

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

USING ICT TOOLS IN MANAGING CUSTOMARY LAND, DEMARCATION, CONFLICT AND TENURE DATA IN DEVELOPING COUNTRIES: A CASE STUDY OF ZAMBIA

BY

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**A Dissertation submitted to the University of Zambia in partial
fulfilment of the requirements for the award of the degree in Masters
of Engineering in Information Communication Technology (ICT)
Security.**

2016

DECLARATION

I, the undersigned, declare that this has not previously been submitted in candidature for any degree. The dissertation is the result of my own work and investigations, except where otherwise stated. Other sources are acknowledged by given explicit references. A complete list of references is appended.

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DEDICATION

I dedicate all the works to my mother (Mrs. Anna Mpolokoso) and my late father, Mr. Luciano Lushinga Mpolokoso.

LIST OF KEYWORDS

Land demarcations

PGIS

ICT

Mobile Application

Land allocation

Boundary conflicts

LIST OF ABBREVIATIONS

GIS	Geographic Information Systems
PGIS	Participatory geographical information system
ICT	Information Communication Technology
ZLA	Zambia Land Alliance
RS	Remote Sensing
LIS	Land Information System
GPS	Geographical Positioning System
LBS	Location-Based Service
RDBMS	Relational Database Management Systems
GNSS	Global Navigation Satellite Systems
LiDAR	Light Detection and Ranging
NSDI	National Spatial Data Infrastructures
SMS	Small Messaging System
STDM	Social Tenure Domain Model
LAS	Land Administration System
LAN	Local Area Network
LAP	Land Administration Project
CLS	Customary Lands Secretariats
LMC	Land Management Committee
OASL	Office of the Administrator of Stool Lands
CBD	Customary Boundary Demarcation
LMP	Land Management Paradigm
FAO	Food and Agriculture Organisation
SOLA	solution for open land administration
MAST	Mobile Applications to Secure Tenure
USAID	United States Agency for International Development
LADM	Land Administration Domain Model
ERD	Entity Relationship Diagram

ABSTRACT

Abstract – The high demand for customary land due to urban-rural migration has brought about domestic and international land boundary conflicts in Zambia. The unsuitable land demarcation mechanism and partial documentation of customary land parcels has contributed to the prevailing land disputes. The study proposes the utilization of Information Communication Technology (ICT) tools such as the Participatory Geographical Information System (PGIS) and the mobile application in the implementation of the customary land management system. ICT will facilitate the demarcation process of customary land boundaries and documentation of land records thereby reducing land conflicts and provide security of tenure. The study began by a baseline survey in Chief Munkonge’s chiefdom in Northern Province to ascertain the methods and type of information used in customary land management. The females and males that owned land and were above the age of eighteen (18) years were the main target. Based on the baseline study, a mobile based application was developed using PGIS technologies.

In the baseline study, the results showed that 61% of the residents had their land demarcated through use of trees, 29.4% had used ant hills and 9.6% used streams. The study also showed the existence of land disputes as a result of incorrect land demarcation system, with 56% of the residents having experienced family boundary conflicts, 40% experienced the sale of land by their traditional leaders and 4% experienced communal land conflicts. Using the results obtained from the baseline study, a mobile customary land management system model was developed. The model is based on three core concept namely the person, land object and the media. Using this model a prototype was developed with capabilities of harmonising land boundaries, document land records and land coordinates for family and communal land and integrate with ownership land details to ensure security of tenure.

Keywords— land demarcations, PGIS, ICTs, Mobile Application, land allocation, boundary conflicts

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CHAPTER ONE: INTRODUCTION TO THE RESEARCH

1.1 Introduction

Some Africa Countries have experienced land conflicts due to lack of proper demarcation system. Zambia in particular has experienced a number of land conflicts ranging from international, Urban-customary and chieftdom land boundary conflict. This chapter outlines the background of the land conflicts prevailing in sub-Saharan African Countries, the latest mapping technologies that are currently been adopted to reduce on land conflicts, motivation and the significance of the study, the scope, the problem statement, aim, objectives and addresses the research questions.

1.2 Background

In sub-Saharan Africa, since human settlement and the birth of civilization, land has been the most valuable asset for a nation or society [1]. As the value of land increases throughout the progress of human civilization, so do conflicts over land. With increasing population growth and consequent demand and exploitation of high-value natural resources, including oil, gas, minerals and timber [2], conflicts over land has become problematic in most parts of the world, especially in less-developed countries where land is still central to production and economic growth.

Some African nations, such as Zambia, have experienced a number of conflicts over land. A major contributing factor to these conflicts is the increasing scarcity of land caused by population growth and urban-rural migration [3]. [4] defines security of tenure as “the individual’s perception of his/her rights to a piece of land on a continuous basis, free from imposition or interference from outside sources, as well as the ability to reap the benefits of labour or capital invested in the land, either in use or in alienation”. Customary tenure is an indigenous form of land ownership, also referred to as traditional African customary tenure, and has a communal character [5]. In

customary land tenure system, people are linked to land through their membership to groups - clans and families.

