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.

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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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CERTIFICATE OF APPROVAL

This document by ……..…… is approved as fulfilling the requirements for the award of the degree of Masters of Engineering in Information Communication Technology (ICT) Security of the University of Zambia

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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 chiefdom 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].

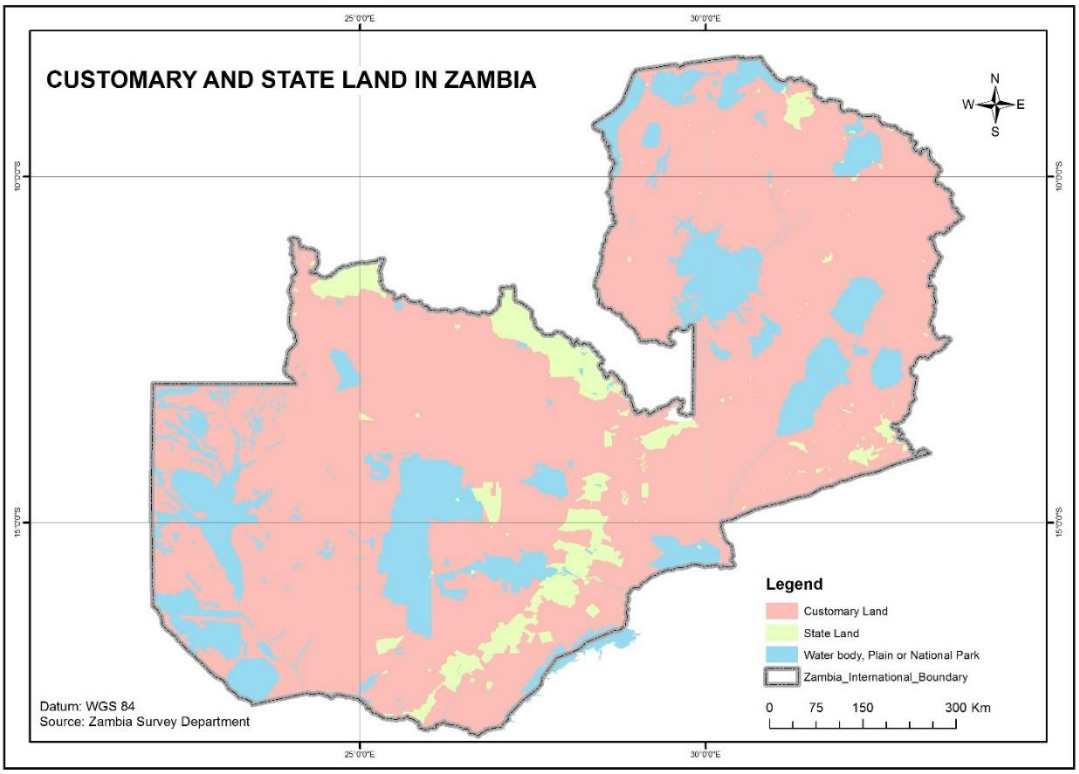


Figure 1: Land Allocation in Zambia [13]

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 Chiefdom land boundary

The boundaries between chiefdoms 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 chiefdoms, 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 study[1].

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.

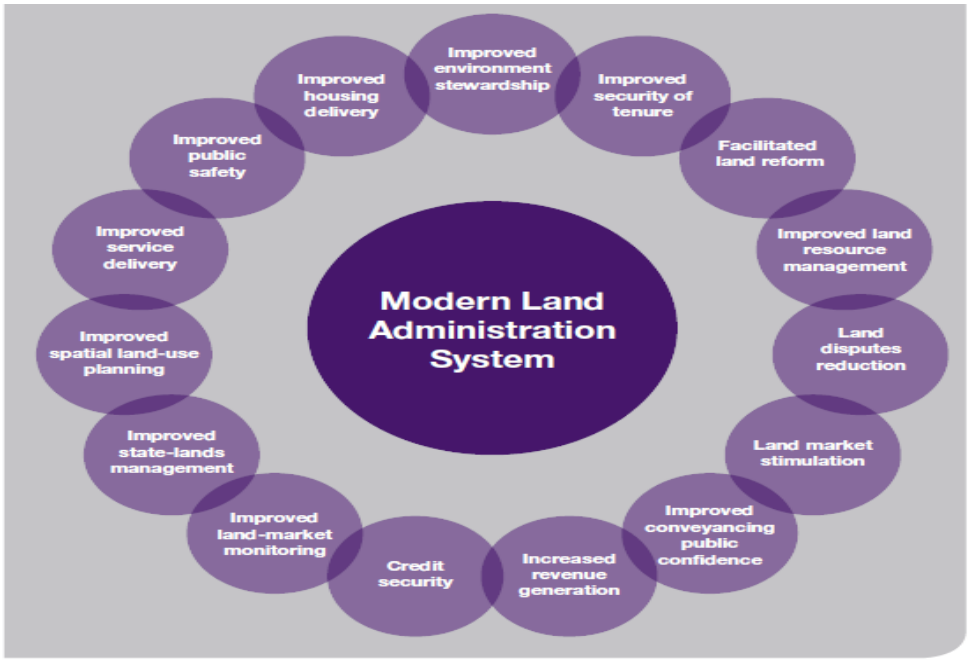


Figure 3: Modern Land Administration System [34]

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.

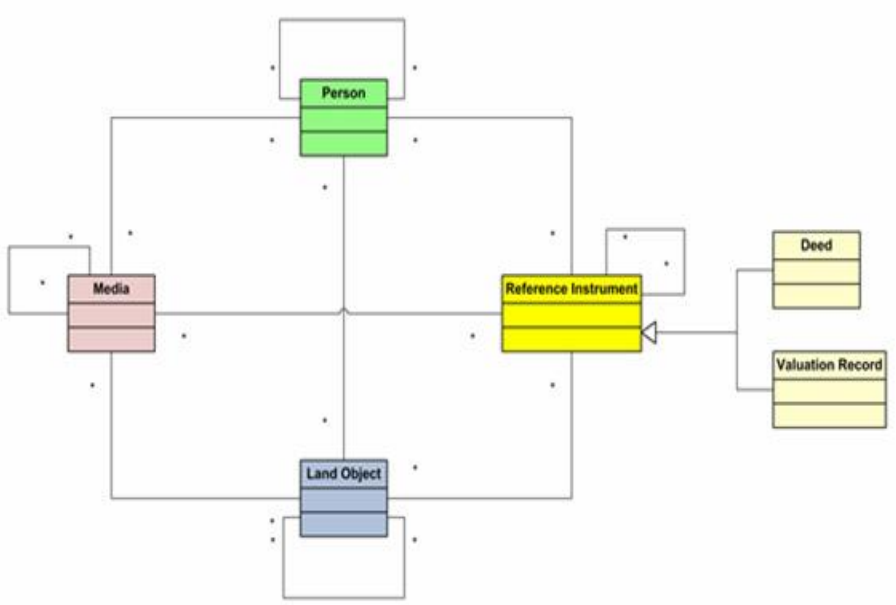


Figure 4: Talking Titler Software Model [44]

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]

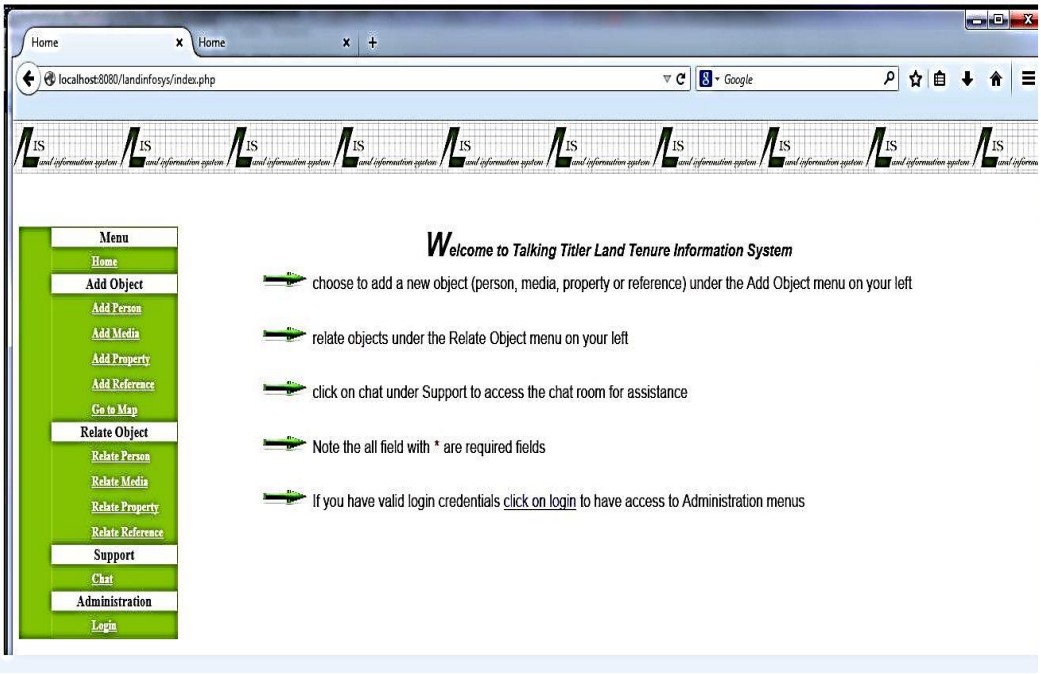


Figure 5: Talking Titler Main Screen [31]

2.4.2 Social Tenure Domain Model: case study Uganda

The Government of Uganda employed the Social Tenure Domain Model (STDM) project that focused on developing tools capable of registering a wide range of land rights including public, private and customary rights [48]. The STDM is a land administration data modelling application developed as a specialization of the International Federation of Surveyors whose aim is to model the person-land relationship regardless of their formal or legal status. The STDM software strives to support various forms of land rights, social tenure relations and possible overlapping claims to land. It is not totally based on the level of 'formalization or legality' of the relations but it can be used as a basis for the development of land administration system that can support all forms of land rights such as obtained in post conflict areas. The model is aimed to be used in undeveloped countries, countries with very little cadastral coverage in urban or rural areas, post-conflict areas, and countries with large scale informal settlement and or large scale customary areas. The STDM software application provides the ability to put rights into a system, rights which are not registered or registerable as well as claims that need to be adjudicated both in terms of the 'who', the 'where' and the 'what type'. The application is focused on recorded rights (or social

tenure relationships) and not on registered rights [48].

The STDM [49] is a terminology for land administration that helps to combine and understand land administration information from different sources in a coherent way. In many developing African existing LAS have limitations because of the fact that slums, informal and customary tenures cannot be included in these registrations. Existing LAS require extensions to include all existing types of tenures including those held by the poor. But the need for this is not always recognized and policy and institutional changes are not so easy to implement. The STDM attempts to bridge this technical gap. The STDM allows for the recordation of all possible types of tenures. STDM enables to capture the realities on the ground and illustrates what information exist particularly the various tenure types regardless of its legal or technical status or situation.

The terminology of STDM allows a shared description of different practices and procedures in various customary and informal areas or jurisdictions. The conceptual model of the STDM is based on three core classes shown in Figure 6 and Figure 7 which include the Social Tenure Relation class, Spatial Unit class and Person class. The relationship between land and people via rights in legislation is the foundation of every conventional land administration. In the STDM it is about the Social Tenure Relation between Persons and Spatial Units. In the model there is no direct relationship between Person and Spatial Units, but only via Social Tenure Relations [49].

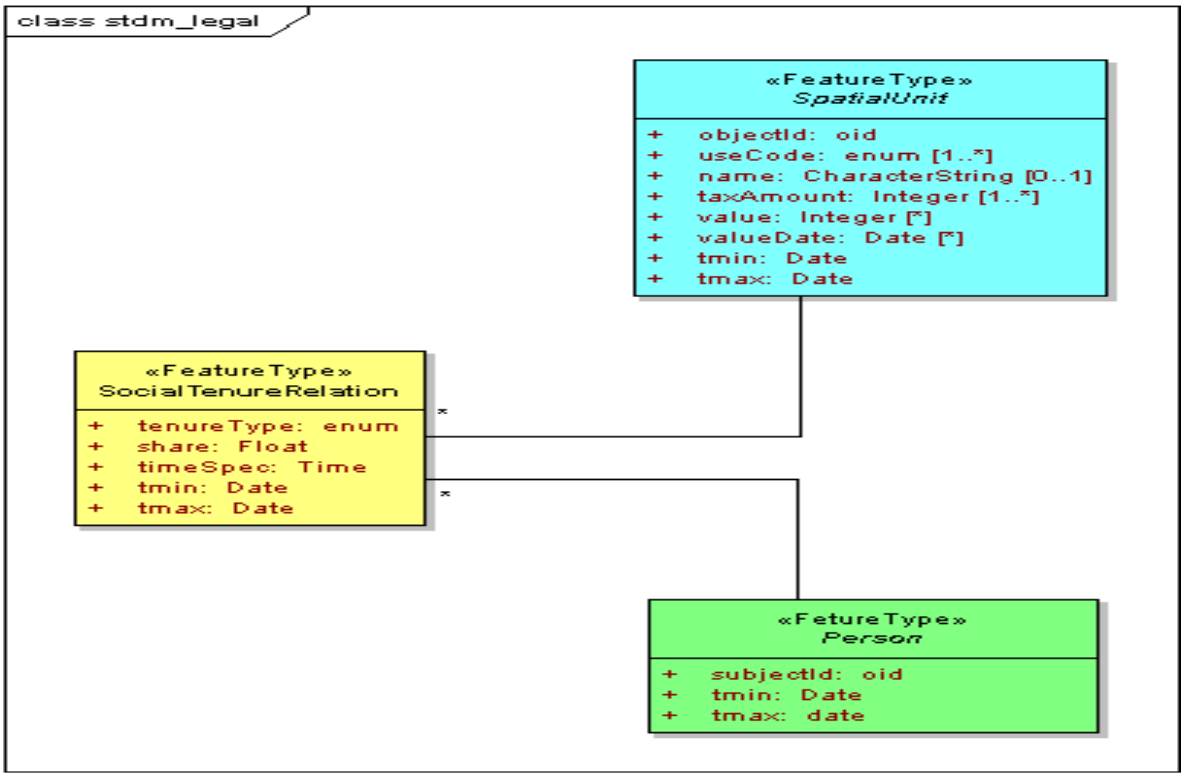


Figure 6: Core of the STDM: Spatial Unit-Social Tenure Relation-Person [48]

