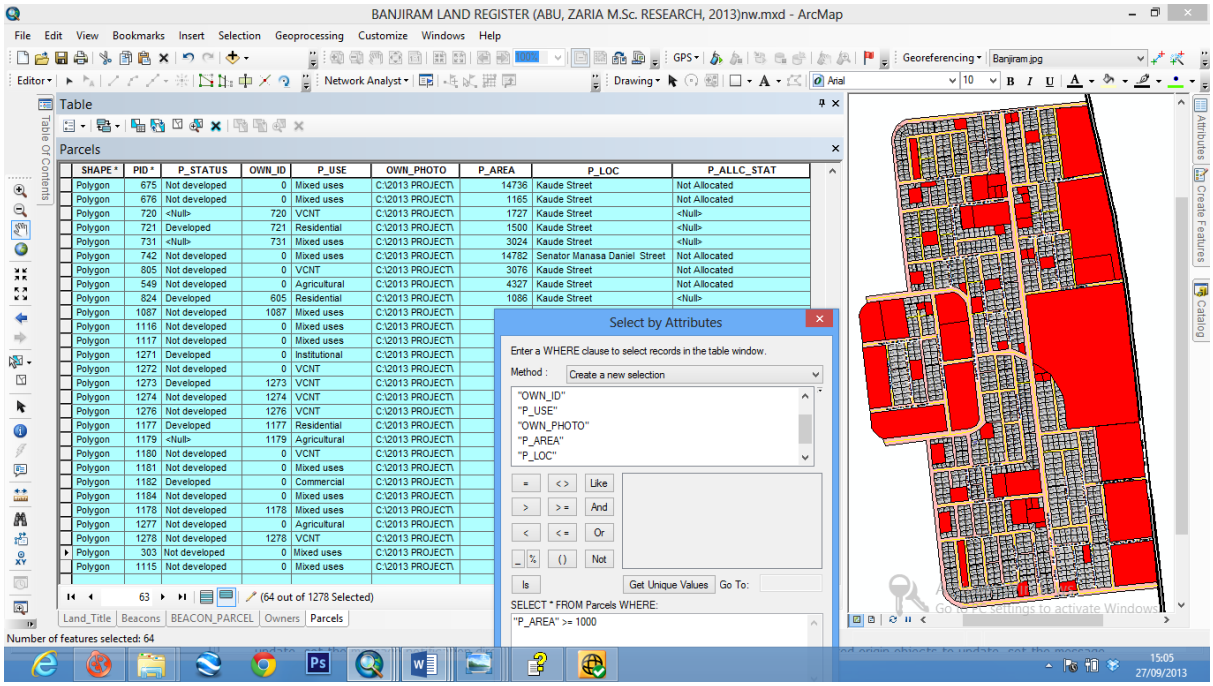


Figure 4.15: Query result showing parcels whose size is >= 1000m square
Source: Author's Analysis

4.2.12 Finding out Parcels that are Used for a Particular Purpose

4.2.12.1 Selecting parcels used for residential purpose

QUERY: SELECT* FROM Parcels WHERE "P_USE" = 'RES'

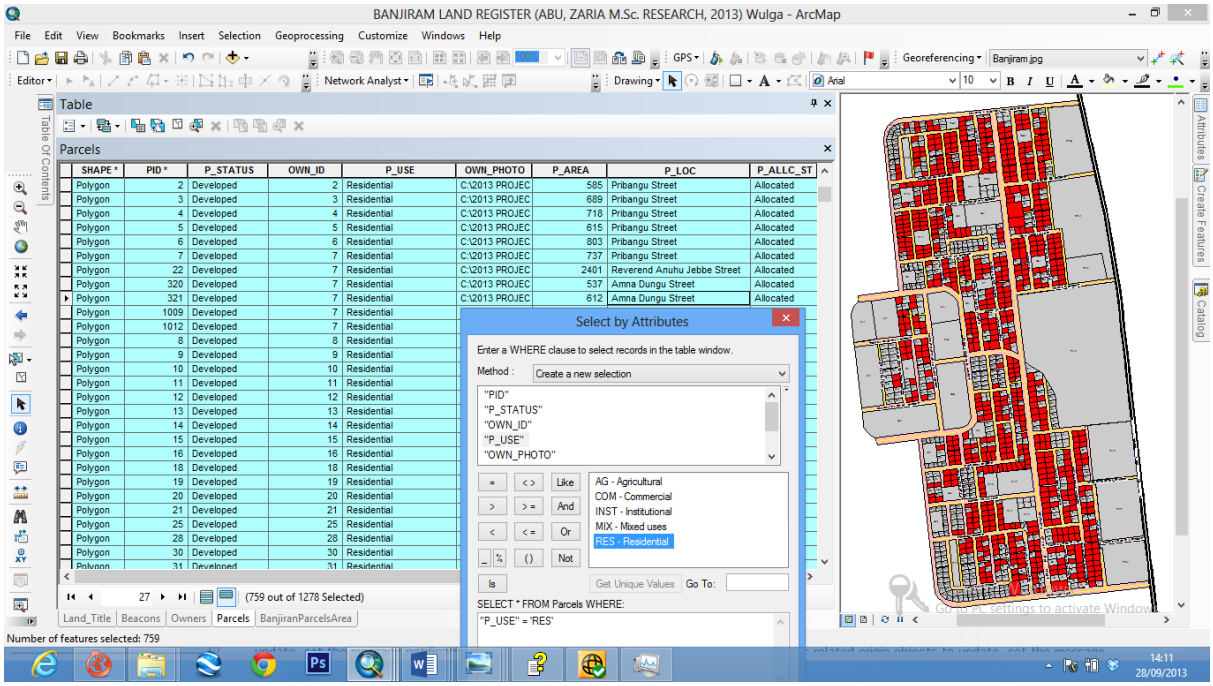


Figure 4.16: Query result showing parcels that are used for a residential purpose
Source: Author's Analysis

Figure 4.16 shows a result of a query to select parcels used for residential purpose. It showed that 759 out of the 1278 parcels are residential.

4.2.12.2 Selecting parcels used for commercial purpose

QUERY: SELECT* FROM Parcels WHERE Parcels WHERE "P_USE" = 'COM'