Geographical Information System (GIS) are a powerful set of computer-based tools used to collect, store, manipulate, analyze and display spatially referenced information [6]. They transform data into knowledge and present this knowledge in various formats for the purpose of supporting decisions. Participatory Geographical Information System (PGIS) is a process of representing local people's spatial information through use of user-friendly applications of geospatial technologies and spatial representation products. PGIS has now become a widespread form of 'counter mapping' enabling local people to make their own maps and models, and using such maps for their own research, analysis, assertion of rights and resolution of conflicts over land [7].

The use of PGIS tools in land management has been discussed in various literature in different parts of the world. In Central America and Southern Mexico PGIS has been used to map native lands as a way of protecting biological and cultural diversity [7]. The tool assists indigenous peoples to develop and carry out their agenda for the preservation of the regions natural and cultural heritage. Christine [8] discuss mapping experience based on local empowerment and Aberto et al [9] describes the community mapping in the Philippines where PGIS was used to map customary lands through community participation; Aderson [10] discusses the Mozambique case where mapping land rights was based on the use of highly enlarged aerial photography to delimit property and community boundaries for entry in GIS database; PGIS has also been used in conflict management where the resultant output has enhanced the courts understanding, synDissertation and resolution of land disputes.

1.3 Motivation and Significance of the Study

Land in most parts of the world and Zambians in particular remains an important asset. Secure access to customary land supported by latest mapping technologies and mobile application can enhance customary land management. This study is based on the practical significance that adopts an iterative design approach to effectively design and develop a mobile application that supports the customary land demarcation and

documentation system. The mobile application will empower local land owners to participate in the land demarcation process, have access to their land details and provide proof of ownership in an event of dispute. This will ensure security of tenure and reduce land conflicts.

1.4 Scope

The research is based on customary land that is managed by traditional leaders. The following is the scope of the project:

1. To review literature on customary land tenure system in selected African Countries.
2. To design and develop a mobile application that will harmonize the demarcation process and document of customary land data.

1.5 Problem Statement

In Zambia, since 1890, land has been held under customary tenure, until the 1960s when freehold and leasehold tenure systems were introduced. Zambia has a total land mass amounting to 752,614, square kilometers of customary land and is estimated at 64% and state land is estimated at 36% as shown in Figure 1.

About 60% of the people in Zambia live in the rural areas. The recognition of customary land tenure does not bring about the registration of ownership rights, but only the protection of use and occupancy rights. The non-availability of written agreements with traditional rulers on land acquisition in customary setup has created disputes in major settlement areas for example in Chongwe where a traditional leader allocated land belonging to another chiefdom to an investor. At the same time, a number of factors have created evolutionary change in the customary tenure systems for example, rules to access, use and transfer land have changed to adapt to the changing context of commercialization, population growth resulting in urban-rural migration, urbanization and high demand for land and its consequent translation into monetary values [12].

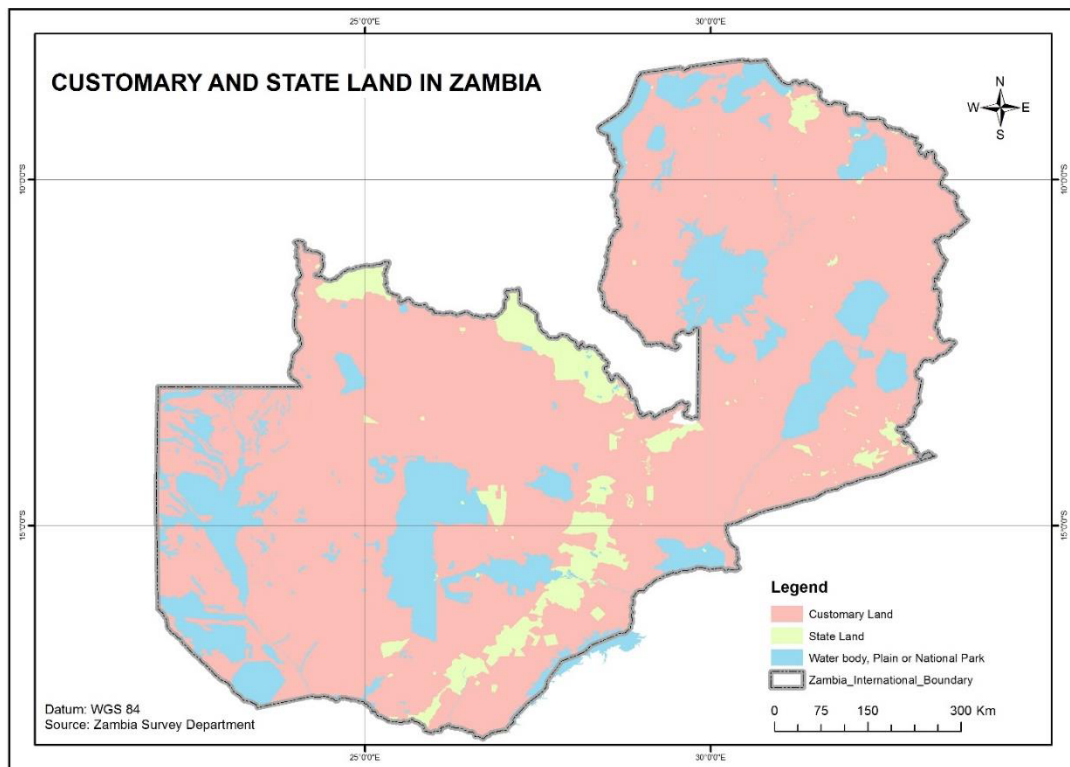


Figure 1: Land Allocation in Zambia [13]