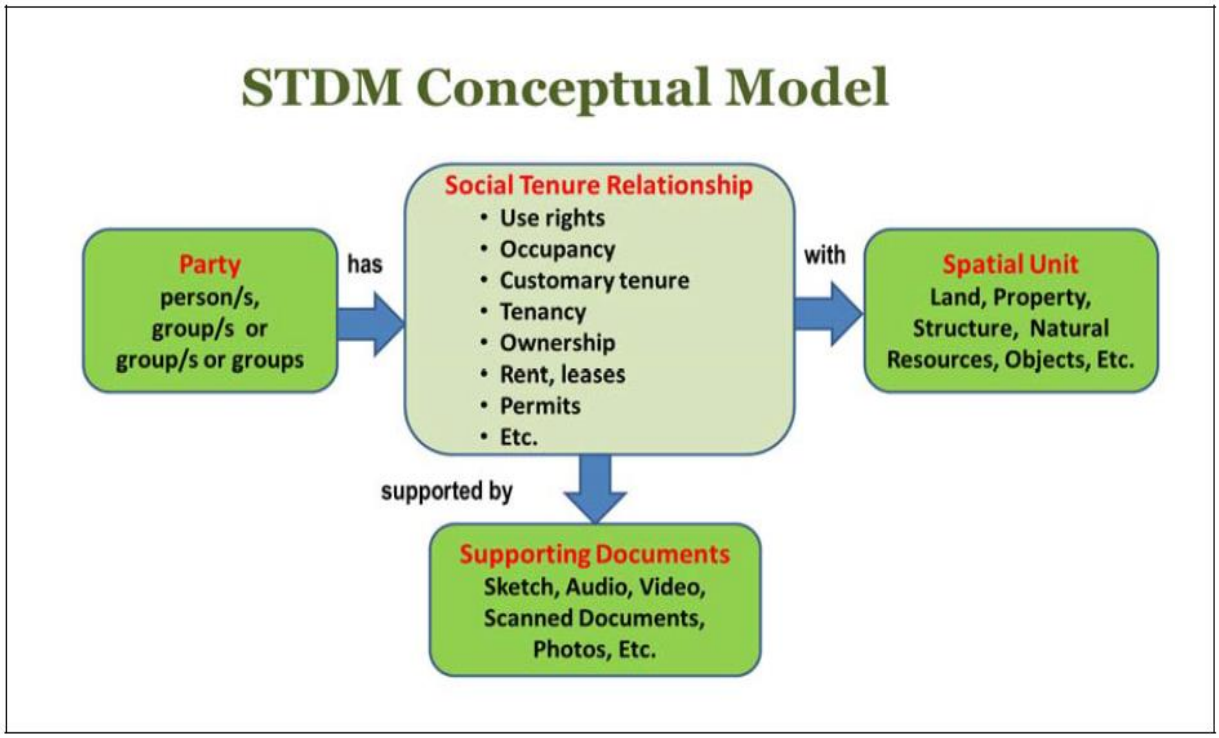


Figure 7: STDM conceptual model [49]

"STDM represents the basic concepts in three ways [50]:

- Party – This can be a person, company, municipality, cooperation, married couple, group or group of groups.
- Spatial unit – discrete area(s) of land, natural resources, properties, structures or objects other than accurate and well established units (relative to those defined by LADM.
- Social tenure relationship – This is the relationship between parties and spatial units and which is in the form of informal rights, tenure rights, long leases, rents, ownership rights, Islamic tenure rights, state property, conflict areas, disagreements, overlaps, and use rights."

STDM as a concept

The concept of STDM [50] "is to bridge this gap by providing a standard for representing 'people – land' relationships independent of the level of formality, legality and technical accuracy". The STDM can represent all types of 'people', all types of 'people-land' relationships and can represent such linkages or relationships by various types and combination of location-based elements or 'spatial units'. STDM can be used generally in all context and situations. It can also serve as an alternative to the current conventional LAS. STDM development is meant specifically for developing countries where there is very little cadastral coverage in urban areas with slums, or in rural customary areas. It is also meant for post conflict and post disaster contexts. The focus of STDM is on all relationships between people and land, independently from the level of formalization, technical accuracy or legality. 'People-land' relationships can be expressed in terms of persons (or parties) having social tenure relationships to spatial units (representing land and other spatial units like structure, natural resources). In the pilot project in Uganda, the main spatial unit used is the house or structure occupied or owned by slum dwellers. Parties are persons, or groups of persons, or non-natural persons, that compose an identifiable single entity. A non-natural person may be a tribe, a family, a village, a company, a municipality, the state, a farmers´ cooperation, or a church community [51]

STDM tends to broaden the scope of land administration by providing a land information management framework that integrates formal, informal, and customary land systems, as well as integrate administrative and spatial components. The STDM makes this possible through tools such as that facilitate recording all forms of land rights, all types of rights holders and all kinds of land and property objects or spatial units regardless of the level of formality. The thinking behind the STDM also goes beyond some established conventions. Traditional or conventional land administration systems, for example, relate names or addresses of persons to land parcels via rights. An alternative option is provided by the STDM, which instead relates personal identifiers, such as fingerprints, to a coordinate point inside a plot of land through a social tenure relation such as tenancy. The STDM thus provides an extensible basis for an efficient and effective system of land rights recording [52]

The data modelling in STDM software is dynamic and can be implemented either as decentralized or a distributed set of (geo-) information systems that can support the maintenance of activities and the information supplied from a given dataset. The software was developed as a modular structure and each module is configured to perform unique functions or to achieve particular objectives. For instance, the software has the ability to capture and display the different stages of a parcel land as well as the rights on the parcel using a geo-code functionality that will reflect the dynamic nature of the application. To make the software simpler and friendlier, the tenure types in STDM software are identified by specific keywords that make it easier to capture different information on land tenure relations in the various situations. Some of the keywords assigned to tenure types in STDM include: Structure owner, Part owner, Tenant, Sub Tenant, Relative of Structure owner, Friend of Structure owner, Relative of Part owner, friend of Part owner, Relative of Tenant, Friend of Tenant, Relative of Sub Tenant, Friend of Sub Tenant, Joint ownership (married), and Child of the owner [52].

System Architecture of STDM

STDM system as stated by [53] is based on a client/server architecture and can be deployed as a standalone application in a single computer or in a LAN environment. In

the former, the server and client components are installed in the single computer whereas in the latter, the server components are installed and configured in a database server and the client components installed in the users' workstation or laptop computers. A typical LAN setup is shown in Figure 8 and Figure 9 shows the STDM main window [53].

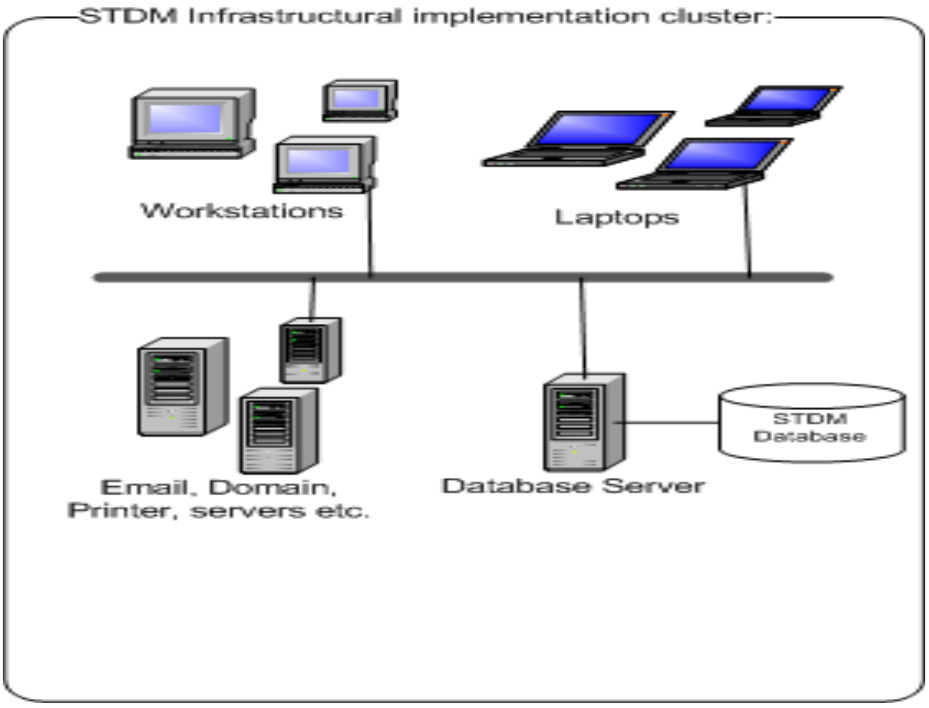


Figure 8: STDM Client/Server Architecture [52]

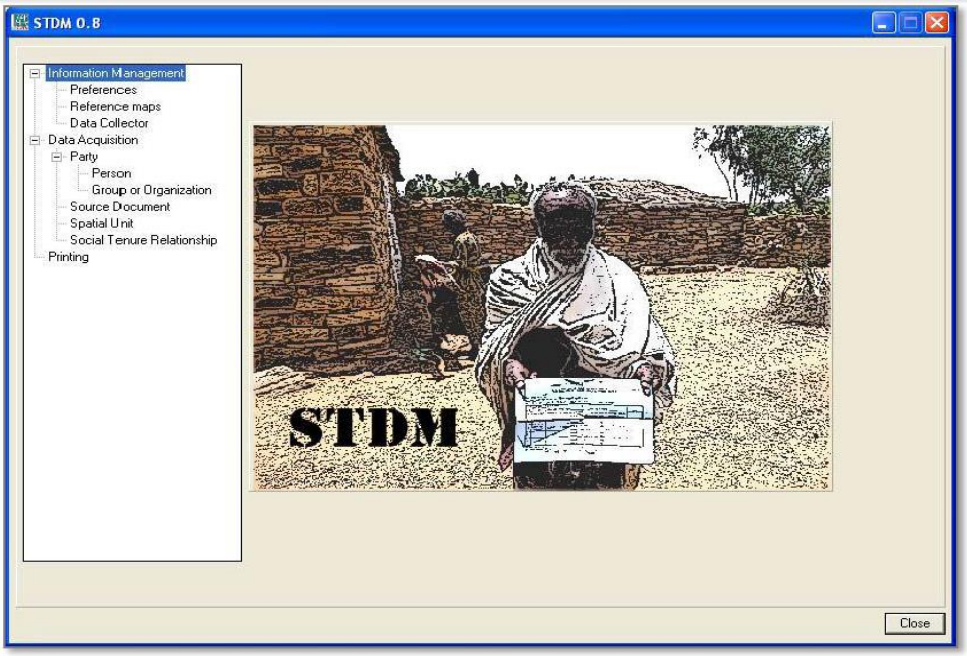


Figure 9: STDM Main Window [52]

The STDM application has capabilities of incorporating photos and fingerprints of land owners as shown in Figure 10.

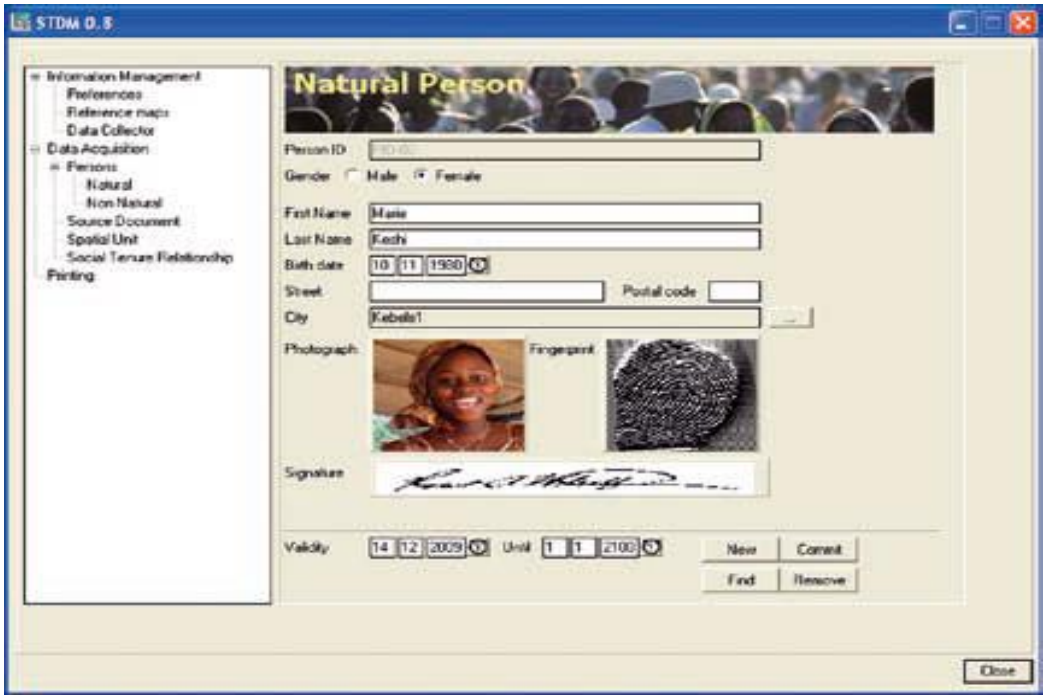


Figure 10: STDM Prototype Software [48]

Benefits of STDM

The author [49] "outlines the benefits of STDM as a contributing factor to sustainable development by the provision of a flexible, unconventional land administration." This can be seen as an extension to existing LAS that starts with the community based mapping processes, supporting the mapping of land and property rights. The local communities usually lack knowledge on land laws and areas where the communities are living are not administered. "Depending on the local situation, different registrations or recordings of land rights are possible with STDM. In rural areas there can be spatial units covering customary areas. Those spatial units can be recorded as 'text based' spatial units, where boundaries are described in words or as 'line based' spatial units, drawn on low accurate satellite images. Formal property based spatial units can concern formally registered ownership with related owner and with identified boundaries by accurate field surveys. Persons living in 'structures' in slum areas may be identified by fingerprints; The social tenure relationship to the spatial units may be represented by points collected with hand-held GPS instruments – source documents may be printed

from websites providing spatial data." "If all data are collected in the same structure (Party – Social Tenure Relationship – Spatial Unit) then the integration with a formal LAS is possible". "STDM can make it possible for all citizens to be covered by some form of LAS, including the poor, thereby improving the land management capacity of the land industry. STDM can contribute to poverty reduction, as the land rights and claims of the poor can be conveyed into the formal system over time. It will improve their security of tenure, increase conflict resolution, limit forced evictions, and help the poor to engage with the land industry in undertaking land management such as city wide slum upgrading and rural land management [49]."

Drawback of STDM

The robustness in the STDM design is a positive point, however the problem lies in its inability to capture the complexity of some of the situations obtained in a customary tenure system. The software is highly technical, the installation process is somewhat complex as it requires a lot of initial configurations and setup of various plugins are needed to run the application. The STDM software requires a QGIS plugin for its mapping. The STDM does not provide users with the flexibility to customize the software to suit their needs. There is no front-end query interface, the system can only be queried through the back-end which is the database. There is a lot of training required for users to be able to operate and use the application [49].

2.4.3 Ghanaian Land Administration project

The Land Administration Project (LAP) as stated by [30] has made attempts to introduce administrative reforms in the land sector in Ghana. These reforms seek to promote harmonisation and regularisation of land management between state and customary authorities. One of the primary objectives of the land administration project is to create a more comprehensive land documentation system which links the formal and customary systems and further create more transparency and efficiency in land administration in Ghana. This has led to the establishment of the Customary Lands Secretariats (CLS) for every organised and recognised land owning communities and the subsequent resourcing of these to take the role of customary land administrative

functions.