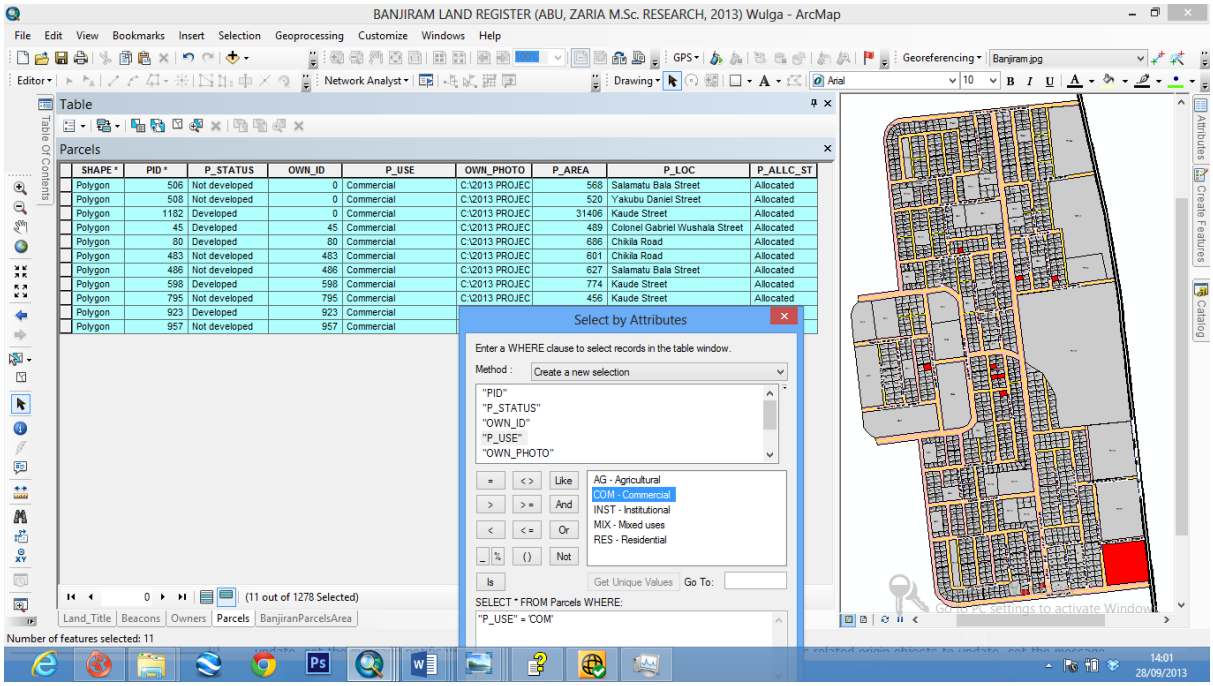


Figure 4.17: Query result showing parcels that are used for a commercial purpose
Source: Author's Analysis

Figure 4.17 shows a result of a query to select parcels used for commercial purpose. It showed that 11 out of the 1278 parcels are for commercial uses.

4.2.12.3 Selecting parcels used for institutional purpose

QUERY: SELECT* FROM Parcels WHERE "P_USE" = 'INST'

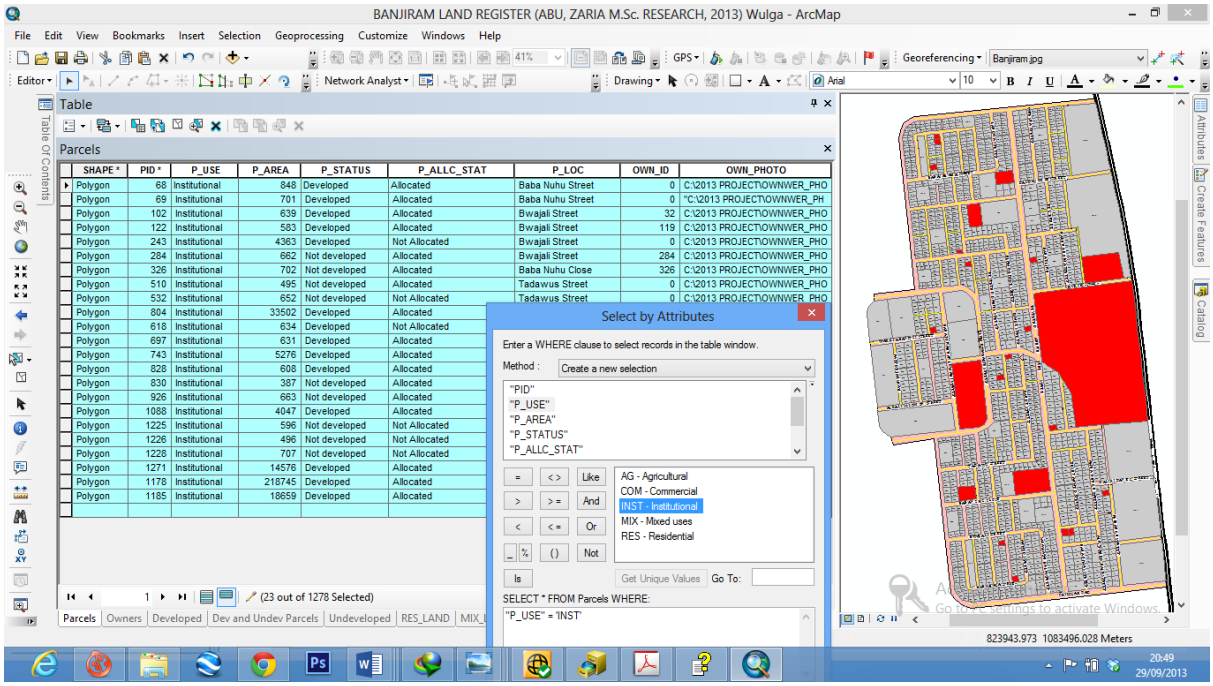


Figure 4.18: Query result showing parcels that are used for institutional purpose
Source: Author's Analysis

Figure 4.18 shows a result of a query to select parcels used for institutional purpose. 23 out of the 1278 parcels were found to be used for institutional purposes.

4.2.12.4 Selecting parcels used for agricultural purpose

QUERY: SELECT* FROM Parcels WHERE "P_USE" = 'AG'

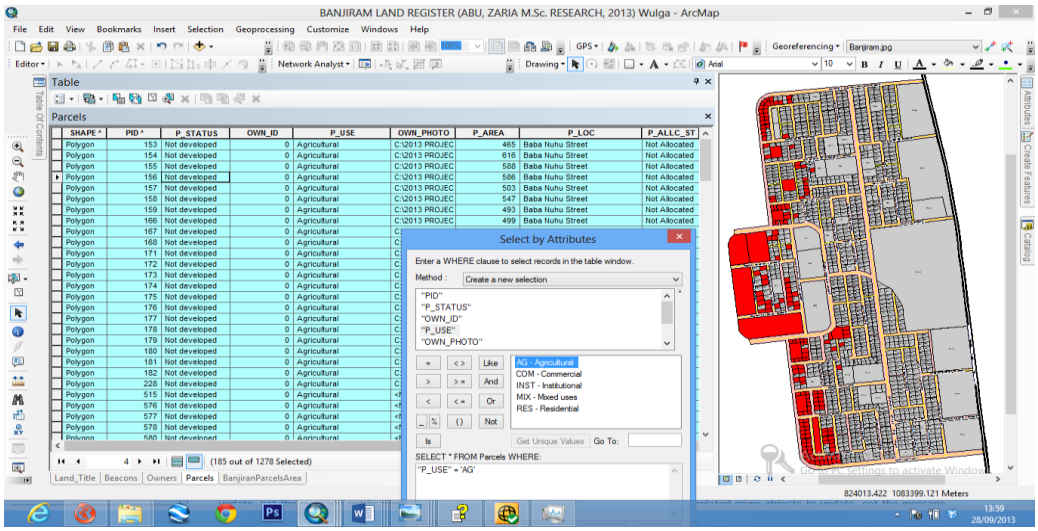


Figure 4.19: Query result showing parcels that are used for agricultural purpose

Source: Author's Analysis

Figure 4.19 shows a result of a query to select parcels used for agricultural purpose. About 185 out of the 1278 parcels were found to be used agricultural purposes.