1.5.1 International land boundary

Zambia has had several international boundary disputes with her neighbours. This has affected livelihoods in rural areas as most of these areas are in customary land. This has also lead to insecurity of tenure since the villagers are often not sure whether they are actually on the Zambian side or not [14].

1.5.2 Urban-customary land boundary

The burden on urban districts to provide land for the urban population exerts pressure on the customary areas bordering the districts. In a case in Chongwe district, the chief complained of encroachment by the district into their land as a result of unclear boundary demarcation between his area and the district. The Zambia land Alliance [12] [15] observed that Government and district councils continued to trespass into traditional land because of unclear boundaries between state land and customary land. Outdated maps bear the testimony of boundaries between the two territories.

1.5.3 Chieftom land boundary

The boundaries between chieftoms were also unclear and that maps were either not available or outdated. Common identifying marks as regards boundaries in customary land include streams, hills, large trees or footpaths. These have often helped in demarcating or identifying boundaries between chieftoms, however the identifying marks are a source of encroachment in customary land [16].

1.6 Aim

To use ICT tools in the management of existing customary land tenure information in order to improve land tenure security for the rural people.

1.7 Objectives

The specific objectives that will enable us to achieve the aim of the study are as follows:

1. To carry out a literature review of various methods used in customary land management in traditional African setup and in the world.
2. To carry out a survey to establish the method and type of information used in customary land management in Zambia
3. To design a customary land management model for management of customary land
4. To automate the process of customary land management by using mobile applications.

1.8 Research Questions

This research will be guided by the following research questions;

1. What are some of the methods used by African Traditional leaders and other developing countries in customary land tenure management?
2. What are some of the methods and type of land information used by chiefs and headmen to document customary lands parcels for their subjects in Zambia?
3. How can a model be developed for customary land management in Zambia?
4. Is it possible to automate the land management system based on the model in (3)?

1.9 Research Contributions

The major contribution is the development of the land management system coupled with the latest mapping techniques to assist the people living in the rural areas of Zambia to demarcate and document their land parcels thereby reducing the prevailing land conflicts. The Journal paper titled “Using Information Communication Technology (ICT) Tools in Managing Customary Land, Demarcation, Conflict and Tenure Data in Developing Countries: A Case Study of Zambia” was published as a major contribution in the study¹.

1.10 Organization of the Dissertation

The work done in this dissertation is organised into five chapters. Chapter one is the Introduction to the Research. In this chapter, a brief overview of the work to be undertaken is given, the problem statement, aims and motivation of this Dissertation highlighted. This chapter concludes by giving an outline of the Dissertation. Chapter two looks at the background information and related works. In this chapter, a comprehensive review on how customary land is managed across developing Countries has been provided. Next there is an insight of the systems and applications that have been designed and developed in the management of customary land using latest mapping technologies. Finally, the related works with regards to customary land management have been reviewed. Chapter three is the methodology. In this chapter, the baseline study was conducted and a customary land management model designed. The results of the project study are analysed in chapter four and finally the discussions and conclusion of the project is done in Chapter five.

¹ Annie Mporokoso and Jackson Phiri “Using Information Communication Technology (ICT) Tools in Managing Customary Land, Demarcation, Conflict and Tenure Data in Developing Countries: A Case Study of Zambia” Vol 3, March-2016

1.11 Summary

This chapter introduced the research by briefly discussing the context within which the research was conducted and the background of the research. The motivation, significance and scope of the work in this study have been outlined. The problem statement, research objectives, the research aim, research questions and the dissertation plan were outlined.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

ICT has an important role to play in improving the operation of land administration and in making information services more readily available in support of customary land tenure [17]. The advancement of mapping technology and PGIS has made land administration more accurate and effective in the management of customary land [18]. This has improved security of tenure for many communities in developing Countries. This chapter looks at existing land management systems across Africa, Asia and South America and the latest technologies in land mapping

2.2 Land Management System

2.2.1 Land Tenure System

Amone and Lakwo [19] define land tenure as the relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. The authors describes land tenure as an establishment of rules devised by societies to regulate behaviour in which land is owned, occupied, used and disposed of within a community. A properly defined and managed land tenure system is essential to ensure balanced and sustainable development. Rules of tenure define how property rights to land are to be allocated within societies. They describe how access is granted, the rights to use, control, and transfer land, as well as associated responsibilities and limitations. In simple terms, land tenure systems determine who can use what resources for how long and under what conditions [19] .