CLS [54] are specialised offices established by local land owning communities with the support from central government under the auspices of the LAP Project of the Ministry of Lands and Natural Resources to improve land management and administration at the local level in Ghana. The land secretariats serve as an interface between the landowning communities and the public land sector agencies. They provide land administrative services for holders and seekers of customary land rights working under the direct authority of traditional authorities. Manned by local people (mainly volunteers), CLSs preserved records are available to all members of the community and the public in general. They operate under a well-constituted land management committee (LMC) appointed by the traditional authorities. The idea to have chiefs and the traditional authorities keeping records and documenting land transactions is a noble one under the Ghana LAP Project, which is a long-term plan of 15-25 years to improve land administration which includes reviewing existing laws on land, cutting cost and time of doing business as regards to land title and deed registration, and decentralising land administration for an efficient, transparent and sustainable land system for Ghana [54]

The author [54] further explains the exciting thing about the CLS, in that the project provides technical assistance in the form of training and skill development in areas such as land administration and management. The project, under the auspices of the Office of the Administrator of Stool Lands (OASL), also provides basic equipment to the CLSs. Another unique feature of LAP under the auspices of OASL is the provision of the customary boundary demarcation (CBD) which is expected to be undertaken with the active participation of adjoining communities and landowners. The CBD is responsible for the identification, demarcation and survey of allodial lands of a beneficiary traditional or family land with the adjoining paramount stools or families to ensure easy identification and documentation. The LAP is demand driven, meaning the owners of the land or traditional authorities who wish to have their boundaries demarcated must apply to the OASL. The idea is to let the locals own these ventures so as to be able to run, operate and maintain them effectively.

The CBD has improved land tenure security in Ghana through "reducing risks such as land grabbing, encroachment, disputes and expropriation since the demarcation ensures that land boundaries of beneficiary family or traditional authority are easily identified with a map". "In addition to the CBD enhancing the opportunity to resolve boundary-related disputes and the recording of accurate data on land boundaries, it also ensures the registration of land to improve and increase the value of land [54]."

2.4.4 Land Management Paradigm - Asokore-Mampong (peri-urban Ghana)

The theoretical framework, called the Land Management Paradigm (LMP), has been used by authors [55] [56] which encompasses a holistic approach to land tenure, use, value and development with its concomitant rights, restrictions and responsibilities. The author [56] states that the LMP is applicable in the context of customary land administration in Ghana, in which traditional authorities manage all four aspects included in the framework in an integrated manner. The LMP described in Figure 11 and Figure 12 enables land administration systems designers to manage changes in institutional arrangements and processes reflecting the specific local conditions of each country.

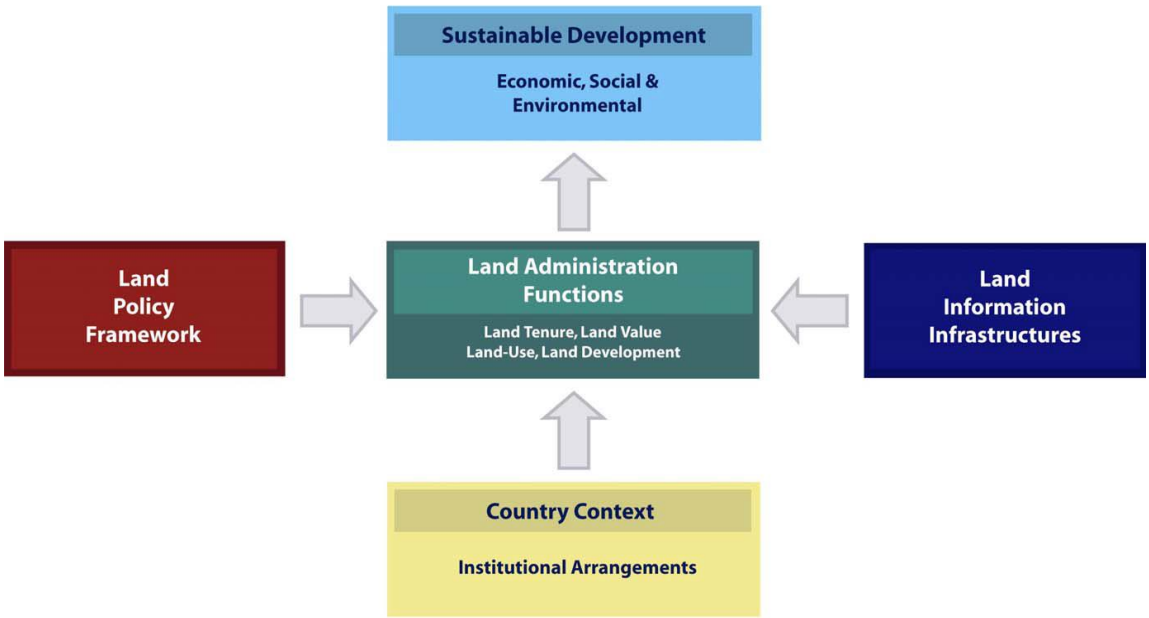


Figure 11: Land Management Paradigm [55]

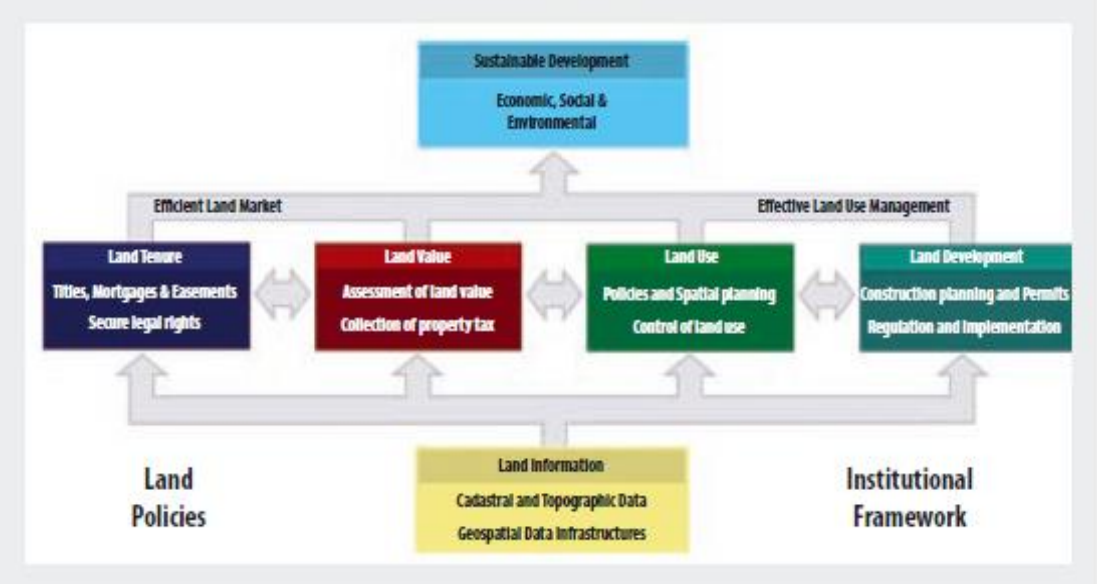


Figure 12: Land Administration Model [55]

Land administration systems provide the infrastructure for implementation of land polices and land management strategies in support of sustainable development [56] The need for a complete coverage of all land by LAS is imperative, not only for the registration of formal rights and for the recordation of informal and customary rights, but also for the management of land use and land development plans.

"The land administration system [49] comprises an extensive range of systems and processes to manage:"

- "Land tenure which is the allocation and security of rights in lands; the legal or informal surveys to determine boundaries of spatial units; the transfer of formal or informal rights or use from one party to another through sale or lease and the management and adjudication of doubts and disputes regarding social tenure relationships and boundaries."
- "Land value which is the assessment of the value of land and properties; the gathering of revenues through taxation; and the management and adjudication of land valuation and taxation disputes."
- "Land use: the control of land use through the adoption of planning policies and land use regulations at national, regional and local levels; the enforcement of land use regulations; and the management and adjudication of land use

conflicts."

- "Land development: the building of new physical infrastructure; the implementation of construction planning and change of land use through planning permission and the granting of permits. Certainly, all the four functions are interrelated."

2.4.5 Lesotho's mobile GIS Land Administration system

The land administration system [57] in Lesotho has traditionally been based on the influence of local chiefs, known as the Morenas. Several land legislation changes since the 1960's have tried to introduce a more formal system. In most parts of Maseru however, there were no leases beforehand and the land administration was handled by the Morenas only. A mobile Geographical Information System (GIS) for municipal field work was later designed and implemented for the prevailing circumstances of a land regularisation project in Lesotho in Southern Africa. The GIS was developed as an application for the Android platform, primarily with the tablet-computer format to be used for land registration field work. With the mobile GIS application, the field officers fill out the Parcel Plans directly in the tablet. The parcel boundary type needs are normally noted in the parcel plans as well. Automatic input of GPS coordinates into the Parcel plans are a useful feature and this has been implemented successfully. Another possibility of acquiring parcel coordinates could be to not rely on the GPS but to obtain them from tapping inside a parcel on the geo-referenced orthophoto [57].

2.4.6 Open Tenure System-Cambodia

Open Tenure [58] "supports a crowd sourcing approach to the collection of tenure related details by communities has been implemented and tested in Oddar Meanchey Community Forest, Cambodia. The community usually discusses and agrees to the way tenure right claims shall be collected, moderated and displayed on a Community Server that has been established." Figure 13 shows the Open Tenure System Architecture.

"Typically the recording of tenure rights include these stages: [58]"

- "Community information dissemination;"

- “Community Recorders download details of existing tenure rights and fit-for-purpose map imagery; In-the-field recording of claim details including mapping of claims and the collection of document images and photos;”
- “Upload claims to Open Tenure Community Server;”
- “Display of claims and the potential submission of challenges to claims on Community Server;”
- “Review of claims (and associated challenges);”
- “Moderation of claims (community endorsed) including modification of claims based on community based consensus;”
- “Publishing of community endorsed tenure rights on Community Server.”

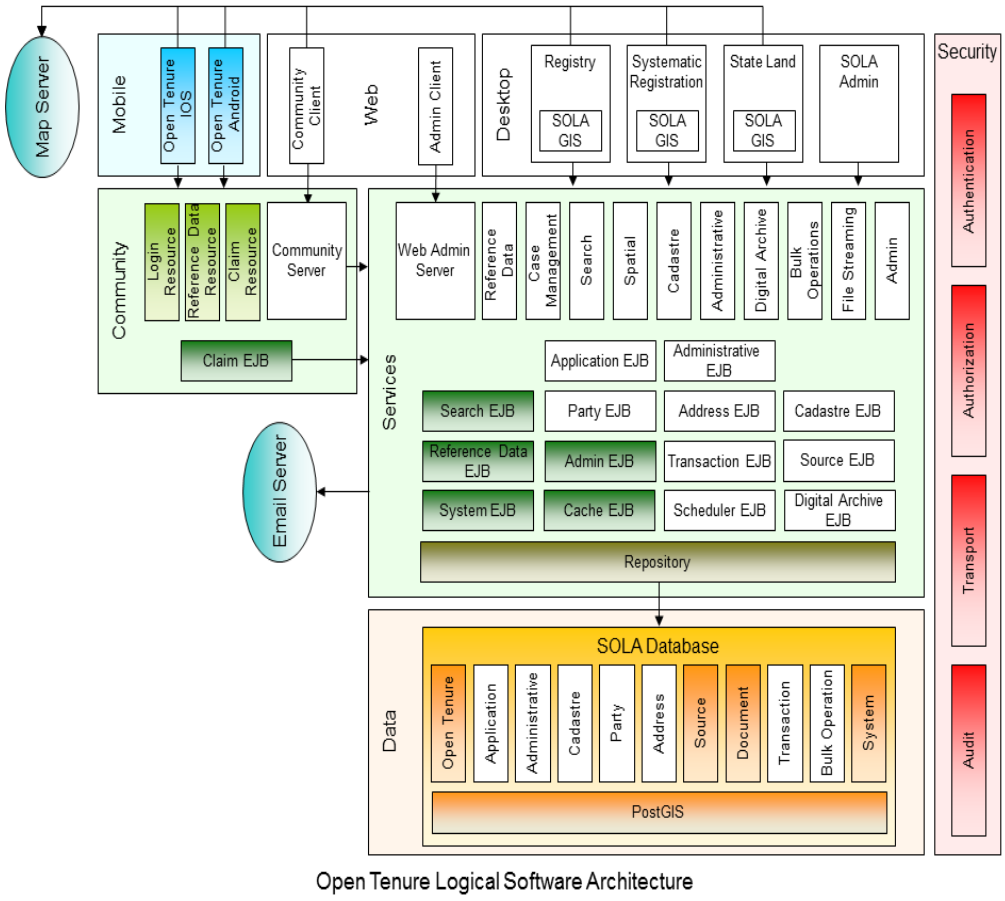
Figure 13: Open Tenure System Architecture [57]

2.4.7 FAO SOLA Open Source Software for land administration

FAO SOLA open source software has developed a system supporting registration and cadastral functions in a typical land office. SOLA is now a suite of software which includes a newly released mobile application called Open Tenure that gives communities outside of formal tenure administration the opportunity to initiate their own tenure recording as well as manage their own resources through a form of community based crowd sourcing of tenure relationships. A first field test of Open Tenure with the Monks Community Forest community in the north-west province of Oddar Meanchey, Cambodia was done in February 2015 [59]. Figure 14 shows the open tenure logical software architecture.

“Open Tenure is an open source software app for mobile devices that gives communities

and individuals the ability to record tenure rights within their community. It was designed to be used in conjunction with a web based "community server" where tenure details captured with Open Tenure can be publicized and moderated by the community. It is the first SOLA software application to specifically address tenure recording at the community level outside of formal land administration. The tablet based Open Tenure software application necessitated extensions to the overall SOLA software architecture and a different software development environment (Eclipse)." Open Tenure takes advantage of more affordable technology in the form of mobile devices including tablets and smart phones that are common within many of these communities [59] [58]."



Open Tenure Logical Software Architecture

Figure 14: Open Tenure Logical Software Architecture [58]

Open Tenure Software Operation

Open Tenure allows community based recorders using Android based tablets or Apple iPads to record claims to tenure rights. Details captured with Open Tenure include a description of the tenure right, identification of the owners, images of supporting documents and photos and the boundaries of the tenure right in terms of fit-for purpose

map imagery augmented by GPS positions. Once captured these details are stored on an Open Tenure Community (cloud based) Server where they can be viewed by other community members and challenged if there is a dispute. The Open Tenure Community Server also supports processes that lead to community recognition of the recorded tenure rights [58] [59]. Figure 15 and 16 shows an open tenure land information details and land demarcation process.