4.2.12.5 Selecting parcels used for mixed purpose

QUERY: SELECT* FROM Parcels WHERE "P_USE" 'Mixed uses'

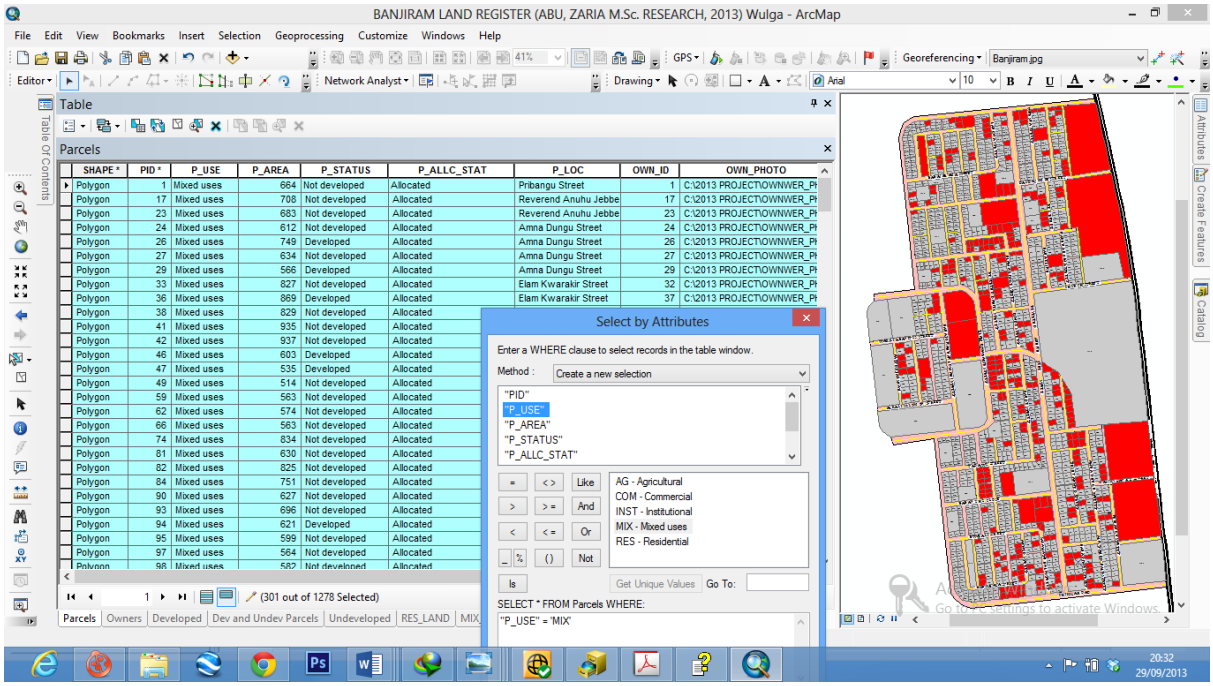


Figure 4.20: Query result showing parcels that are used for mixed purpose
Source: Author's Analysis

Figure 4.20 shows a result of the query to select parcels that are used for mixed purpose. 301 out of the 1278 parcels were found to be for mixed uses.

4.2.12 Land use statistic of parcels in Banjiram

As shown on table 4.1, there were 1278 parcel in the study area. About 759 were used for residential, 21 for institutional, 11 for commercial, 185 for agricultural and 301 for mixed purposes. See figure 4.22 for the bar chart of land use types and number of parcels and figure 4.23 for the land use map of the study area.

.

Table 4.1: Land use statistics of Banjiram

Land use type	Maximum Area (Sq m)	Average Area (Sq m)	Number of plots	Total Area (Sq m)	Percentage Area (%)
Residential	34639	4119	759	490672	31.9112
Institutional	218745	218745	21	308206	20.04623
Commercial	31406	3398.455	11	37383	2.43145
Agricultural	34639	1180.092	185	218317	14.1997
Mixed Uses	34639	69865	301	482898	31.40849
Total	**354068**	**297307.5**	**1278**	**1537476**	**100.00**

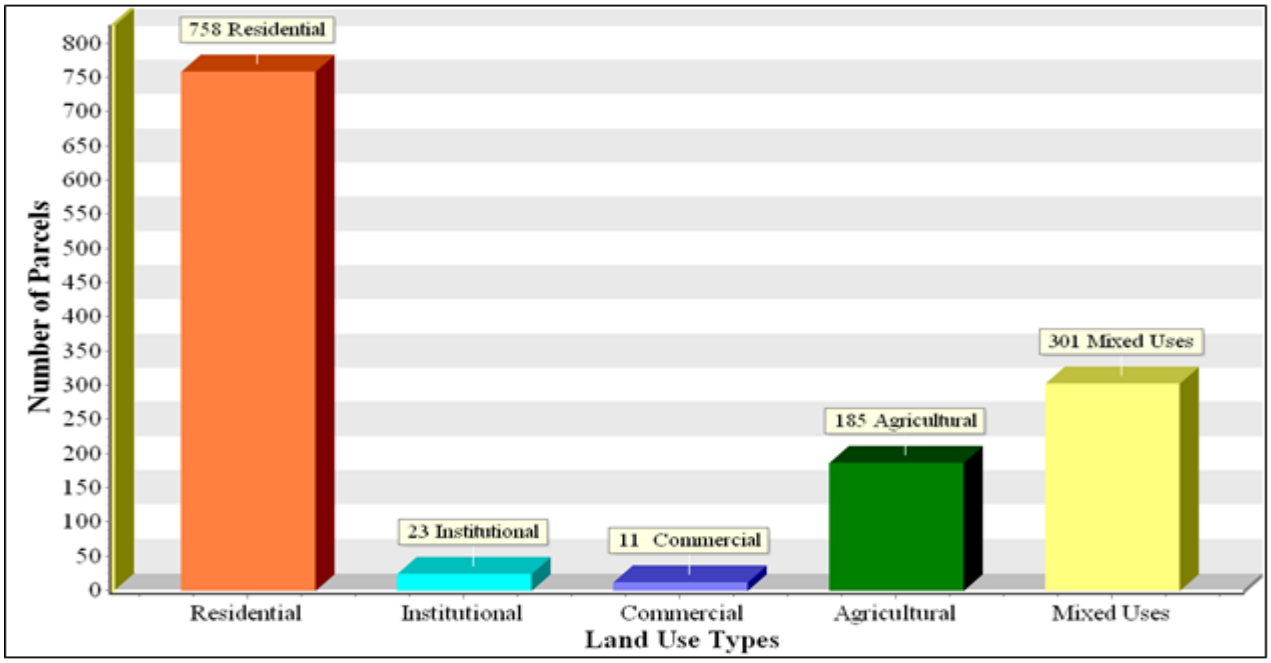


Figure 4.22: Bar Chart of Land Use Types and Number of Parcels
Source: Author's Analysis