Customary land tenure as described by [20] constitutes a set of rights in land that are derive from customs or practices handed down from generation to generation. The right to use or to dispose of use rights over land under customary land tenure rests on the fact that such rights are recognised as legitimate by the community where the rules governing the acquisition and transfer of these rights are usually explicitly and

generally known, though they are not normally recorded in writing. This implies that an individual's rights in land under customary land tenure derive from his/her membership to a social group such as a clan or family [20]. With customary land local people still find it difficult to defend their land rights against such outside claims simply because their holdings are not demarcated and registered, and therefore not identifiable on Maps and in official cadastres [20] .

2.2.2 Land Tenure Management

2.2.2.A Land tenure system across Africa

There are three types of land tenure systems in Nigeria and these include communal, individual (private) and public (state). Communal land tenure is established on the inalienable and equal rights of joint ownership of land by every member of the community, with some selected members, usually elders and titled men, given the responsibility to act on behalf of others as custodians of the land. Under individual land tenure system, land is accessible to the individual owner for agricultural proposes, but may be given out to others on a rental basis, especially for cultivation. State-held land is obtainable to individual or private investors, cooperative societies and other organizations or groups of individuals on request, if approved by the state governor. The acquired land can be used for agricultural, industrial, commercial or residential purposes [21] . Customary land tenure systems in Nigeria as stated by the author [21] are related to family and inheritance systems and are centered on the concept of group ownership of absolute rights in land, with individuals acquiring usufructuary rights. Customary land rights create the basis for access to land resources and the chance to use land for productive purposes.

Uganda has four main land tenure systems as indicated by [22] [23] and these are freehold, leasehold, Mailo and Customary land tenure systems. Customary land tenure system is the dominant land tenure system in which individuals' use of land is subject to regulations and sanctions determined by the community, clan and family. The use of the land is usually overseen by elders, clan heads or other assigned committees to ensure the rights of the entire group are being honoured. Mayanja et al [24] further describes

customary land tenure as a system whereby the rights to own, use and dispose of land are held in accordance with customary rules and regulations that may vary according to different ethnic groupings and regions. Freehold land tenure system is a system that allows ownership of land in ‘perpetuity’ giving full powers over its use and disposition. Freehold land is primarily given to church missionaries and academic institutions. The leasehold land tenure system refers to the use of land for agreed period of time. In Uganda, a person can receive a lease from an individual, local authority or government for a period up to 99 years with agreed terms and conditions. Mailo land tenure is primarily practiced in Buganda (Central region) and in some parts of Western Uganda. This tenure system recognizes the occupancy of bibanja holders’ (tenants), whose relationship with the landlords is governed and guided by the provisions of the Ugandan ‘1998 Land Act’ [24].

In Ghana, different types of land tenure and the land administration [25] has evolved over-time from the interplay of socio-political organisation of several ethnic groups, clans and families. Customary and state laws play an important role in the management and administration of customary lands. Customary lands are lands owned and organised by stools (ethnic groups), clans or families where traditional and customary norms and practices govern their tenures and administration. “The customary land sector controls roughly 80% of the land holdings in Ghana and ownership of these lands is vested in traditional institutions or structures, which is headed by chiefs, clan and family heads or tendamba”. “Technically, the heads of these institutions hold and manage land resources for and on behalf of the entire land owning group under customary rules and regulations. The management of customarily owned lands has been the preserve of these traditional institutions with the state having an oversight regulatory responsibility [25].

Malawi’s 1965 Land Act and the 2002 Land Policy as stated by [26] [27] recognize three categories of land and these are public land, private land and customary land. Public land including government land is land occupied, used, acquired and held by the government in the public interest. Public land includes national parks, conservation and

historical areas. Government land is owned and used by the government for public purposes, including schools and government offices. Public land is vested in perpetuity in the President, as trustee for the government. Between 15% and 20% of land in Malawi is classified as public land. Private land is owned, held and occupied under freehold title, lease, Certificate of Claim, or land registered as private land under the Registered Land Act of 1967. According to the Land Policy, land registered as private land under the Registered Land Act includes privately owned freehold land and customary land registered by communities or individuals (upon registration, the land loses its character as customary land). Between 10% and 15% of land in Malawi is classified as private land. Customary land is all land held, occupied, or used by community members under customary law. Customary land is vested in the President in trust for the people of Malawi and is under the jurisdiction of customary traditional authorities. Customary land may be held communally or individualized in the names of a lineage, family, or individual. Customary land does not include public land. Between 65% and 75% of land in Malawi is customary land.

2.2.2.B Land tenure system in South America and Asia

Bolivia's land is held individually by private individuals and entities; communally by families and indigenous people as Original Community Lands and by the government [28].

Bolivia's has four tenure types namely [28]:

- **Ownership:** Ownership (individual and collective) that is based on formal and customary law.
- **Leaseholds:** Bolivia's urban areas support an active lease market. Leases may be obtained on traditional terms, under which the lessee pays a nonrefundable rate for occupation of the property, or under an anticretico agreement
- **Rural land leasing:** Leasing is increasingly common in rural areas as the land becomes more individualized. Families and communities may rent out land for the production of cash crops.
- **Squatting:** It is common for peasant households, landless people, and rural-

urban migrants to squat on land in urban and rural areas.