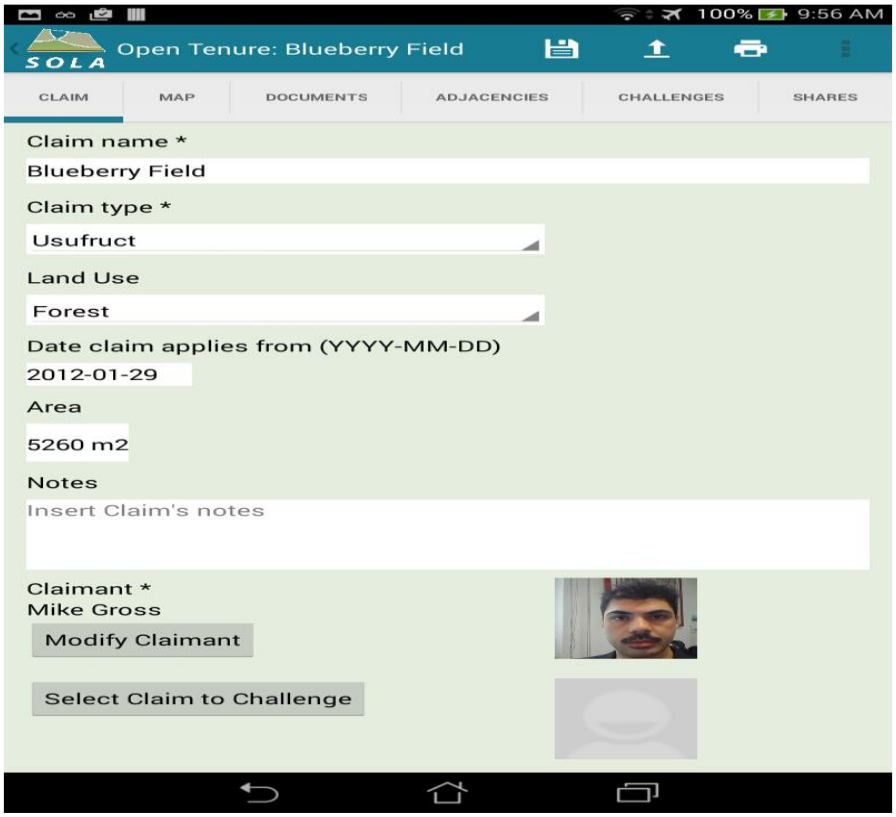


Figure 15: Open Tenure Land Information details [58]

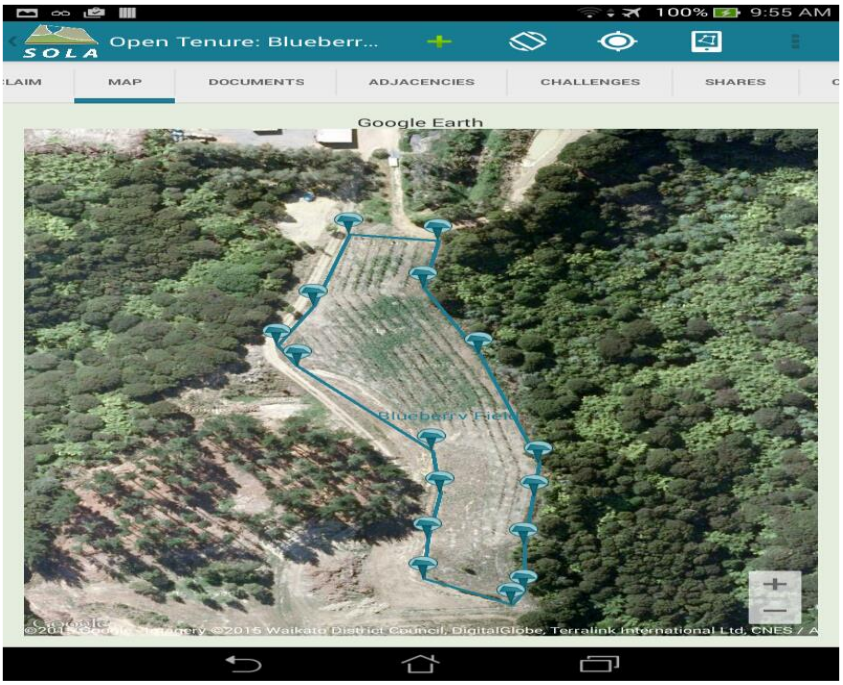


Figure 16: Open Tenure land demarcation screen [58]

2.4.8 Open Data Kit - Brazil

Computer scientists at the University of Washington have used Android, the open-source mobile operating system championed by Google, to develop an Open Data Kit to turn a mobile phone into a versatile data-collection device. It is being used by organisations around the world that need inexpensive ways to gather information in areas with little infrastructure. For example, members of the Surui tribe in Brazil have tested the Open Data Kit as a tool to raise awareness of illegal logging on their lands. The tribe also plans to use the tool to take an inventory of its forests so it can participate in global carbon markets [60].

2.4.9 Mobile Application to Secure Tenure - Tanzania

"The USAID [61] in Tanzania developed the Mobile Applications to Secure Tenure (MAST) project, which is an easy-to-use, open-source smartphone application that captures information needed to issue formal documentation of land rights. Coupled with a cloud-based data management system to store geospatial and demographic information, the project is aimed at lowering costs and time involved in registering land rights and making land process more transparent and accessible to local people."

The project [61] “is being implemented in rural Tanzania where USAID is working directly with villagers to map and record individual land rights, strengthen local governance institutions, and build government capacity.” “The MAST Application Suite comprises of two principal components: a smartphone application for the capturing of land rights information and a cloud-based data management infrastructure [61].”

“The Data Capture Application component is an Android-based mobile application with two functions:

- “Capture land rights information (spatial, alphanumeric, and multimedia)”
- “Capture data in offline mode and transfer data to cloud-based data management server when a connection is available”

The Land Rights Infrastructure component is an open-source data management and storage facility that is designed to receive, manage and store land rights information collected on mobile devices. The Land Rights Infrastructure has the following functionalities [61] :

- “Provides administration tools which allow for customizable set-up and security of data;”
- “Facilitates to intake and validate data into a relational database management system that is configured on the Land Administration Domain Model/Social Tenure Domain Model;”
- “Configures the database, including the addition of customized fields and porting of attributes to data collection forms on mobile applications;”
- “Processes and validates data according to predefined rules;”
- “Visualizes and edits spatial data collected in the field, via a Web-based GIS; and
- “Configures and integrates template reports and land rights documentation”.

“The MAST Application Suite is flexible and adaptable to a variety of country contexts and uses. Some potential uses include [61]:”

- “Systematic Registration”

- “Spot Registration”
- “Adjudication”
- “Conflict Resolution”
- “Sustainability Planning”
- “Natural Resource Management”
- “Land Use Planning”

Figure 17 shows the screenshot of a MAST application showing land demarcations

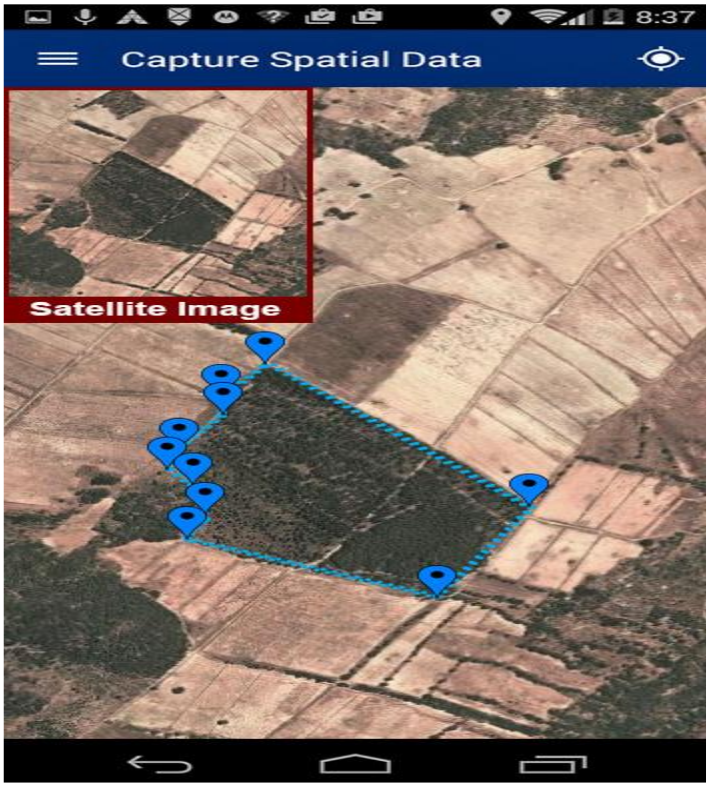


Figure 17: MAST demarcation screen [60]

2.5 Summary

This chapter reviewed different literature on customary land management in Africa and Cambodia. The latest mapping technologies and land management models from different countries were studied together with their advantages and disadvantages. This chapter concluded with the related works on how customary land is managed in different countries.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

In this chapter, the baseline study, the sampling method and the research methods have been discussed. I will begin by looking at the type and methods used by chiefs in managing customary land in Zambia.

3.2 Baseline Study

Zambia is a landlocked country located in Southern Africa with an estimated population of 15.5 million as of 2015. It covers an area of about 752,614 square kilometres between latitudes 8 and 18 degrees south, and the longitudes 22 and 23 degrees east. This means that if the total landmass of the country was divided against the population, every Zambian would have at least twelve acres of land [62]. Land in Zambia is formally owned by the state and can be divided into two legal categories: customary land tenure system, meaning communal land, and privately or state titled land under the statutory land tenure system. The President holds state land on behalf of the population, while traditional authorities hold customary land on behalf of their communities. Customary land tenure is the dominant system governing land administration of the land mass of Zambia. Approximately 64% of Zambian land is currently held as customary land and 36% is held as state land [63]. Statutory law comprises rules and regulations which are written down and codified. Customary law, on the other hand, is not written, but it is assumed that the rules and regulations under this system are well known to members of the community [63]. The authors in [63] and [13] define customary law in the perspective of land alienation as referring to rules, traditions, and customs that regulate the system of land holding, occupation and use in customary areas.

Zambia has more than seventy-two (72) tribes and each of these tribe's practices diverse customs and practices. The continuing attrition of customary land management within a context of investor interest has increased the demand for customary land, which is

already under pressure with rising numbers of people dependent on it for survival such as farming and hunting. Despite the fact that most land is under customary power, there are no resources obtainable to manage the land system. Tenure insecurity continues to destabilize local land rights, especially for women and orphans.

In the recent past, Zambia has experienced artificial shortages of land in major towns such as Lusaka, Solwezi, and Choma due to high demand of customary land. At the same time, a number of factors have created evolutionary change in the customary tenure systems. The rules to access, use and transfer land have changed to adapt to the changing context of commercialization, population growth resulting in rural-urban migration, tourism, monetary economy, urbanization and high demand for land and its consequent translation into monetary values [62]. Land administration and ownership has proved a major problem for the pre-urban and rural population. The failure by government to provide better mechanism of land ownership is considered to be a major factor contributing to the mass relocations and non-preservation of land for future generation [13]. In many places commercial agriculture has taken root. Further, due to increasing population and the increase of land under cultivation, land has become a valuable and scarce commodity [64]. In such cases, traditional authorities and local elites are often facilitators of deals, making money at the expense of their communities. Reports abound of chiefs or local elites in Zambia, persuading communities of the benefits of releasing their land to investors, and even reinterpreting their trusteeship as entailing their due right to sell and benefit from those sales. Communal rights are being grossly interfered with, farming systems upturned, livelihoods decimated, and water use and environments changed in ways which are dubiously sustainable [64]. There is therefore a need to make customary tenure more secure than it is now to ensure equal distribution of land to all Zambian citizenry.

3.2.1 Sampling

This study employed stratified random sampling. Stratified random sampling is one way that investigators address the issues of diversity. In stratified random sampling, the population is divided into the smaller subgroups, or strata, that the researcher

determines to be of importance on the basis of literature support. Elements are then chosen from each stratum. The main purpose of sampling is to select a subgroup that can accurately represent the population. The intent is to be able to draw accurate conclusions about the population by studying a smaller group of elements (sample) [65]. The study area selected for this research is Munkonge Chiefdom, situated in the Northern Province of Zambia. The study area is headed by Chief Munkonge and his supported by four (4) village headmen as shown in Table 1.

Table 1: Village and respective headperson

Village Number	Village Name	Headperson
1	Makonde	Makonde
2	Kalebaila	Kalebaila
3	Nakulukatongo	Nakulukatongo
4	Nsange	Nsange

A total of one hundred and two (102) questionnaires were administered, twenty five (25) questionnaires were distributed to the female and male village committee members who are in decision making and seventy seven (77) questionnaires were distributed to the ordinary subjects. The targeted groups were male and female residents that own land from the age of eighteen years to above one hundred years.

3.2.2 Research Approach

The study employed both quantitative approach and the qualitative approach. Qualitative data were collected from four village communities of Munkonge Chiefdom in the Northern Province of Zambia as shown in Figure 19. The process involved conducting individual interviews with chief Munkonge and group interviews and focus group discussions with the village headmen and village committee members from a sample size of 25 participants. Questionnaires were also designed for further quantitative data from a sample size of 77 participants from the four village communities.

Most of the land from the study area is administered by customary laws, thus making it an ideal place to understand how customary land is managed. The one hundred and two (102) questionnaires were distributed as shown in Table 2.

Table 2: Questionnaire distribution

Village number	Village name	No. of questionnaires distributed
1	Makonde	30
2	Kalebaila	25
3	Nakulukatongo	25
4	Nsange	22

The targeted groups were male and female residents that owned land from the age of eighteen years to above one hundred years. Figure 18 and Figure 19 shows the map of Munkonge chiefdom.

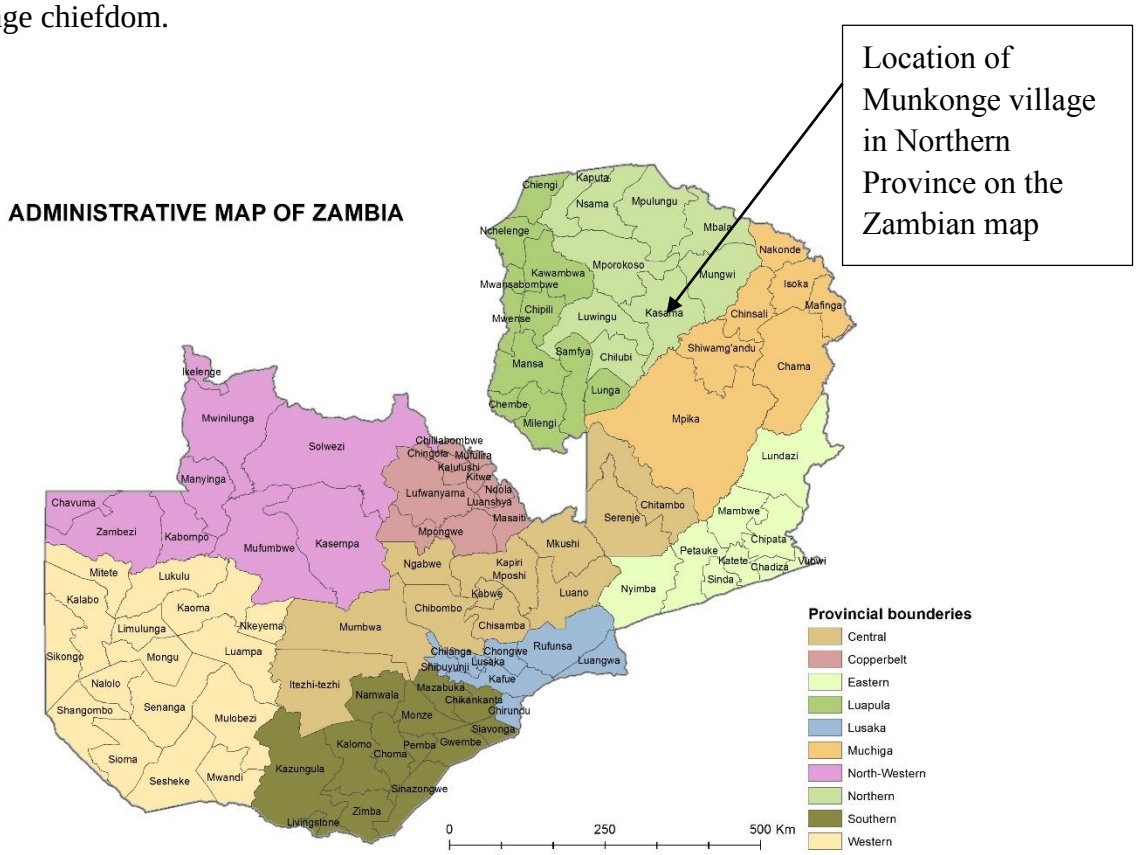


Figure 18: Administrative Map of Zambia

3.3 Summary

In this chapter, I looked at the baseline study, sampling method and the research approach. I came up with the 102 questionnaire responses as the sources of the current land information for the study area.