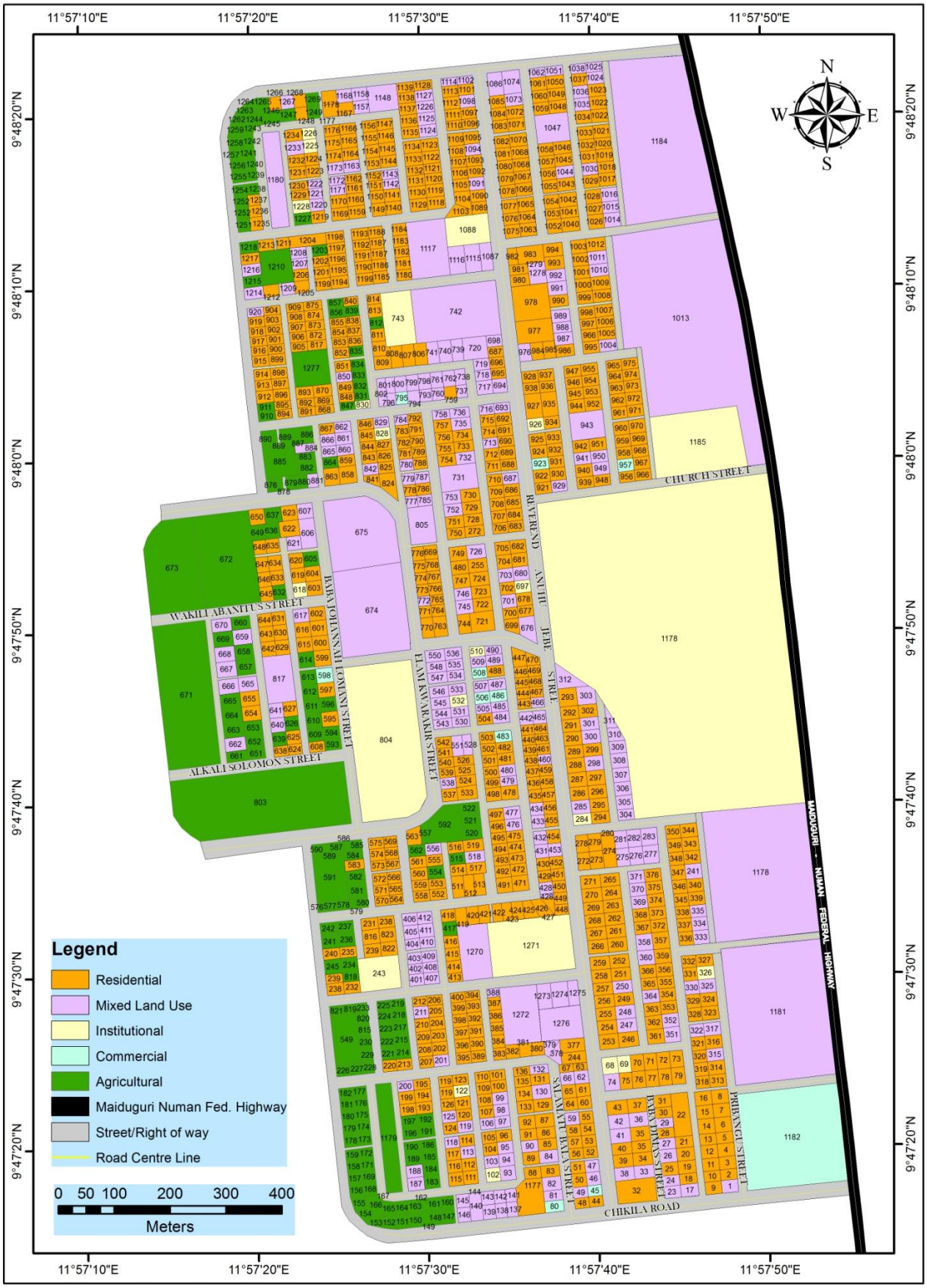


Figure 4.23: Land Use Map of Banjiram
Source: Researcher's Analysis

As shown on figure 4.24 about 32.238% of the 1278 parcels were not developed. About 1.91% were found to be used for residential purpose; 20.016% for institutional purpose; 2.431% for commercial purpose; 14.2% for agricultural purpose and 331.408% for mixed uses.

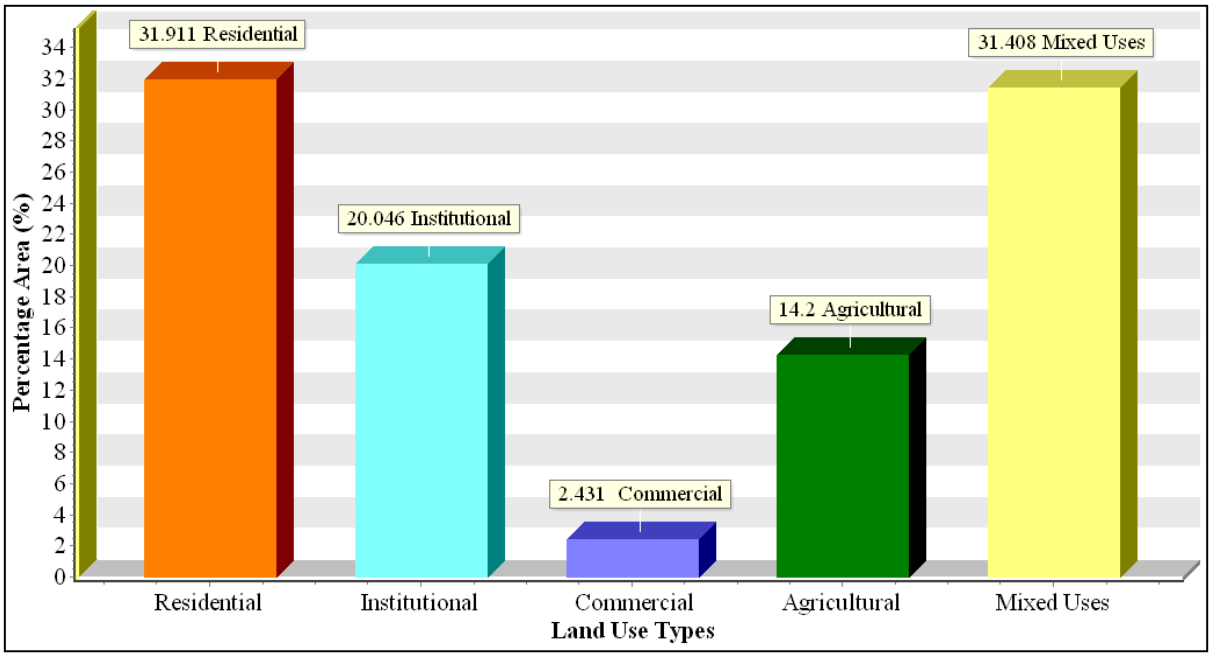


Figure 4.24: Bar Chart of Land Use Types and Number of Percentage Area
Source:
Author's Analysis

4.4 Report Creation

Reports were created for the four entities. Below are the screen shots of the reports.

Figures 4.25, 4.26, 4.27 and 4.28 shows report created for parcels, parcel owners, beacons and land title respectively. They contain the list of all attributes in each entity.