Cambodia recognizes five categories of land private land; state public land; state private land; common property; and indigenous land. State land (both state public and state private) accounts for approximately 75-80% of Cambodia's total land area. Unregistered land held in collective land ownership by indigenous communities is considered to be collective property on state public land. Cambodia has a small amount of common property, which is primarily land held by monasteries.

Cambodia's law recognizes three forms of land ownership: private ownership, state ownership and collective ownership by indigenous communities. Land may be leased, granted by concession, and held in usufruct. Private ownership consists of individual ownership, undivided ownership, divisible co-ownership and joint ownership [28] [29].

2.2.3 Customary Land Conflicts

Land disputes remain a major hindrance to land use and tenure security in Africa. As Niang and Dieng [30] observe, land in Africa has become a resource that easily polarizes all sorts of desires and arouses the territorial instincts of individuals and groups, leading to a number of violent communal clashes on the continent. Land disputes remain a major hindrance to land use and tenure security in most parts of developing Countries. Traditional authorities control over 80% of all lands [30] and it is argued in a number of studies that urbanization with its consequent effects of population increase, pressure on land and land commercialization has resulted in the erosion of traditional values that serve to mitigate the excesses of customary trustees. In a number of sub-Saharan African Countries land disputes have resulted in violent conflicts that have devastated communities, livelihoods and relations [30].

2.2.3.A Customary land conflicts across Africa

Ghana [30] has not been spared of land disputes, some of which have been violently expressed. Competing claims to land and disputed land boundaries between individuals; between individuals and traditional authorities; between communities; between community members and their traditional authorities; and between traditional authorities and state institutions, abound throughout the country. The author [30]

describes customary land management in Ghana as having had major challenges because of poor record keeping. A case study is the Wassa Amenfi District in the Western Region of Ghana, where management of both stool and family lands in the district had been haphazard. The chiefs who are the administrators of lands and hold the authority to allocate and lease lands do not have maps as evidence of lands given out. They hardly coordinate any land transaction with other institutions involved in land management such as Town and Country Planning, the District Assembly or the Lands Commission. The prospective lessee can be given land anywhere in so far as that land is vacant and alienable [30].

In Nigeria, particularly in Akabor area, land conflicts on customary land were on an increase because of population growth and consequent demand and exploitation of high-value natural resources, including oil, gas, minerals and timber [31]. The dynamics of customary tenure system in Akabor community resulted in a high rate of disputes over land ownership, which were difficult to resolve because of the lack of adequate or easily accessible concrete evidence. Good governance and proper land management system with capabilities of integrating complex social relationship that exist among people and between people and their land was cardinal for the Akabor community in order to reduce land conflicts. The author [32] therefore, designed a web based customary land tenure information system based on the TalkingTitler model to suit the needs of the Akabor community, whose land tenure evidence was based on the oral testimony of land owners and their witnesses alone.

In Uganda most land is held under customary tenure. The law of Uganda declares that this kind of land must be run according to whatever rules people have always accepted locally. This means that land under customary tenure is still subjected to customary laws, as well as being recognized officially. For the greater percentage of Uganda, where customary tenure still abounds, the roles of traditional institutions of land management, dispute resolution and land governance have not been legally accepted, integrated and mandated to execute their functions. Manual record keeping system has severely hindered progress in the delivery of land services to the public, making it slow,

cumbersome and frustrating. Unregistered customary land is vulnerable to expropriation by the government and “grabbing” by political and economic elites [33]. This has created customary land conflicts among the people living on customary land.

2.2.3.B Customary land conflicts in Cambodia

Rural Cambodia “rely on the use-based approach to ownership where common understandings between neighbors and villagers are believed to be sufficient in demarcating boundaries” [34]. This has resulted in millions of Cambodians lacking documentation and full recognition of their rights that comes with a land title. Lacking a hard title of ownership over land builds greater insecurity and vulnerability to land grabbing and forced evictions. Without proper land titles, populations are left defenseless and authorities or companies take advantage to claim their land [34].

2.3 Technology and Land Mapping

2.3.1 Introduction

The rapid development of spatial technologies has made available new tools and capabilities for management of spatial data. The advancement of GIS, GPS and RS technologies has enabled the collection and analysis of field data in ways that were not possible before the advent of the computer. In addition mobile technologies such as location based services have made a bigger difference to the lives of more people, more quickly, than any previous communications technology. Mobile phones have spread the fastest and proved the easiest and cheapest to adopt in many land administration [35] [36] [37] . Mobile GIS solutions have been implemented in different contexts across the globe. The GIS Company ESRI, for example, uses Computer tablets as one of the latest advancements in mobile GIS.