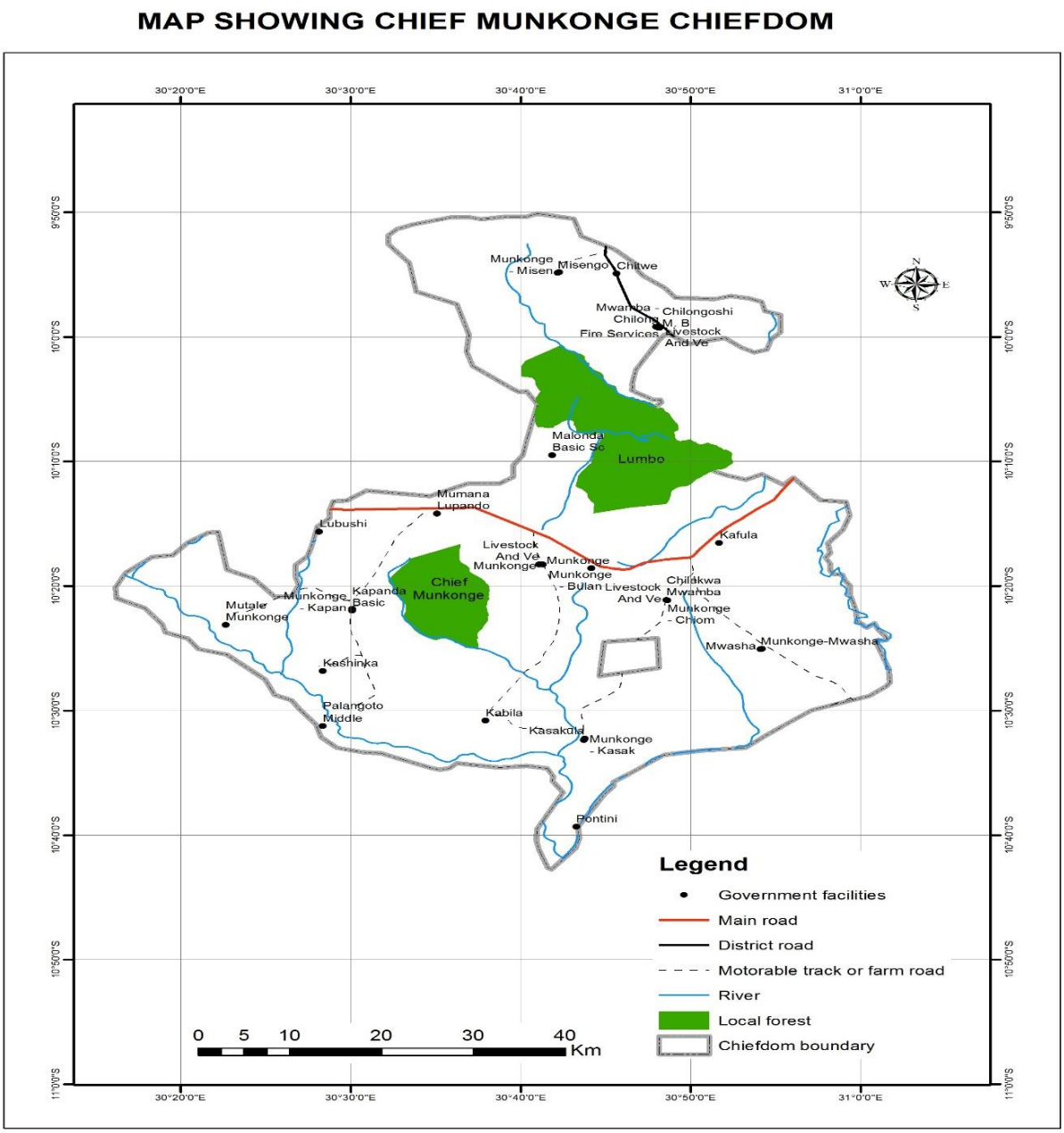


Figure 19: Map showing Munkonge Chiefdom

CHAPTER FOUR:
SYSTEM IMPLEMENTATION

4.1 Introduction

In this chapter, I discuss the design and the development of the mobile based customary land management system as a solution to the land conflicts which are currently prevailing in Munkonge chiefdom.

4.2 System Design

4.2.1 Business Process Mapping

In the current system customary lands not under occupation can be requested from either the chief or the headman. The chief retains paramount power over land allocations, although decisions concerning village residents can often be made by the headman alone. There are two general processes through which land is acquired. The first involves strangers seeking land in the village; the second involves a local resident seeking land. In the first case, a stranger is usually expected to bring a letter explaining his departure from his previous village. Land is normally allocated as long as the chief or headman accepts this explanation, approves of the family, and or accepts the stranger's reasons for wanting to move to the village. Other terms and conditions, possibly including a token gratuity or grant of money, may also be required. The second scenario is where the applicant is a current or former resident of the village—e.g., a son who has not received land through inheritance, a farmer who wishes to expand farm size, or a male resident who returns to claim land following a long absence. In this case, it may be either the chief or the headman who will allocate the land. In all cases, the size of the allocation is based in large part upon the amount of land the household will be able to cultivate [66].

4.2.2 Proposed System Architecture

The proposed mobile based customary land management system will enhance the management of customary land through use of effective land documentation process, GPS and secure storage and access to land information. All land information collected by the committee members and the residents will be stored either on local servers or cloud servers. Cloud computing is a computing paradigm, where a large pool of systems are connected in private or public networks, to offer dynamically scalable infrastructure for application, data and file storage. With the advent of this technology, the cost of computation, application hosting, content storage and delivery is reduced significantly [68]. Figure 20 shows the proposed system architecture of mobile based customary land management system.

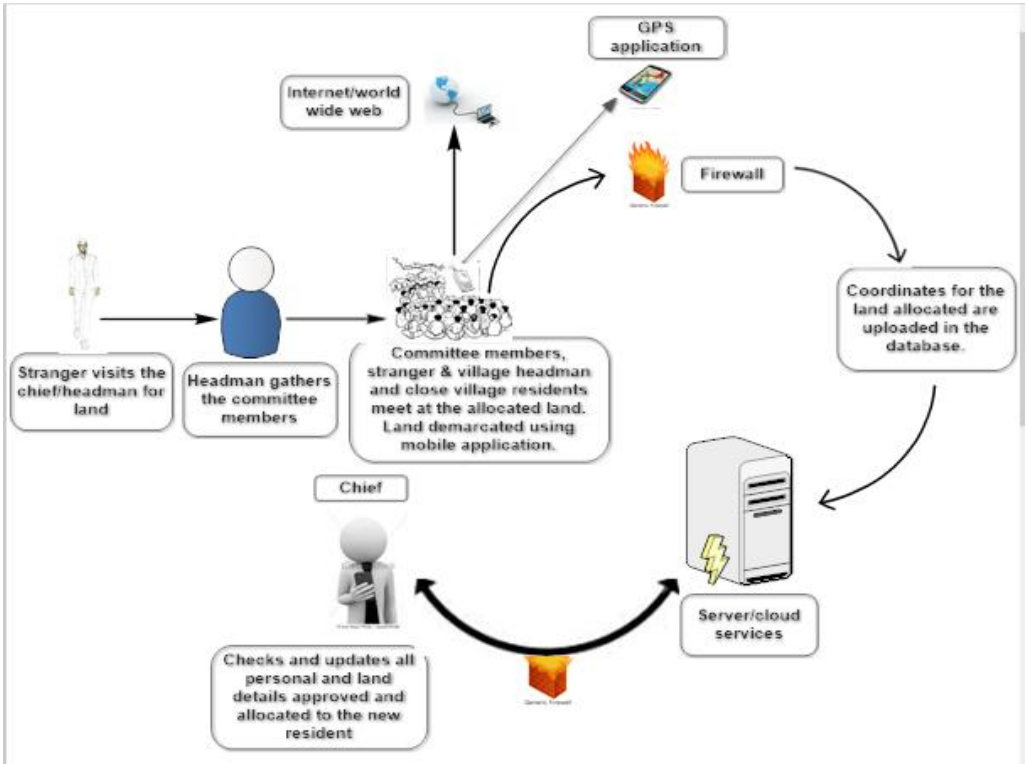


Figure 20: Proposed system architecture [67]

4.2.3 Use Case Diagram for customary land management information system

The use case diagrams describes the system's behaviour from the user's point of view. They allow defining the system's boundaries and the relationships between the system and the environment. The use case diagrams represent use cases, actors and the relationships between the use cases and the actors. The primary purpose of the use case diagram is to define how users and stakeholders, called actors, use the system.

The purpose of use case diagrams are as follows:

- Used to collect requirements of a system.
- Recognizes external and internal factors influencing the system.
- Demonstrates the interacting among the requirements are actors.

The administrator or chief will perform the following activities in the customary land management system:

- Land registration
- Assign land
- Update land details
- View land details
- Delete user and land details.

Figure 21 shows the administrators use case diagrams

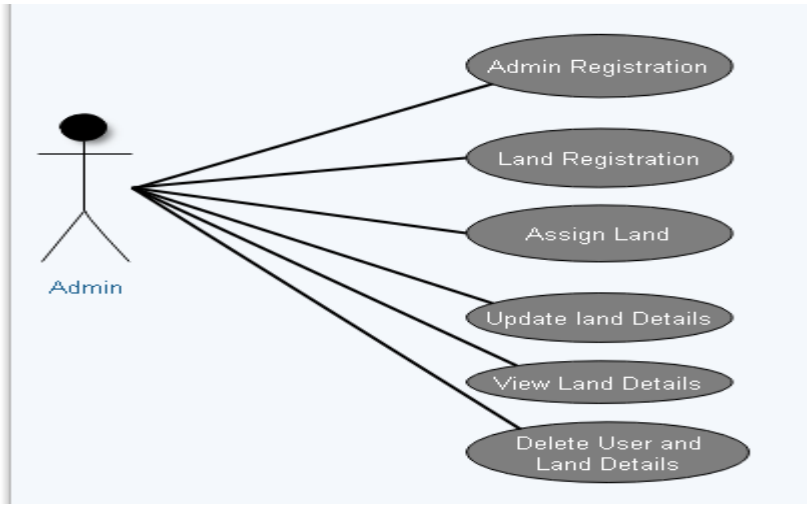


Figure 21: Administrators use case diagrams

The residents of the study area will also be able to perform the following activities:

- Client Registration
- Create land details
- View land details

Figure 22 shows the use case diagram for the residents or clients

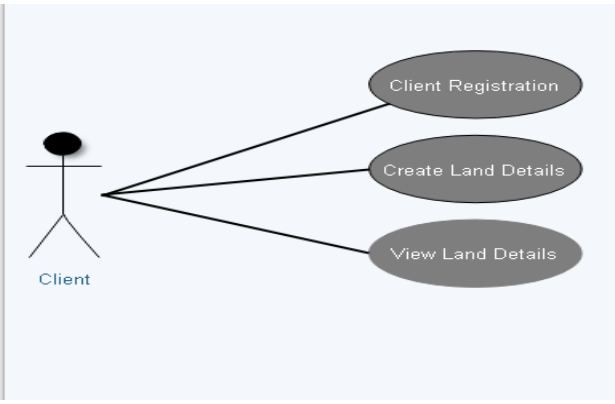


Figure 22: Residents or clients use case diagram

4.2.4 Entity Relationship Diagram (ERD)

An Entity Relation diagram (ERD) is a pictorial representation of the information that can be captured by a database. An entity set is a set of entities with common attributes where as a relationship is an association among several entities that needs to be represented in the database. The ERD demonstrating the data connection between the tables in the customary land management information system is shown in Figure 23. The tables used in the development of the mobile based customary land management are all linked through the use of primary keys and foreign keys.

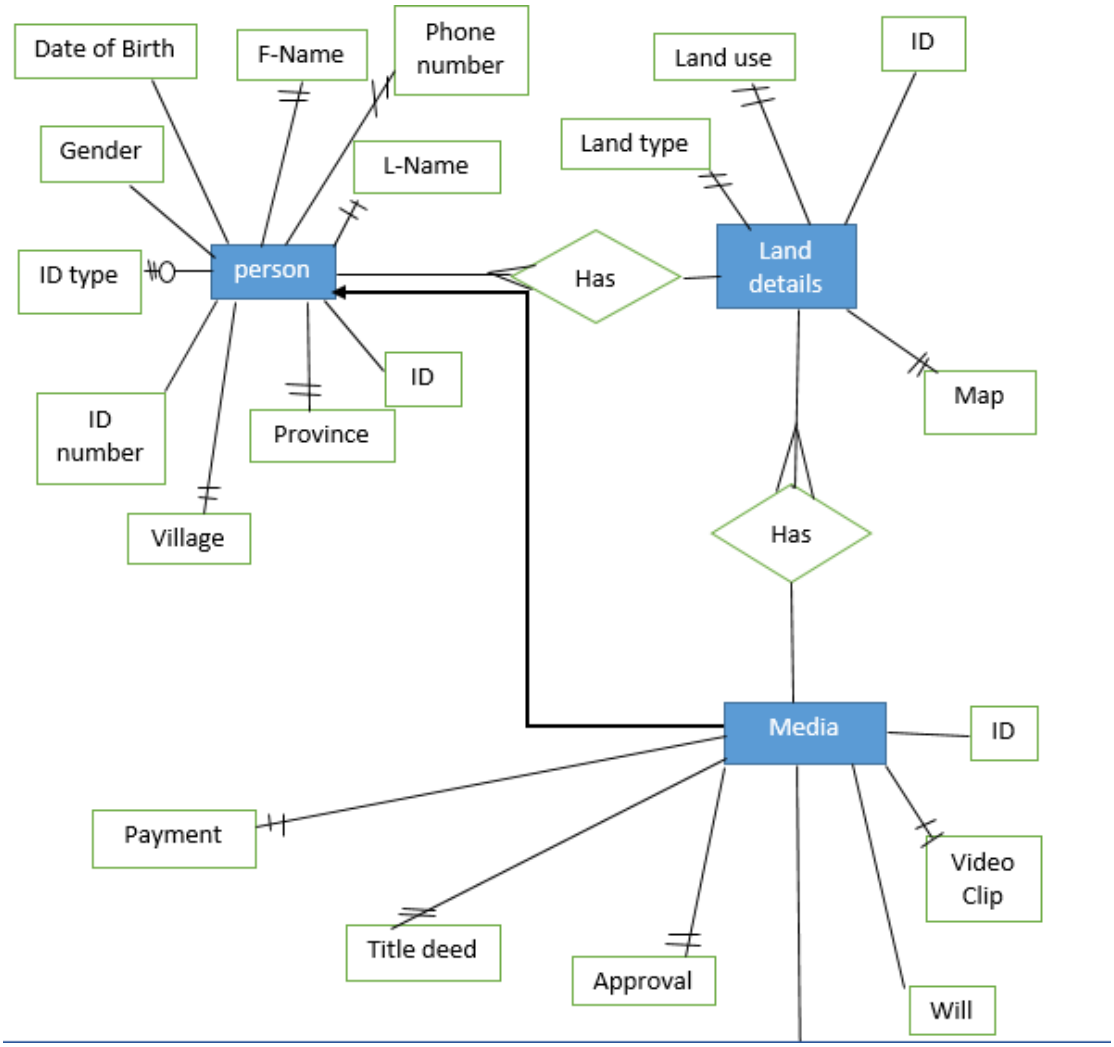


Figure 23: ERD for mobile based customary land management information system

4.2.5 The Sequence Diagram for mobile based customary land management information system

The Sequence Diagram models the relationship of objects based on a time sequence. The sequence diagram shows how the objects in a system interact with others in a particular scenario. The sequence diagram has been used primarily to show the interactions between objects in the sequential order that the interactions occur as shown in Figure 24.