Figure 4.25: Parcels table report

Source: Author's analysis

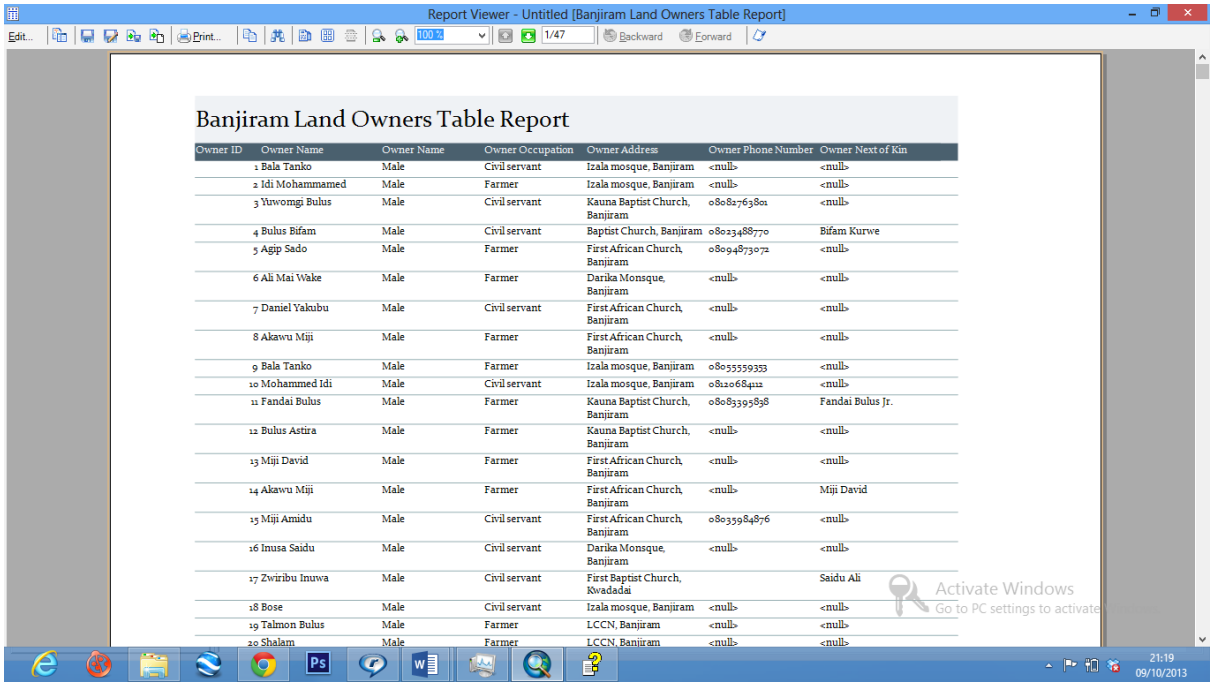
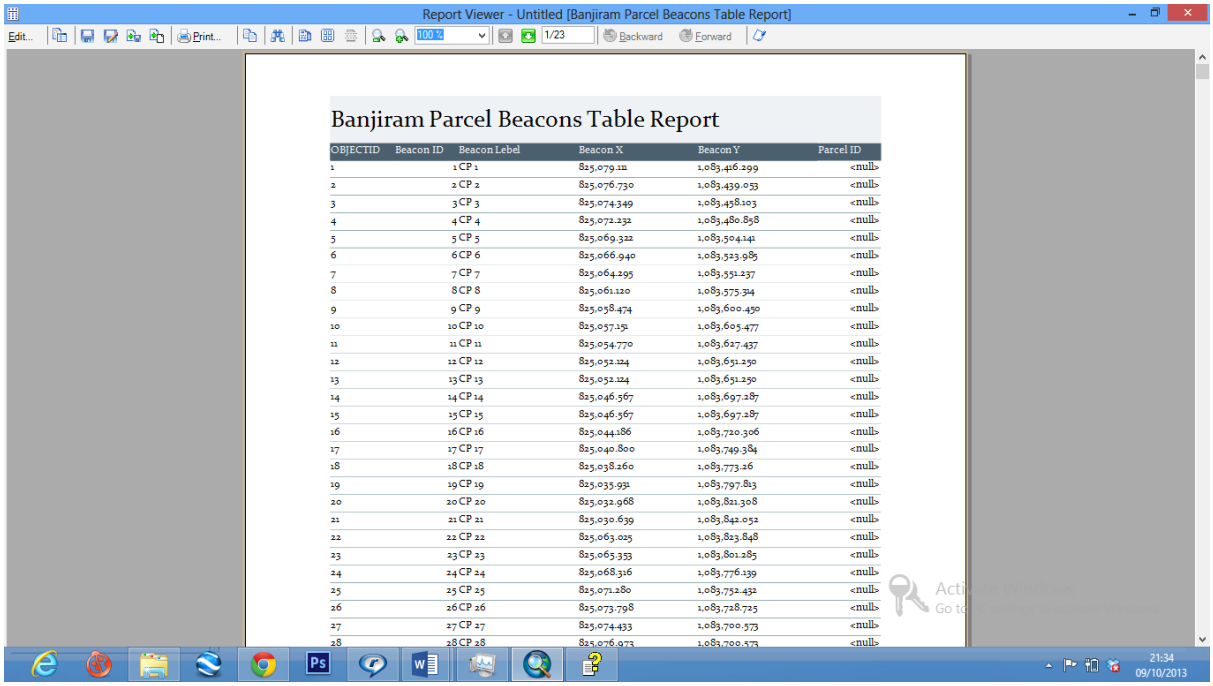