2.3.2 Geospatial Technologies

2.3.2.A GIS

“GIS applications allow the storage, management, and analysis of large quantities of spatially distributed data” as stated by [36]. “These data are associated with their respective geographic features”. Mapping is a central function of GIS which provides a visual interpretation of data. GIS store data in database and then shows it visually in

a mapped format. A GIS can manage different data types occupying the same geographic space. “The power of a GIS lies in its ability to analyze relationships between features and their associated data”. This analytical ability results in the generation of new information when the patterns and spatial relationships are revealed. “GIS has proved to be a vital tool in land management because of its ability to conduct complex spatial analysis and wide applications”. It has supported many successful implementations such as Land Information Systems (LIS). “GIS technology has the capability to offer cadastres a method of quickly access and production of maps, leveraging database information, and automating enterprise work processes” [36].

2.3.2.B GPS

“GPS technology has provided an essential tool for management of natural resources”. GPS is a satellite- and ground-based radio navigation and locational system that allows the user to define accurate locations on the surface of the Earth. Despite the complexity and sophistication of GPS technology, the user interfaces has become accessible to the non-technical user” [36].

2.3.2.C Remote Sensing

“Remote Sensing (RS) technologies are used to gather information about the surface of the earth from a distant platform, usually a satellite or airborne sensor. Most remotely sensed data used for mapping and spatial analysis is collected as reflected electromagnetic radiation, which is processed into a digital image that can be overlaid with other spatial data” [36].

2.3.2.D Internet Mapping Technologies

“Software programs like Google Earth and web features like Microsoft Virtual Earth are changing the way geospatial data is regarded and shared. The developments in user interface are also making such technologies available to a wider audience. Mobile computing technologies have evolved constantly and quickly and new mobile devices, technologies, methods, and applications have been introduced” [36]. Software such as Google Earth and Mobile computing are making land and location mapping easier for users.

2.3.2.E Database management system used in developing land management systems

- **PostgreSQL**

“PostgreSQL as defined by [38] is the most advanced open source database management system, a pioneering object-Relational Database Management System with full-featured, safe, stable and powerful highly extensible capabilities”. The author [38] further describes the advantages and disadvantages of PostgreSQL as follows:

Advantages of PostgreSQL [38]

- “PostgreSQL is an open source software, anyone can download the source code and modify it to suit specific needs.”
- “It’s open source nature insures a quicker development cycle, and thus more frequent updates language interfaces for popular programming languages, including Perl, Python, PHP, and Java via JDBC, C/C++, Embedded C, and TCL”
- “Can easily handle large amounts of data”
- “It's free”

Disadvantages of PostgreSQL [38]

- “Lack of documentation”
- “Steep learning curve”
- “Lack of commercial support”
- “Somewhat slower than other RDBMS used in web application.”

PostGIS

PostGIS [39] enhances support for geographic objects to the PostgreSQL object-relational database. In effect, PostGIS “spatially enables” the PostgreSQL server, allowing it to be used as a backend spatial database for GIS. PostGIS is great spatial database, and it is built on top of a great standard database, PostgreSQL. The core database provides transaction management, disk storage routines, SQL processing and planning. PostGIS provides spatial types, functions and indexes. The author [39] outlines the advantages and disadvantages of PostGIS as follows:

Advantages of PostGIS [39]

- “PostGIS spatially enables PostgreSQL by adding spatial objects, functions, and indexing.”
- “PostGIS is free software (GPL)”
- “PostGIS follows the OpenGIS Simple Features for SQL”
- “PostGIS is an important component in open and free GIS.”
- “PostGIS is an important building block for all future open source spatial projects.”

2.3.2.F ICT in land administration

ICT is an umbrella term that encompasses all forms of computing, information technology, internet and telecommunications. In land administration, the terminology covers surveying and positioning technology, including Global Navigation Satellite Systems (GNSS) such as the GPS; measuring equipment such as total stations and electronic theodolites; Light Detection and Ranging (LiDAR), digital aerial photography, and satellite data acquisition systems and imagery processing; GIS; land data records management systems built on relational database management systems, workflow management systems; wide and local area networks; wireless technology; data storage systems, including data warehouses and Data as a Service on the Internet; and web services delivered by Internet [40]

Database management systems, usually of the relational variety, provide robust and secure repositories to manage the significant volumes of land information (textual and geospatial) in a distributed environment and to support efficient searching and querying of the information. The associated digital record management systems efficiently store and retrieve raster scanned documents such as paper deeds. GIS supports the capture and editing of geospatial information such as parcel boundaries and interfaces to the land information repositories and wider National Spatial Data Infrastructure (NSDI) to support spatial analysis and visualization, including a map-based interface for web information services [40].

2.3.2.G Web and Mobile Phone-Based Information Services in Land Administration

Mobile phones [41] have made a bigger difference to the lives of more people, more quickly, than any previous communications technology, and their use is growing most significantly in developing countries. “Online access to information services related to land administration is expanding with the expansion in broadband infrastructure and the use of mobile phones to deliver Internet and SMS-based services. Figure 2 shows women using mobile GIS Instruments to Map Land.