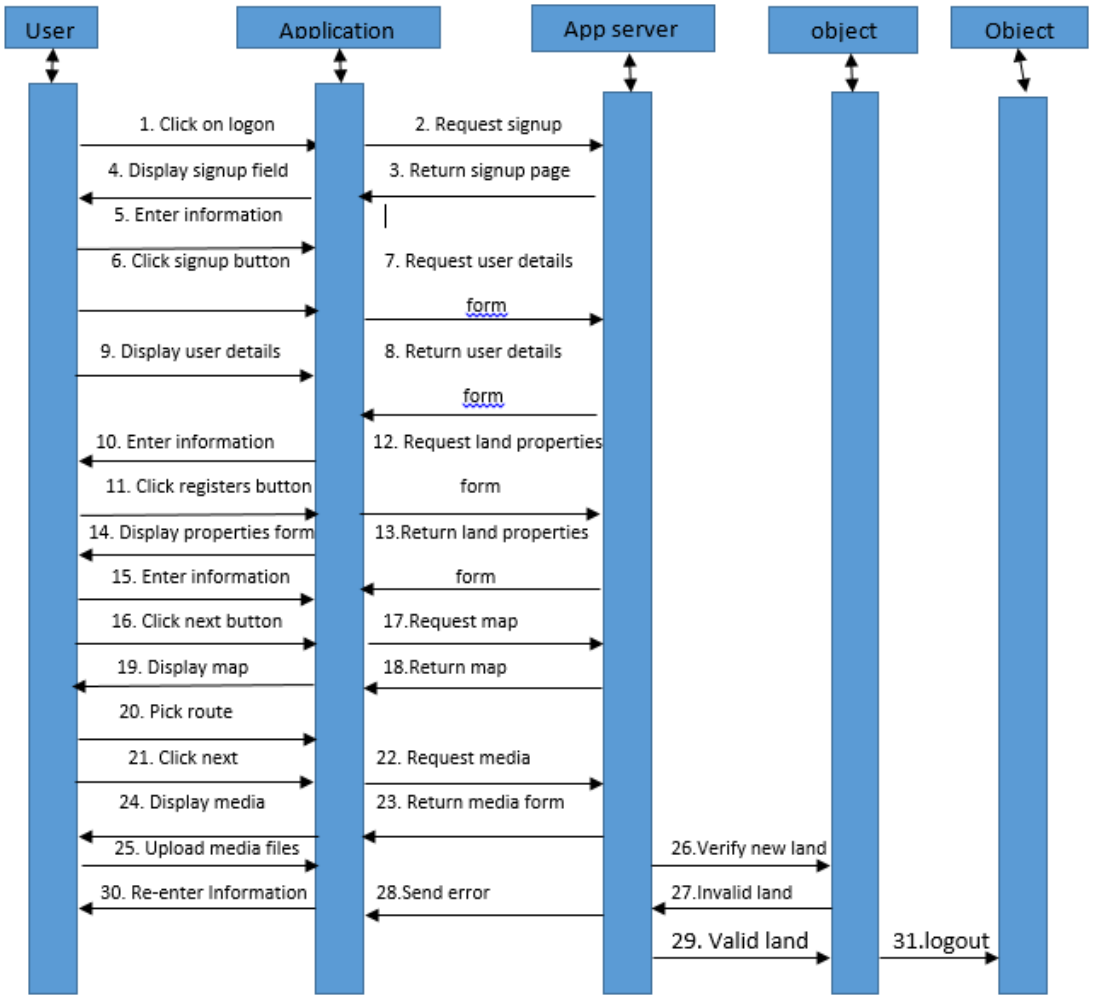


Figure 24: Sequence diagram for mobile based customary land management information system

4.2.6 Data Design

The proposed mobile based customary land management system designed comprise of the main tables such as; Lands, Users and the Media tables. The Lands table, Table 3 stores all land related records such as land id, land type, land use, longitude and latitude. The Users table, Table 4 stores all personal related data and the Media table, Table 5 stores all the supporting documentation for the user such as video clips, wills, marriage certificate.

Table 3: Lands Table

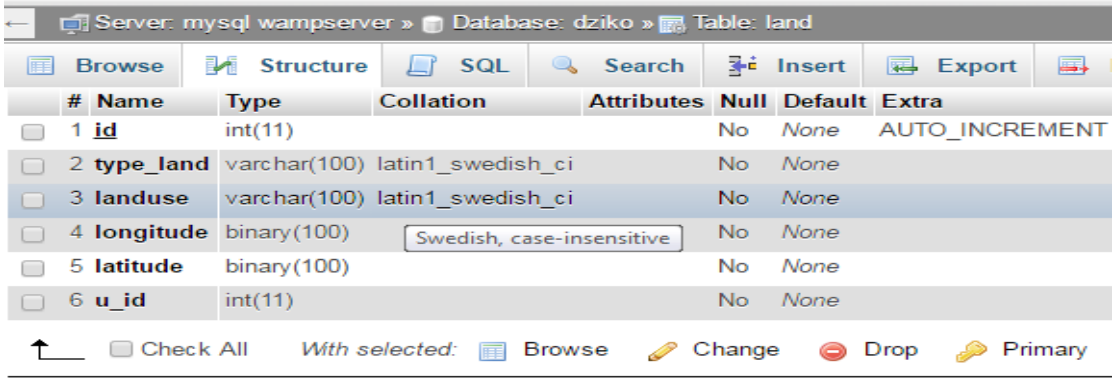


Table 4: Users Table

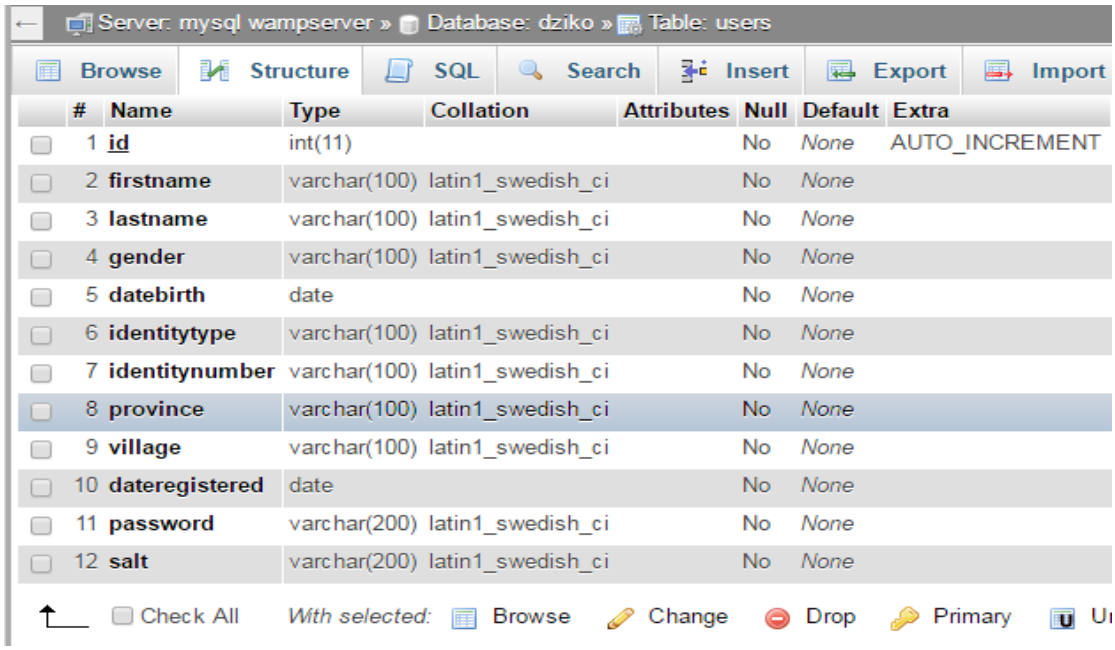
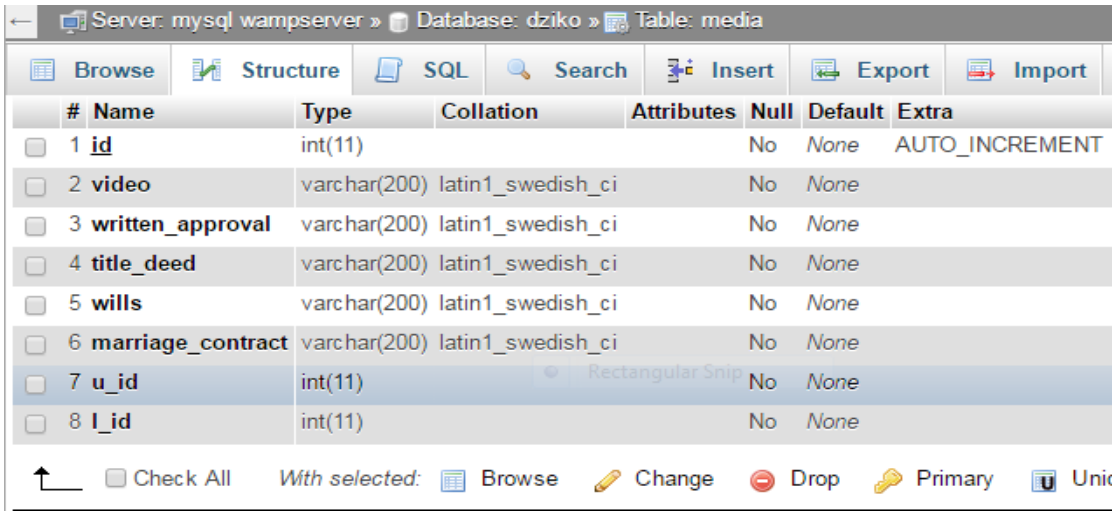


Table 5: Media Table



4.2.7 Hardware and Software Requirements

The Laptop computers used in this implementation were running on the Pentium ® Core i5 CPU at 2.60GHz with a minimum of 2GB RAM. The device used to run the application is the mobile phone, running android operating system. I used Windows 7, 32-bit operating systems, but the system is able to work on both windows 2000 and Windows XP. The other software requirements included the Java language SDK, Andriod SDK and google maps API. The google map API is the only licence required. For the database, I used MySQL database to store the coordinates and the user credentials captured during the registration. Android studio IDE was used as the development environment. Wampserver was used to run the developed customary application. I used the mobile phone to test the application.

4.2.8 System Architecture

The implemented system is developed using Java technology. Figure 21 showed the architecture of the mobile based customary land management information system. MySQL database is used to store both the land records and the land coordinates.

4.2.9 Code Listing – land demarcation

The main activity of the mobile based customary land management information system is the demarcation process. The following code shows the land demarcation process that was developed. The code is able to pick the location of the user or resident and later provide the latitude and the longitude of the area.

Pseudocode – land demarcation process

Mappng.java

```
1. package com.kce.zdiko;
   /**
    * Created by Annie Mporokoso i5 on 2/1/2016.
    */
   public class Mapping extends FragmentActivity implements
   OnMapReadyCallback {
       String id;
       InputStream is=null;
       String result=null;
       String line=null;
```

```
        int code;
        // this is all
        private EditText statusdate;
        // Progress Dialog
        private ProgressDialog pDialog;
        String insertcordinates";
        private Button statusbtn;
        String ids , lat, lng,zom, id2;
        int x =1;
       // JSONParser jsonParser = new JSONParser();
        private GoogleMap mMap;
        ArrayList<LatLng> points;
        // Create a LatLngBounds
        private LatLngBounds = new LatLngBounds(
                new LatLng(-12.871593, 20.980588), new LatLng(-12.451796,
    34.609365));
```

The full code is in the appendix

4.3 Summary

In this chapter, I conducted the business process mapping, designed the Use Case Diagram, the Entity Relationship diagram and the Sequence diagrams for the mobile based customary land management system.

CHAPTER FIVE: RESULTS

5.1 Introduction

In this chapter I look at the results of the research that was conducted at Munkonge Chiefdom. The findings indicate lack of systematic way of handling land related records. It was discovered that the area experiences land conflicts due to non-existence of a proper documentation mechanism and an effective demarcation process.

The results obtained from the survey enabled the design and develop the mobile based customary land management information system using Java and MySQL. The mobile application uses Android operating system and google API.

5.2 Baseline Study Results

In this section I look at the results of the study conducted and the justification for the development of the mobile based customary land management information system. The last section looks at the implementation results of the system.

5.2.1 Survey Sampling

The data was collected from the four villages namely Makonde, Kalebaila, Nakulukatongo and Nsange under Munkonge Chiefdom through use of questionnaires and face to face interviews. The covered area represents only a small portion of the total land mass of customary land in Zambia.

5.2.2 Survey Results and Discussion

The data collected from the study was analysed using Statistical Package for Social Sciences (SPSS) application software.

5.2.2.A Respondents Age

The age of the respondents in the study area plays a critical role in terms of intergeneration of land information. Land information memories are kept by the elderly who later pass it on to the younger generation. Figure 25 shows that there are more

males between the ages of seventy (70) and eighty (80) representing 90.9% and less females representing 9.1% between the ages of seventy (70) years and eighty (80) years.