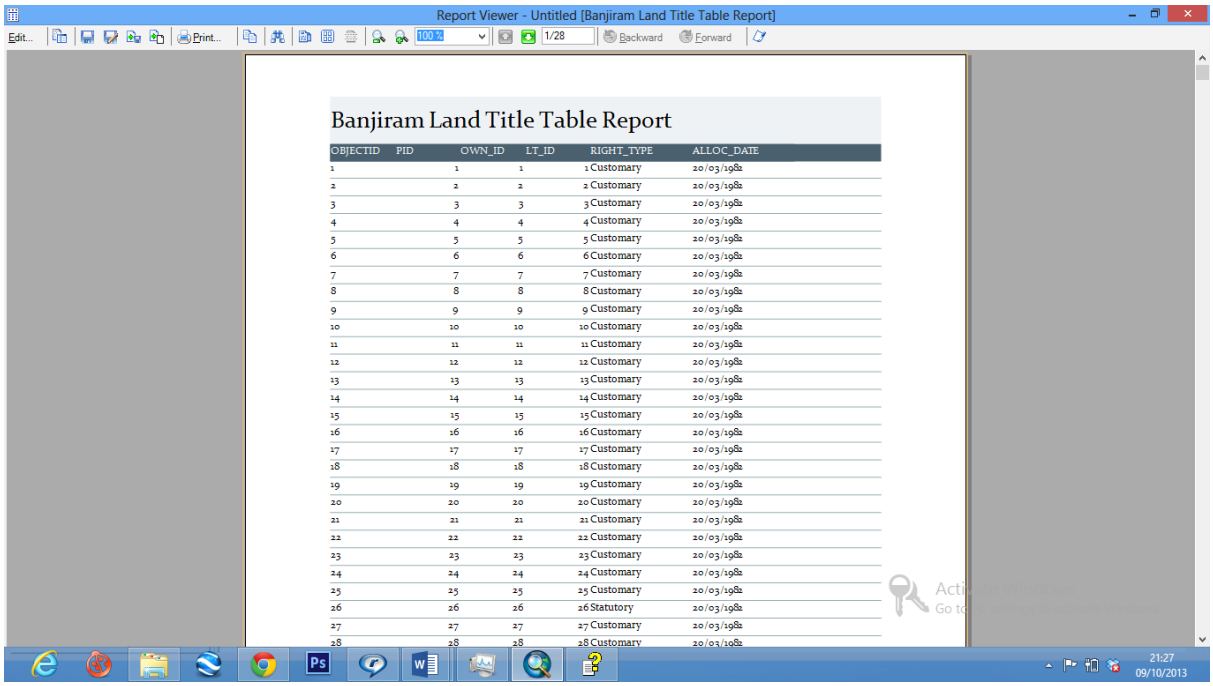
Figure 4.26: Land Owner table report

Source: Author's analysis



OBJECTID	Beacon ID	Beacon Lebel	Beacon X	Beacon Y	Parcel ID
1		1 CP 1	825,079.111	1,083,416.299	<null>
2		2 CP 2	825,076.730	1,083,439.053	<null>
3		3 CP 3	825,074.349	1,083,458.103	<null>
4		4 CP 4	825,072.232	1,083,480.858	<null>
5		5 CP 5	825,069.322	1,083,504.141	<null>
6		6 CP 6	825,066.940	1,083,523.985	<null>
7		7 CP 7	825,064.295	1,083,551.237	<null>
8		8 CP 8	825,061.120	1,083,575.314	<null>
9		9 CP 9	825,058.474	1,083,600.450	<null>
10		10 CP 10	825,057.151	1,083,605.477	<null>
11		11 CP 11	825,054.770	1,083,627.437	<null>
12		12 CP 12	825,052.124	1,083,651.250	<null>
13		13 CP 13	825,052.124	1,083,651.250	<null>
14		14 CP 14	825,046.567	1,083,697.287	<null>
15		15 CP 15	825,046.567	1,083,697.287	<null>
16		16 CP 16	825,044.186	1,083,720.306	<null>
17		17 CP 17	825,040.800	1,083,749.384	<null>
18		18 CP 18	825,038.260	1,083,773.26	<null>
19		19 CP 19	825,035.931	1,083,797.813	<null>
20		20 CP 20	825,032.968	1,083,821.308	<null>
21		21 CP 21	825,030.639	1,083,842.052	<null>
22		22 CP 22	825,063.025	1,083,823.848	<null>
23		23 CP 23	825,065.353	1,083,801.285	<null>
24		24 CP 24	825,068.316	1,083,776.139	<null>
25		25 CP 25	825,071.280	1,083,752.432	<null>
26		26 CP 26	825,073.798	1,083,728.725	<null>
27		27 CP 27	825,074.433	1,083,700.573	<null>
28		28 CP 28	825,076.973	1,083,700.573	<null>

Figure 4.27: Parcel Beacons table report
Source: Author's analysis



OBJECTID	PID	OWN_ID	LT_ID	RIGHT_TYPE	ALLOC_DATE
1		1	1	1 Customary	20/03/1982
2		2	2	2 Customary	20/03/1982
3		3	3	3 Customary	20/03/1982
4		4	4	4 Customary	20/03/1982
5		5	5	5 Customary	20/03/1982
6		6	6	6 Customary	20/03/1982
7		7	7	7 Customary	20/03/1982
8		8	8	8 Customary	20/03/1982
9		9	9	9 Customary	20/03/1982
10		10	10	10 Customary	20/03/1982
11		11	11	11 Customary	20/03/1982
12		12	12	12 Customary	20/03/1982
13		13	13	13 Customary	20/03/1982
14		14	14	14 Customary	20/03/1982
15		15	15	15 Customary	20/03/1982
16		16	16	16 Customary	20/03/1982
17		17	17	17 Customary	20/03/1982
18		18	18	18 Customary	20/03/1982
19		19	19	19 Customary	20/03/1982
20		20	20	20 Customary	20/03/1982
21		21	21	21 Customary	20/03/1982
22		22	22	22 Customary	20/03/1982
23		23	23	23 Customary	20/03/1982
24		24	24	24 Customary	20/03/1982
25		25	25	25 Customary	20/03/1982
26		26	26	26 Statutory	20/03/1982
27		27	27	27 Customary	20/03/1982
28		28	28	28 Customary	20/03/1982

Figure 4.28: Land Title table report.
Source: Author's analysis

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter a review of the purpose and objective established at the outset of the study are discussed. This chapter also states limitations of this study. Appropriate conclusions drawn from the findings of this research are also presented. Recommendations made are presented as well.

5.2 SUMMARY OF THE STUDY

The purpose of this study was to apply Remote Sensing and GIS in carrying out cadastral mapping in Banjiram, Adamawa state, Nigeria.

This study depended on Remote Sensing for carrying out adjudication which provided information on land ownership and ownership information. A remotely-sensed high resolution Google Earth imagery of Banjiram that was acquired in November, 2013 was used to build an index map by overlaying the delineated parcels from the layout plan to enable easy identification of land parcel on the map by the land owners themselves during adjudication (fieldwork).

Geographic Information System (GIS) majorly used to build a digital cadastral map (database) using the data obtained from the field and those generation from the layout plan. The cadastral database allows the entry, updating, display and generation of results and report.

5.3 SUMMARY OF FINDINGS

Remote Sensing and GIS are powerful tool in mapping and analysing land information. It has been found that there are 1278 parcel with 1166 owner. It was found that

192 (15.023%) out of the 1278 parcels were not allocated. It was also that 413 (32.238%) out of the 1278 parcels are not developed. Out of the 1278 parcels: 758 (31.91%) were found to be used for residential purpose; 32 (20.016%) for institutional purpose; 11 (2.431) for commercial purpose; 158 (14.2%) for agricultural purpose and 301 (31.408%) for mixed uses. Table 5 shows the land use statistic of parcels in the study area.

5.4 CONCLUSION

GIS and Remote Sensing have been proven to be efficient in cadastral mapping. They allow easy means of collecting, analysing, updating, storing and communicating vast amount of land information which is necessary for informed decision making. This research has come to a conclusion that Remote Sensing and GIS are important tools for carrying out cadastral mapping most especially in areas where land records do not exist. The digital cadastral map (database) can provide various kinds of information in different forms (reports, graphs, maps, etc.). High resolution imagery-based adjudication has proven to be interesting to land owners as they can see and identify boundaries of their parcels. Moreover, community participation in carrying systematic adjudication is crucial to the success achieved in carrying out this research.

5.5 RECOMMENDATIONS

The method applied in this study in carrying out cadastral mapping could serve as a template for other areas. The process of land adjudication used in this research could help in land registration especially, in area where no land record ever existed.

There is a need for authorities responsible for land management to use the result and data provided by this research as a basis for providing official Certificates of Occupancy (C of O) to land owners in the study area.

There is great need for land management authorities to keep updating the cadastral database provided by this research to keep it up-to-date.