Indonesia has taken a lead in this approach. Agencies that previously excluded many people, especially in rural areas, are becoming more open and rapidly building public trust through the provision of simple, transparent, and accessible services. The mobile GIS application was developed for habitat conservation and environmental monitoring. A similar application, geared towards crowd management and pilgrim mobility in the city of Makkah, used location based services and augmented reality technologies to provide Hajj pilgrims with timely information on mobile phone. In Saud Aramco, an integrated system was developed, based on mobile GIS technology and high precision surveying process, to monitor land encroachments on land reservations and pipeline corridors. The system generated and propagated encroachment data. The emerging applications that integrate geospatial technologies with ICT are based on wireless network of spatially-aware sensors “geosensor networks” that “detect, monitor and track environmental phenomena and processes [41].



Figure 2: Women using GIS Instruments to Map Land [40]

This anticipated improvement relies especially on three crosscutting themes for creating and organizing land information [42]. These are:

- I. “Designing land management systems for sustainable development”
- II. “Building on new technical support in land administration”
- III. “Moving into spatial enablement technologies.”

The Internet [43] has significantly improved availability of land information. “State territory and local governments increasingly provide digital information about planning initiatives, citizens’ facilities and other activities, through initiatives generically called eLand.” The idea is that spatial enablement of land administration systems managing tenure and registration, valuation, planning and development will allow the information generated by these activities to be much more useful. Achievement of sustainable development goals will be easier to evaluate. Adaptability and usability of modern spatial systems will encourage much more information to be collected and made available. The map-mashing trend following Google Earth and other major international applications shows a high public take up and popularisation of spatially enabled systems. More integrated and accessible information will assist governments to design and implement land policy. The services available to business and public sectors, and to community organisations and citizens, should commensurably improve. Ideally these processes are interrelated: with modern ICT, the engagement of users in design of suitable services, and the adaptability of new applications mutually influencing each other. The global initiatives are the starting point, but in a national case, modifications to suit the particular context will be built. The new land administration systems of the future will be local, regional and global in their capacity. The expense of building and maintaining spatial information has always been a major issue, but, given the new opportunities for using spatial information and location enabling systems in general, the investment is about to deliver not only better land administration but improved land management and government [43].

2.3.2.H Mobile phone support of Land Administration Services

The increase in functionality of the mobile phone and its migration to lower cost devices, its increasing pervasiveness across developing countries and its connection to Internet and information services is opening up significant opportunities for its use in delivering more effective and accessible land administration services. The areas where the mobile phone have effectively been used are [35]:

- Recording Ownership Rights

The mobile phones allow citizens to directly record the boundaries of their properties. This can be achieved in several ways [35]:

- I. A textual description of the boundaries recorded on the phone;
- II. A verbal description recorded on the phone;
- III. A video and commentary recorded on the phone – this could include contributions from neighbours as a form of verification.
- IV. The co-ordinates of the boundary points recorded using the GNSS capability of the phone [35].

The adoption of the new model as shown in Figure 3 provides benefits to a wide range of stakeholders across the land administration sector and beyond

The following are the benefits offered by the new model

Citizens [35]:

- I. Access to affordable land administration services, especially for the poor and vulnerable
- II. Direct involvement in the land registration process that strengthens the relationship between the citizen and the land, leading to greater trust and legitimacy in the land administration process
- III. Recognition of a level of land rights that at worst would lead to fewer evictions and at best would lead to formal land rights
- IV. Fully open and transparent access to land information services that will help to reduce levels of corruption associated with public and private land.

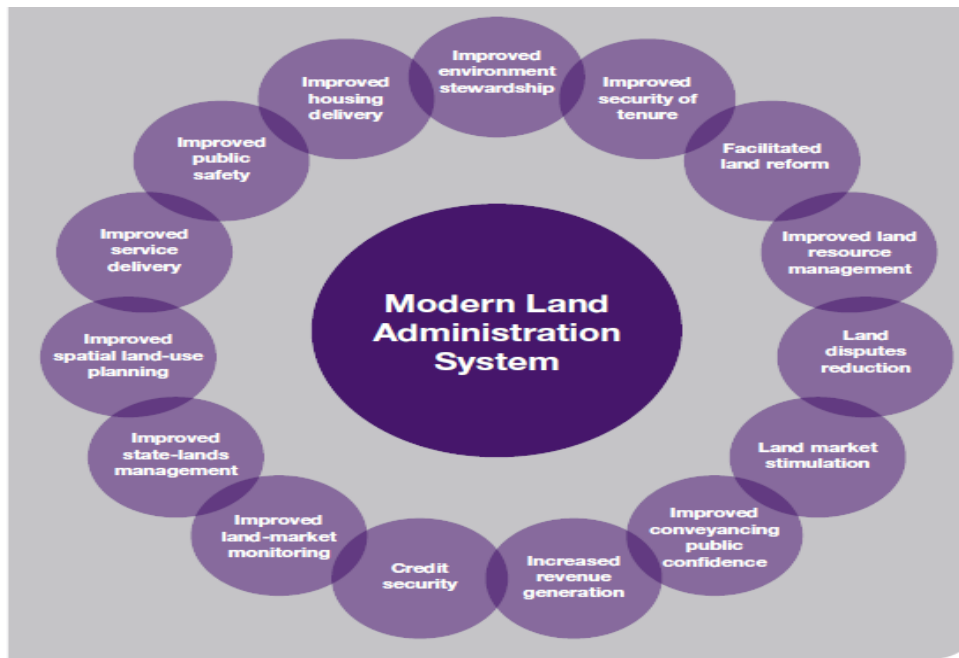


Figure 3: Modern Land Administration System [34]