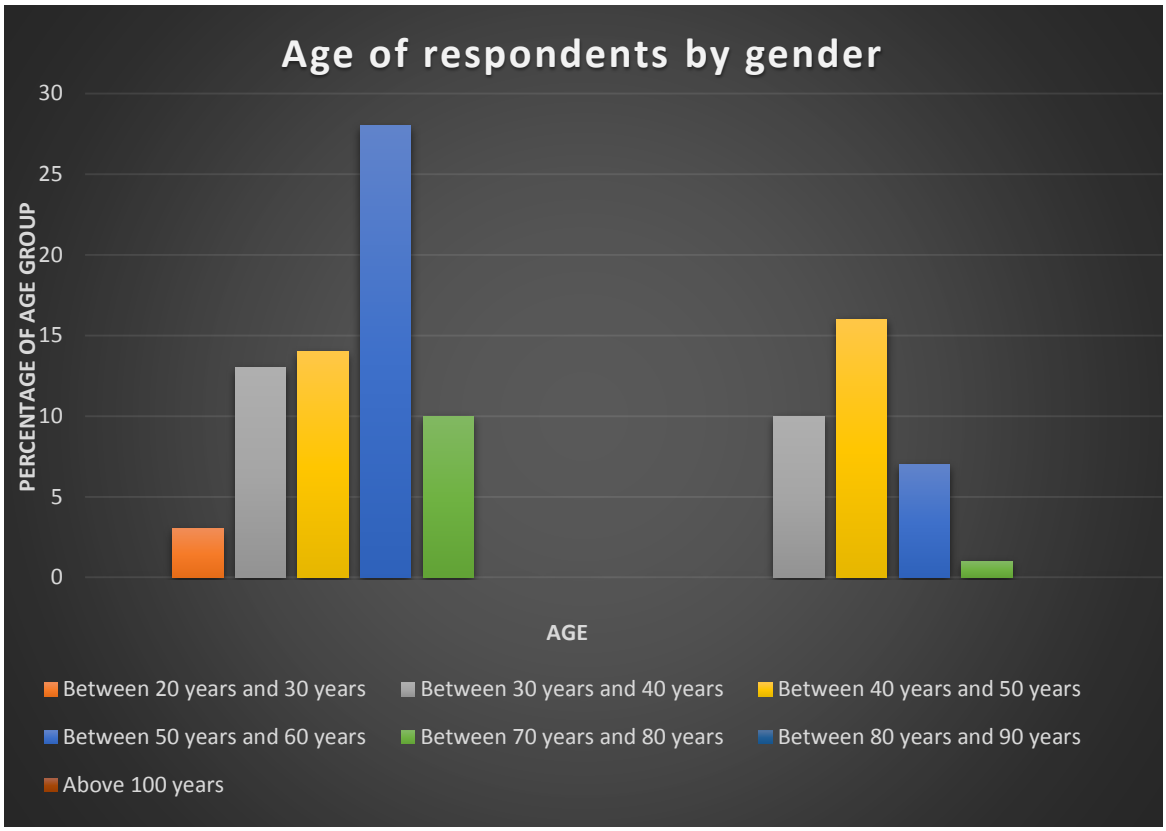


Figure 25: Age of Respondent by Gender

5.2.2.B Respondents' period of stay

The land history and land administration of the study area is kept by people who have lived longer in the chiefdom. It is important to know how long the respondents have lived in the study area as this will afford an opportunity to understand how historical land information is passed on to the future generation. Figure 26 shows that 66.3% male respondents between the ages of forty (40) years to sixty (60) years have outlived the female respondents representing 33.7%.

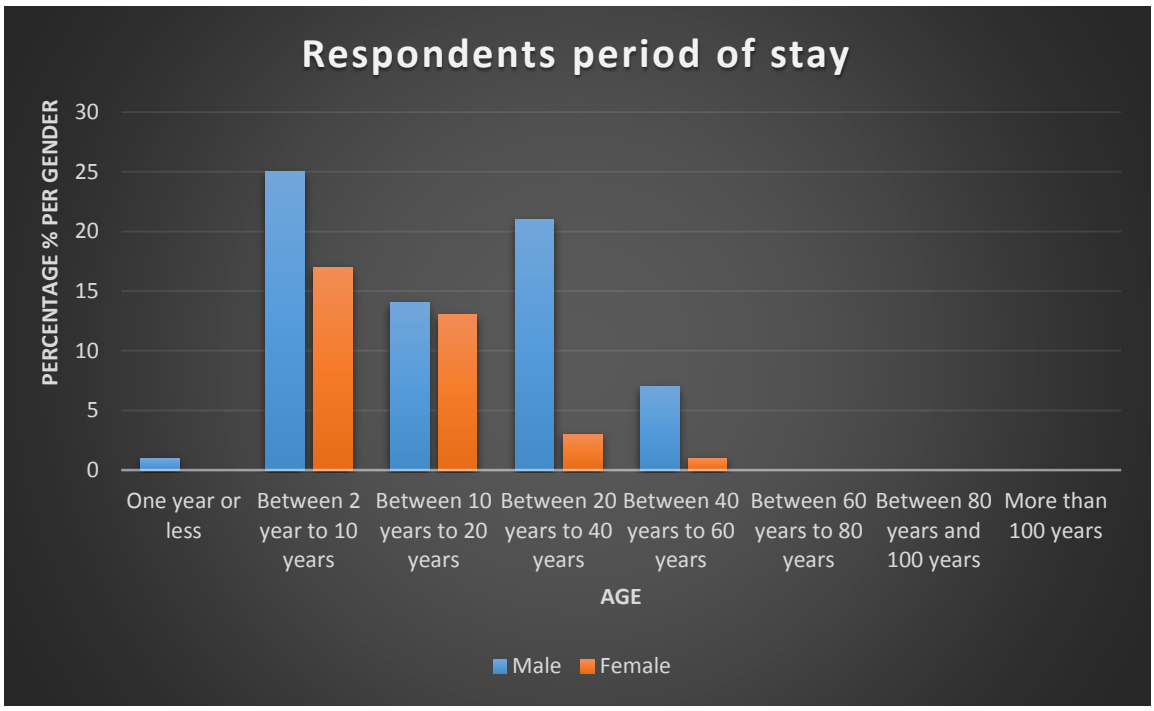


Figure 26: Respondents period of stay

5.2.2.C Land allocation

The residents of the study area agreed that land is an important asset and it is treated as sacred from the ancestral beliefs. The residents occupy land ranging between two (2) hectares and twenty (20) hectares which is allocated by the headman. The male residents occupy 49% of land between the 2 to 10 hectares while the female residents occupy 38% of the same range as shown in Figure 27.

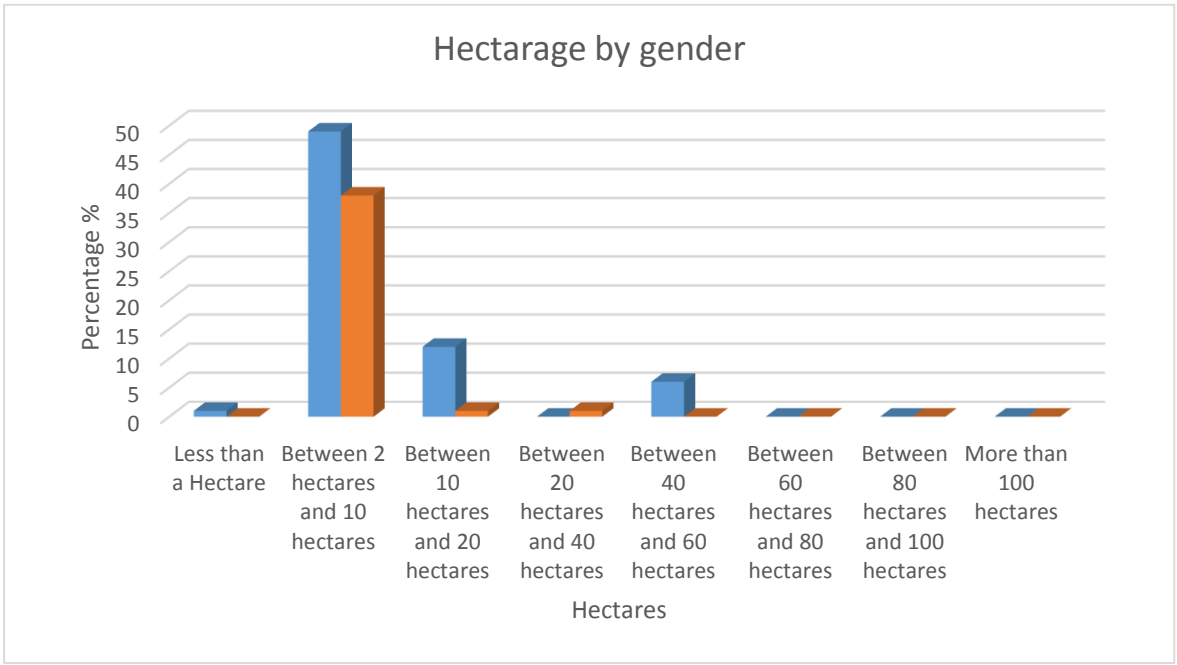


Figure 27: Hectares Owned by gender

5.2.2.D Land Utilisation

Majority of the residents in the study area practice subsistence farming as a means of sustaining their livelihood. Subsistence farming focuses on growing enough food to feed themselves and their families. The hectares ranging from two (2) to twenty (20) in the study area are mainly used for subsistence farming and this type of land is classified as small holdings. Figure 28 that shows 65.6% of male and 34.4% of the female respondent's practice subsistence farming as a means of supporting their families. This shows how important land is to the residents of the study area.

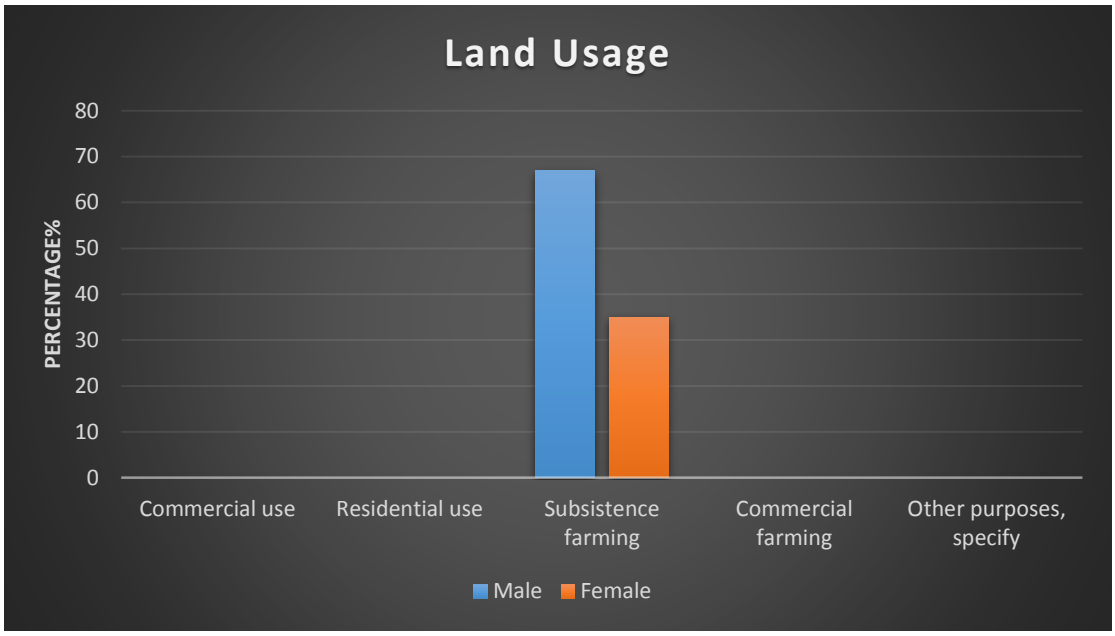


Figure 28: Land utilization

5.2.2.E Document Generation

Record keeping plays an important role in land administration. Land documents provides evidence of land ownership for an individual as well as the entire community. The respondents of the study area are not provided with any documentation pertaining to their individual land that they possess. However, the village headman captures the respondent's details such as their names, age and specific area of stay. Figure 29 shows that 98% of the respondents agreed that the headman keeps personal details in the membership book, while 2% disagreed to recording of personal details in the membership book.

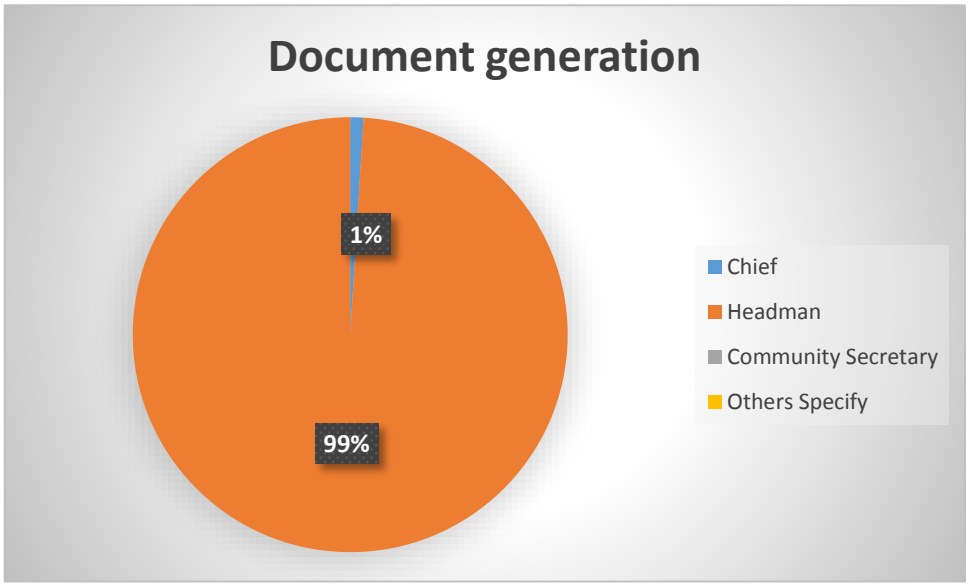


Figure 29: Document generation

5.2.2.F Land demarcation

Land demarcation are vital in land administration and trained land surveyor or proper land demarcation systems must be used to apportion correct land measurements to individuals and communities. The land in the study area is not properly demarcated by trained or experienced land surveyors or system. However, most of the land demarcations are done by the village headmen with the involvement of the villagers through use of big trees and anthills.

Figure 30 shows that 67.6% respondents claim that the land demarcations are done by the village headmen, while 32.4% of the respondents agreed that land demarcations are done by the villagers themselves.

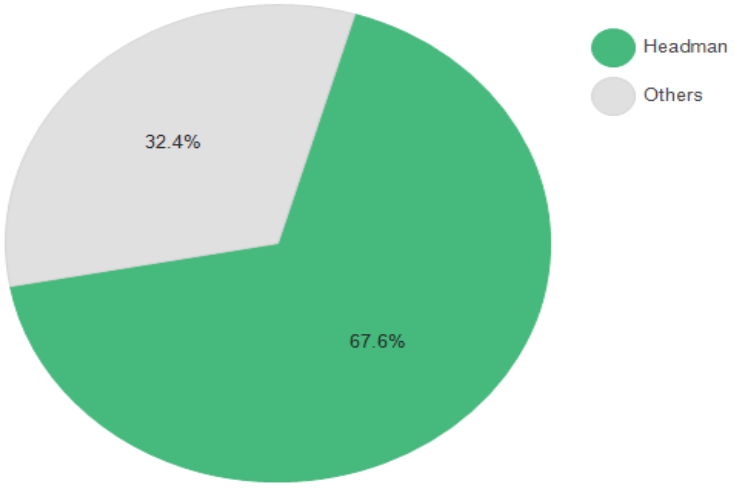


Figure 30: Land demarcations

5.2.2.G Demarcation type

The village headman and the residents of the study area demarcate the family land boundaries and communal land using trees, streams and ant hills. The study reveals that 62% respondents agreed that the land is demarcated by trees, while 30% said that the land was demarcated using ant hills and 12% respondents agreed the demarcation of the land through use of streams as shown in Figure 31.