There present highly centralized system of land management in Nigeria where the process of obtaining an official certificate of occupation is confusing and inaccessible in terms of money and distance to poor customary land should be looked into. Land office should be set up at a community level where poor land owner can go and register or access information on any land parcel.

5.6 RECOMMENDATIONS FOR FUTURE RESEARCH

The findings and recommendations from this study suggest some future research topics related to this particular area. This research is mainly concerned with mapping land ownership and use. It is recommended that broader base research such as those that would involve multipurpose cadastral mapping which would incorporate not only land ownership and use, but also; tax information, natural resources, utilities, etc. be carried out.

REFERENCES

Ablameyko, S. (1997). An Introduction to Interpretation of Graphic Images, The society of Optical Engineering, Belligharm, Washington.

Addai, A., Owusu, J., Poku – Gyamfi, Y., and Gyambibi, D. A. (2011). Systematic Land Title Registration: A Dynamic Approach to Land Registration Using GIS. Paper presented at FIG Working Week 2011 in Morocco.

Adebayo, A. A. and Tukur, A. L. (1999). Adamawa State in Maps, 1st Ed., Paraclete Publishers. Yola. P. 8.

Adeel, M. (2010). Evaluating the role of cadastre maps in Pakistan's Land Administration: A GIS Perspective. Paper presented at FIG Congress 2010 in Sydney, Australia. P10.

Adeniyi, P. (2013). In Vangard Newspaper (2013). 97.5% of Nigeria's land not registered – Presidential Committee. Available at http://www.vanguardngr.com/2013/02/97-5-of-nigerias-land-not-registered-presidential-committee/. Accessed on March 14, 2013.

Akingbade, A. O., Navarra, D. D., & Georgiadou, Y. (2010). The impact of Abuja Geographic Information Systems on corrupt practices in land administration in the Federal Capital Territory of Nigeria. IFIP technical Commission, 9.

Albert, J., Edmund, O., Merem, C., and Yaw, A. T. (2006). Use of GIS and Remote Sensing Technology as a Decision Support Tool in Land Administration –The Case of Lagos, Nigeria. 5th FIG Regional Conference Accra, Ghana, March 8-11, 2006. 12-15.

Andersson, S. (1986). Cadastre as a Base for Land Information Systems. International Federation of Surveyors-FIG XVIII Congress, Toronto, Canada: FIG. 369-378.

Babalola, S. O. & Kardam, M. S. (2012). Developing a Cadastral Information System for Part of Fadaman-Mada Area of Bauchi Metropolis for Sustainable Development. *ATBU Journal of Environmental Technology, 4(1), 105-118.*

Bekure, S., Abegaz, G., Frej, L., and Abebe S. (2006). Standardization of Rural Land Registration and Cadastral Surveying Methodologies. Proceedings of a National Conference. Addis Ababa, Ethiopia.

Bell, K. C. (2009). Trends in Land Administration and Management with Particular Reference to World Bank Support for Projects in the East Asia Region. *International Federation of Surveyors (FIG) Article of the Month* – November 2009.

Birner, R. and Okumo A. (2011). Challenges of Land Governance in Nigeria: Insights from a Case Study in Ondo State. *Nigeria Strategy Support Program (NSSP) Working Paper* No. 22 October 2011. Institute of Agricultural Economics and Social Science in the Tropics and Sub-Tropics, Hohenheim University, Stuttgart, Germany.

Borzacchiello, M., and Craglia, M. 2012. 'Estimating benefits of Spatial Data Infrastructures: A case study on e-Cadastres.' Computers, Environment and Urban Systems. Elsevier Ltd. Retrieved February 28 2013, from http://www.sciencedirect.com/science/article/pii/S019897151200052X,

Dale, P. & McLaughlin, J. (1999). Land Administration. Oxford University, New York, USA.

De Soto, H., (2000). The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else. Basic Books, London.

Delville, P. L. (2006). Registering and Administering Customary Land Rights: PFRs in West Africa, World Bank, London.

Edmead N. (2010). Open Title: a Low Cost Tool for Inventorying Property Rights - Experiences from Ghana. A paper presented At FIG Congress on 'Facing the Challenges – Building the Capacity' held in Sydney, Australia, 11-16 April 2010.

FIG (1995*). FIG Statement on the Cadastre*, International Federation of Surveyors Bureau, Canberra, Australia. Retrieved 12 February, 2012, from http://www.sli.unimelb.edu.au/fig7/cadastre/statement_on_cadastre.html

Elayachi, M., & Semlali, E. (2001, October). Digital cadastral map: a multipurpose tool for sustainable development. In Proceedings of international conference on spatial information for sustainable development, Nairobi, Kenya (pp. 2-5).

Gavish, J. & Ester Benin (2009). A GIS Based Cadastral Database at the Survey of Israel - Infrastructure for Future Modern, High Accuracy Cadastre. FIG Working Week 2009 Surveyors Key Role in Accelerated Development Eilat, Israel, 3-8 May 2009

Glaskin, K. (2003). Native title and the" bundle of rights' model: Implications for the recognition of Aboriginal relations to country. In *Anthropological Forum* (Vol. 13, No. 1, pp. 67-88). Taylor & Francis Group.

Goodchild, M. F. (1991). Geographic information systems. *Journal of Retailing*, *67*(1), 3-15.

Goodwin, D. W. (1994). Digital parcel mapping using orthophotoquad base maps: A working model, Doctoral dissertation, University of Massachusetts, Amherst.

Guanfu, S., & Ershun, Z. (1998). Research and Development of Components Geographic Information Systems [J]. *Journal of Image and Graphics*, *4*.

Hanstad, T. (1997). Designing Land Registration Systems for Developing Countries. Am. U. Int'l L. Rev., 13, 647.

Harcombe, P. R., & Williamson, I. (2003). A Cadastral model for Low Value Lands: The NSW Western Lands Experience. University of Melbourne, Department of Geomatics.

Haunold, P., & Kuhn, W. (1994). A keystroke level analysis of a graphics application: Manual map digitizing. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 337-343). ACM.

Henssen, J. (1995). Basic principles of the main cadastral systems in the world. In Proceedings of the One Day Seminar held during the Annual Meeting of Commission 7, *Cadastre and Rural Land Management*, of the International Federation of Surveyors (FIG).

Hespanha, J. P., Van Oosterom, P., Zevenbergen, J., & Dias, G. P. (2006). A modular standard for the cadastral domain: Application to the Portuguese Cadastre. *Computers, environment and urban systems, 30*(5), 562-584.

Jain M. (2009). GIS and Remote Sensing Techniques- a case study of a developing urban centre. Himanshu Publication. New Delhi, India.

Jing, Y. (2011). Assessing Larsi-Integrated Participation Procedure for Urban Adjudication in China (Doctoral dissertation, Dissertação. University of Twente. Ensched, Holanda, 2011. 105 páginas.

Kabir K. H. (2009). An Investigation into Geospatial Tools for a Multipurpose Digital Cadastre Prototype in Bangladesh -A Case Study of Kotwali Thana of Dhaka City Kazi Humayun Kabir. An MSc. Thesis, School of Architecture and the Built Environment Royal Institute of Technology (KTH) 100 44 Stockholm, Sweden. P1.