Land Administration Agencies [35]:

- I. More inclusive set of land administration services, directly involving the citizens that leads to a stronger and more trusting relationship with citizens
- II. Potential outreach of services to remote rural regions and slums within urban environments
- III. More comprehensive coverage of land rights with fewer professional resources
- IV. Greater number of transactions in the formal land market that leads to higher revenues to increase the sustainability of land administration service and lower the cost of transactions.

2.4 Related Works

2.4.1 Nigerian web based customary Land tenure information system

To address the major land conflicts that existed in the Akabor community of Nigeria, the author [32], designed a web based customary land tenure information system based on the TalkingTitler model to suit the needs of the Akabor community, whose land tenure evidence was based on the oral testimony of land owners and their witnesses alone.

2.4.1.A Talking Titler Model

In the Talking Titler system, flexibility in creating relationships between people and between people and their interests in land is the primary design feature. It is a tool for prototyping different designs and for developing land tenure information systems using evolutionary strategies [44]. Talking Titler as described by [44] is a land tenure information software system, that allows a great deal of flexibility in the way data relating to people, land and evidentiary media (titles, deeds, survey plans, descriptive documents, audio records of oral testimonies, videos, photographs, valuation records) can be stored and related. The system also supports the use of a mix of paper-based and digital documents and seeks to incorporate human and technical systems that will provide the right kind of evidence that particular situations demand. The Talking Titler conceptual model [32] [45] has four primary classes Media, Person, Land Object and Reference Item as depicted in Figure 4. The primary design objective is flexibility so that the system may evolve according to multiple, changing needs in highly uncertain situations. Ease of use and system performance are of secondary importance.

Barry et al [46] further describes the four inter-related class of Talking Titler model as Media item which includes unstructured data items, such as video clips, photographs, sound recordings, written notes and reports, title deeds, contracts, permits, wills, marriage contracts and cadastral survey plans to present multimedia files.

- Person to represent right holders.
- Reference Instrument which represents title and valuation record.
- Land object which represents parcel, trees and houses.

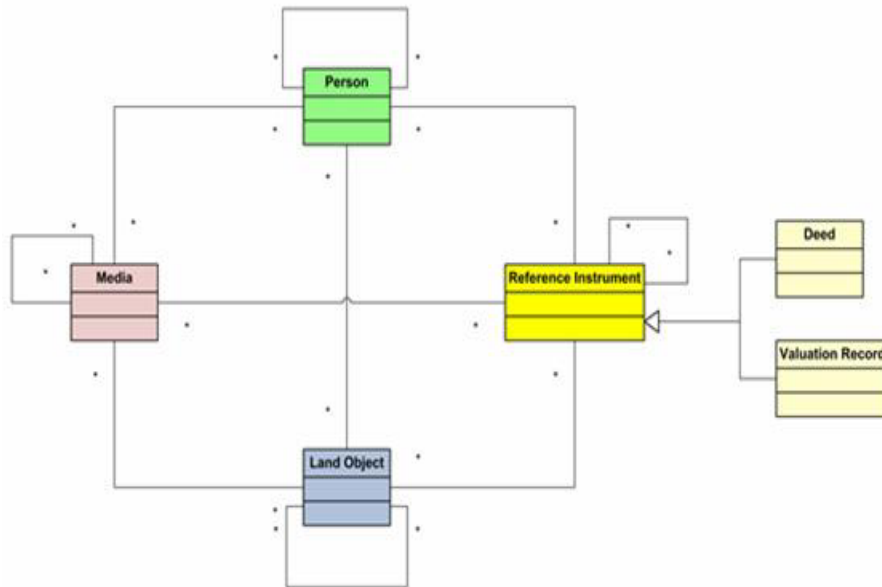


Figure 4: Talking Titler Software Model [44]

The authors [32] [46] designed the web based Talking Titler software based on prototyping and evolutionary approach. A database with spatial extension was created using an open source enterprise-level relational database application, PostgreSQL and PostGIS, which have the capability to record, store and process very large data in all formats such as audio, video, text and pictures.

Advantages of evolutionary design approach

Evolutionary design approach is appropriate for situations where a detailed system specification is unavailable. It is suitable and effective in rapidly producing small systems, software with short life spans and developing sub-components of larger systems [47].

Disadvantages of evolutionary design approach

Evolutionary design approach is quite difficult to measure progress and produce documentation reflecting every version of the system as it evolves. This paradigm usually results in badly structured programs because of continual code modification. Production of good quality software using this method requires highly skilled and motivated programmers [47].

Figure 5 shows a web based Talking Titler main screen designed and developed by [32] [46]