Kenya, K. W. & D, O. (2006). High Spatial Resolution Imagery for pid Improvement in Kenya, FIG Working Week 2006, 8-13 October, 2006, Munich, Germany.

Lawrence, J. C. D. (1985). Land Adjudication, A paper presented on World Bank seminar on Land Information System. Washington DC. World Bank seminar on Land Information System.

Lemmen C., Zevenbergen J., Lengoiboni M., Deiniger, K. and Burns T. (2009). First experiences with High Resolution Imagery Based Adjudication Approach for Social Tenure Domain Model in Ethiopia. Paper presented at FIG – World Bank Conference on Land Governance in Support of the Millennium Development Goals – Responding to New Challenges Washington D.C.

Levachkine, S., & Guzmán-Arenas, A. (2004). Hierarchies measuring qualitative variables. In Computational Linguistics and Intelligent Text Processing (pp. 262-274). Springer Berlin Heidelberg.

Mabogunje, A. L. (2010). Land reform in Nigeria: progress, problems & prospects. Retrieved December 12, 2013, from http://siteresources.worldbank.org/EXTARD/Resources/336681-1236436879081/5893311-1271205116054/mabogunje.pdf.

MASSGIS. (2002). Land use datalayer for the year 1999. *MassGIS, Commonwealth of Massachusetts*.

McLaren, R. A. (2011) Crowdsourcing Support of Land Administration. RICS, London.

McLaughlin, J. D., & Nichols, S. E. (1989). Resource management: the land administration and cadastral systems component. *Surveying and mapping*, *49*(2), 77-85.

Meijs, M. G., Kapitango, D., & Witmer, R. (2009). Land Registration using aerial photography in Namibia: Costs and lessons. In FIG–World Bank Conference on Land Governance in Support of the MDGs: Responding to New Challenges. Retrieved March 11, 2013 from http://siteresources.worldbank.org/INTIE/Resources/M_Meijs_&_D_Kapitango.doc.

Nuhu, M. B. (2009). Enhancing Land Titling and Registration in Nigeria FIG Working Week 2009 Surveyors Key Role in Accelerated Development Eilat.

Oboli, C. E. and Akpoyoware, A. O. (2010). Reform in Cadastre and Land Administration in Nigeria-Coping with Challenges in Development. FIG Congress 2010 Facing the Challenges – Building the Capacity Sydney, Australia.

Orisakwe, K. U., & Bakari, G. (2012). On the Development of Cadastral Information System for Part of Kofare Government Residential Area of Jimeta-Yola in Adamawa State of Nigeria. FIG Working Week 2013, Abuja, Nigeria.

Phadke, D. N. (2006). *Geographical Information Systems (GIS) in library and information services*. Concept Publishing Company.

Sengupta, A., Bandyopadhyay, D., Lemmen, C., & van der Veen, A. (2013). Potential use of LADM in cadastral data-management in India. *International Land System* (ILS).

Star, J., & Estes, J. (1990). Geographic information systems. *An Introduction. Englewood Cliffs, New Jersey (USA)*.

Stephen J. Ventura. (1997). Land Information Systems and Cadastral Applications, *NCGIA Core Curriculum in GIScience*, http://www.ncgia.ucsb.edu/giscc/units/u164/u164.html, posted October 23, 1998.

Struck, O. and Kevin, P. (1999). "Measuring Parcel Mapping Accuracy.", GIS Frontiers: http://www.gisfrontiers.com/page15.html. Internet. Accessed April 25, 1999.

Sugumaran R. & Degroote J. (2011). Spatial Decision Support Systems: Principles and Practices. Tarlor and frands Group LLC. USA.

Tomlinson, R. (2007). Thinking about GIS: Geographic Information System Planning for Managers. ESRI Press, New York.

Ukaejiofo, A. N. (2009). Identifying Appropriate Tools for Land Governance in Nigeria. Paper presented at the 7th FIG Regional Conference on 'Land Governance and the Environment – Building the Capacity' held in Hanoi, Vietnam, 19-22 October, 2009.

Uluocha, N. (2012). Fifty Years of Post-Colonial Mapping in Nigeria: An Overview. Cartographica: *The International Journal for Geographic Information and Geovisualization*, *47*(3), 179-194.

United Nations Economic Commission for Africa (2009). Executive Summary: An integrated Geo-information (GIS) with emphasis on cadastre and land Information Systems (LIS) for decision-makers in Africa, First Meeting of the Committee on Development Information (CODI) Addis Ababa, Ethiopia.

United Nations Economic Commission for Europe (UNECE), (2005). Social and Economic Benefits of Good Land Administration. UNECE, London.

Usman, B. (2010). Cadastral Information System for Title Management in Nigeria. *Pacific Journal of Science and Technology, 11*(2), 408-415.Ventura, S. J. (1995). The use of geographic information systems in local government. *Public Administration Review,* 461-467.

Williamson, I. and L. Ting (1999). Land Administration and Cadastral Trends – A Framework for Re-engineering. UN-FIG International Conference on Land Tenure and Cadastral Infrastructures for Sustainable Development, Melbourne, Australia.

Williamson, I. P. (1986). Cadastral and Land Information Systems in Developing Countries. *The Australian Surveyor* 33.No. 1: 27-43.

Zevenbergen, J. (2002). Systems of land registration; aspects and effects. NCG, Netherlands Geodetic Commision, Delft, The Netherlands.

APPENDIX 1

CADASTRAL MAPPING USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (GIS) IN BANJIRAM, ADAMAWA STATE, NIGERIA

QUESTIONNAIRE/ADJUDICATION FORM

I am WulgaBulusYuwomgi, a Postgraduate student in Ahmadu Bello University, Zaria and in pursuit of an M.Sc. in Remote Sensing and Geographic Information System. My Thesis Topic is Cadastral Mapping using Remote Sensing and Geographic Information System (GIS) In Banjiram, Adamawa state, Nigeria.

Please fill the form/Questionnaire or provide the required information. This information will not be used for reasons other than research intended to secure the rights of land owners. Thank you.

Section A: Parcel owner personal data.

1) First name:
2) Surname:
3) Owner Identification Number:
4) Sex: Male ☐ Female ☐
5) Occupation: Farmer ☐ Civil servant ☐ Others ☐
6) Address
7) Phone Number:
8) Sign…….. Or Thumb print

Section B: Parcel data

1) Parcel Identification Number:
2) Parcel Size (square metre)
3) Parcel use: Residential ☐ Agricultural ☐ Commercial ☐ Institutional ☐ Mixed ☐
4) Parcel allocation status: Allocated ☐ Not allocated ☐
5) Parcel status: Developed ☐ Not Developed ☐
6) Parcel Address (Street name, Block, Subdivision):

Section C: Land Title Information

7) Right of Occupancy: Statutory ☐ Or Customary ☐

8) Year of Acquisition | 1 | 9 | | | | 2 | 0 | | |

Section D: Next of kin (Optional)

1) F
irst Name:

2) S
urname:

3) A
ddress:

Section E: Endorsement

Neighbouring land owner 1:

1) Name:

2) Sign…… Or Thumbprint

Neighbouring land owner 2:

1) Name

2) Sign……. Or Thumb print

Village Head:

1) Full Name:

2) Sign……. Or Thumb print