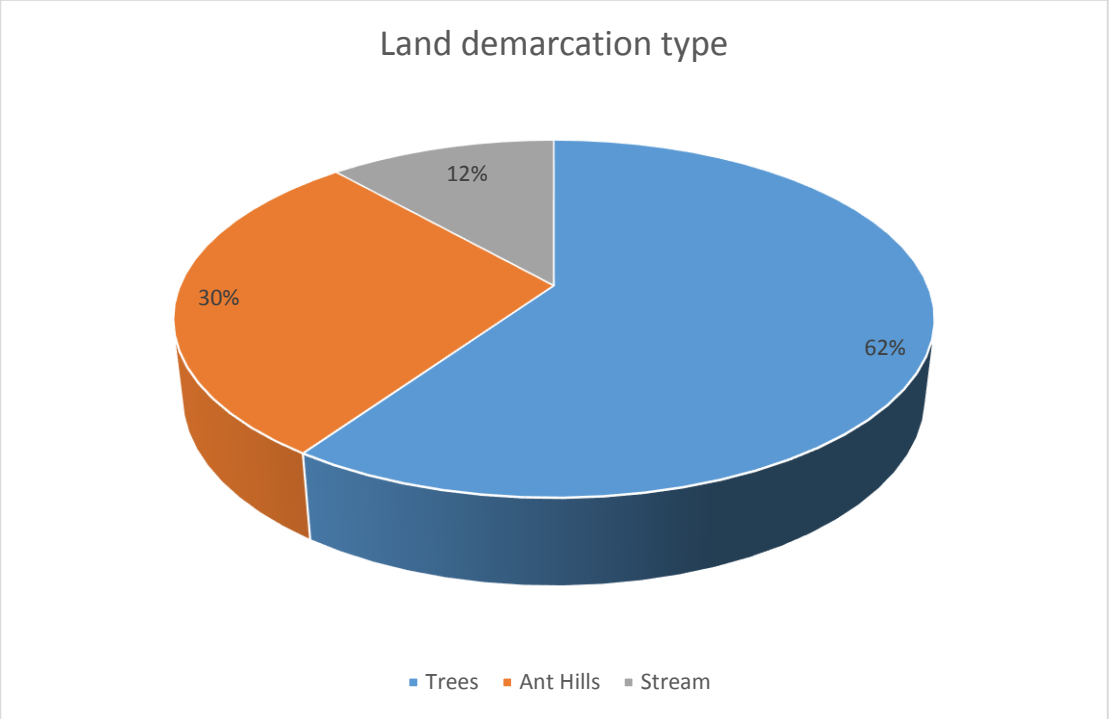


Figure 31: Land demarcations type

5.2.2.H Land Ownership

Personal records such as the names, age, gender, national registration card is what is captured from most of the people in the study area and these details are kept in the membership book. Land ownership details such as the area size, location of the land is not captured in the membership book.

Figure 32 shows that 97% respondents agreed that personal details are kept in the membership book and the residents do not have any other supporting documents of land ownership apart from the membership book, while 1% had certificate of Title, 1% had letter of Occupancy and 1% had other documentation.

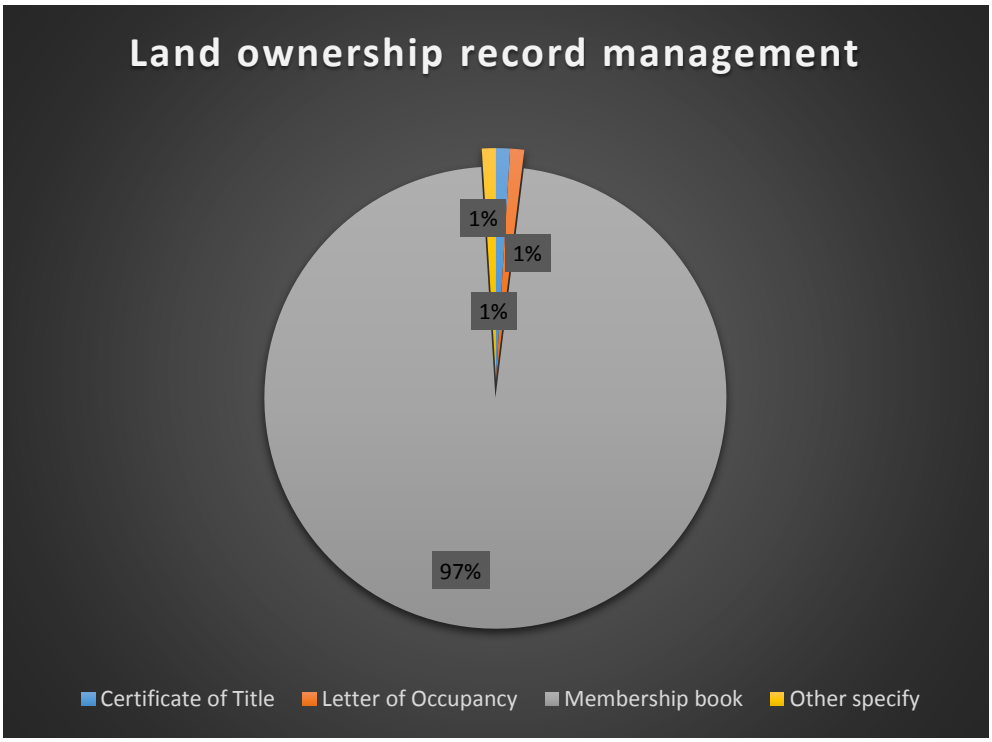


Figure 32: Land ownership records management

5.2.2.I Provision for signature

The membership book being used by the village headmen to store the respondent's ownership details does not provide for signing. Figure 33 shows that 98% respondents agreed that the membership book does not provide for signing. The signature in any land administration acts as proof of ownership and as evidence in the event of land disputes.

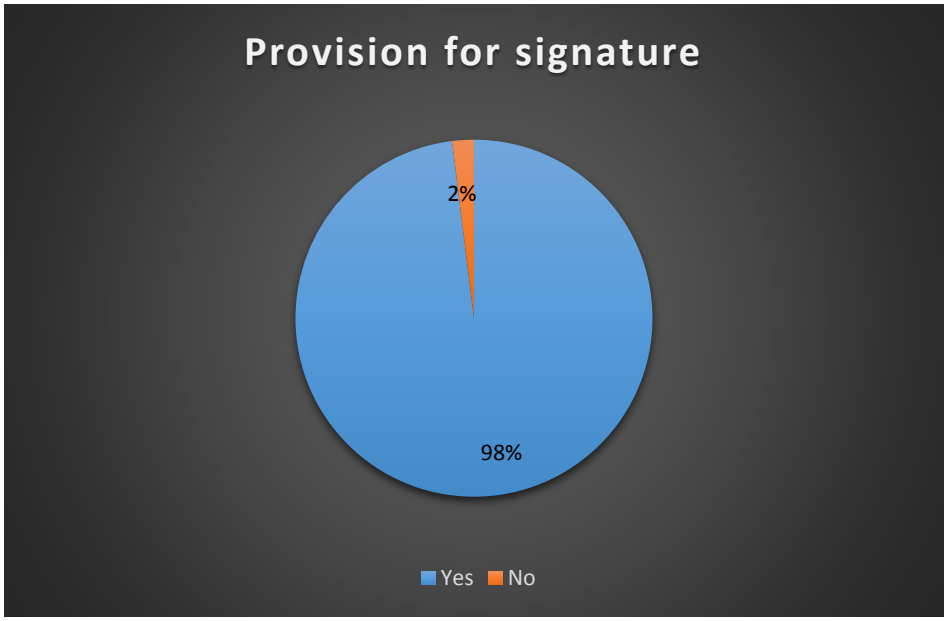


Figure 33: Provision of signature

5.2.2.J Causes of land disputes

The area of study encounters land disputes ranging from family boundary disputes, communal boundaries disputes and selling of land by chiefs and headmen. Figure 34 shows that 54.9% respondents agreed to having had family disputes, 41.2% respondents agreed selling of communal land by chief or headmen and 3.9% experienced communal land disputes.

The family boundary disputes are rampant because of a non-coordinated and systematic land demarcation system supported with proper land ownership evidence. The chiefs and village headmen have also taken advantage of nonexistence of proper boundaries system thereby selling land which certainly belong to individuals.

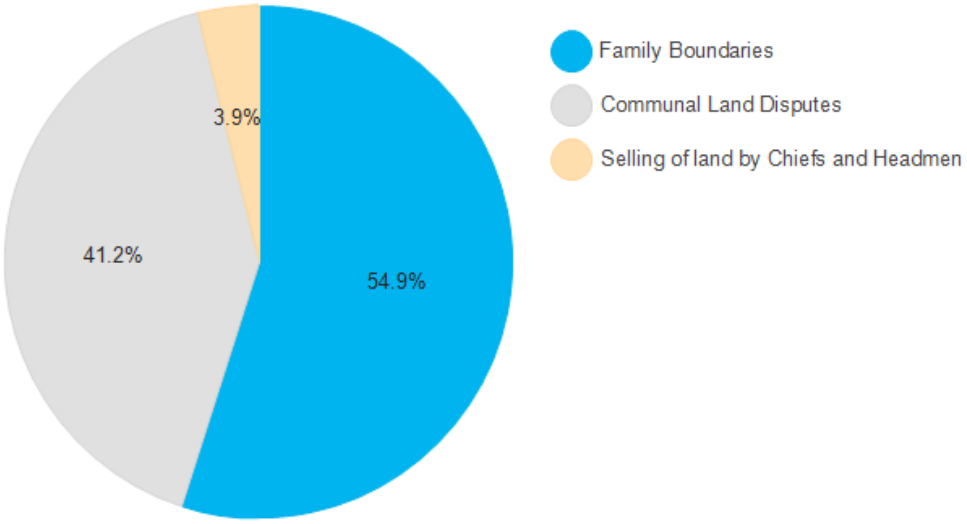


Figure 34: Causes of land disputes

5.2.2.K Resolution of Land Disputes

The resolution of the land disputes in the area of study is done by the village headman, village committee and in some cases, both the village headman and the committee. Figure 35 shows that 56.9% of the disputes are resolved by the village headman, 26.5% of the disputes are resolved by the village committee while 16.7 % of the disputes are resolved by the village headmen and the committee. The study shows that there is no independent body to deal with land disputes matters, as such the same village headmen that administer land also deal with land disputes.

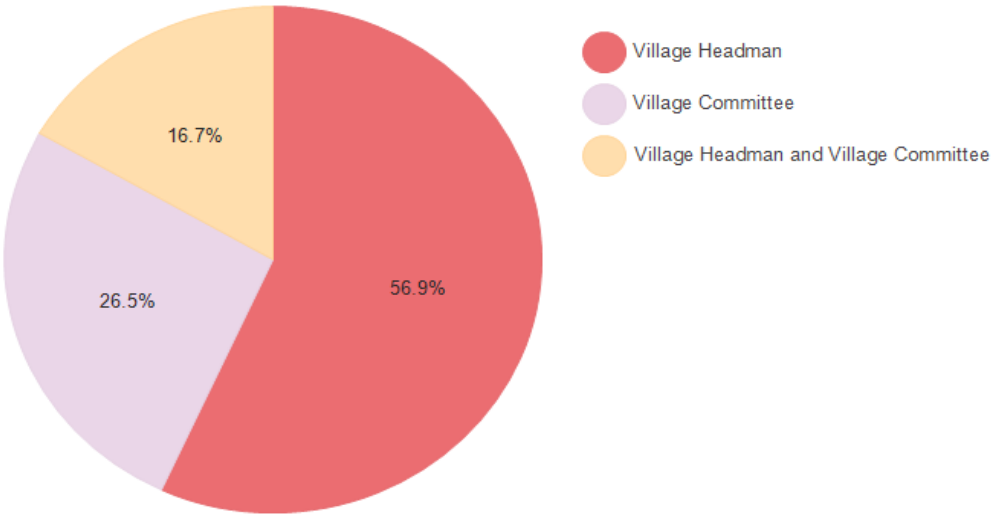


Figure 35: Land disputes resolution

5.3 System Implementation

In this section, the results of the mobile based customary land management information system have discussed and shown. The residents and the administrator (Chief) will have different roles and access to the system. The following screens shows the operation of the system.

5.3.1 Mobile Application Login Screen

Figure 36 displays the Zdiko Login menu for the mobile based customary land management information system. This menu allows both the residents to login to the system if they are already registered or sign up if not registered to access the system.

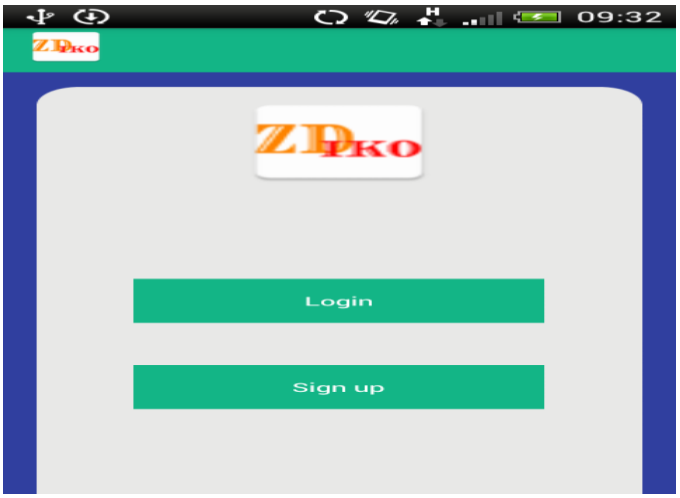


Figure 36: Login Menu

5.3.2 Mobile Application sign up window

Figure 37 shows the sign up window for the mobile application. The sign up window allows residents to register their identity details which will enable them access the system.

Figure 37: Sign up window

5.3.3 Registration Window

Figure 38 below is the registration window that allows the residents to register their location

Figure 38: Mobile Registration window

5.3.4 Land Registration window

Figure 39 depicts the land information details such as the land type and the land usage which the residents will need to enter.

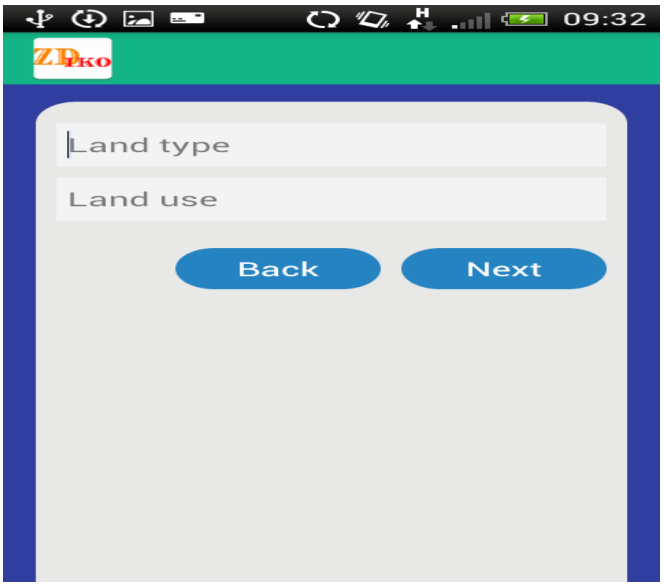


Figure 39: Land Registration window

5.3.5 Land Demarcation process

Figure 40 and Figure 41 shows pieces of land that have been demarcated using the mobile customary land management application.

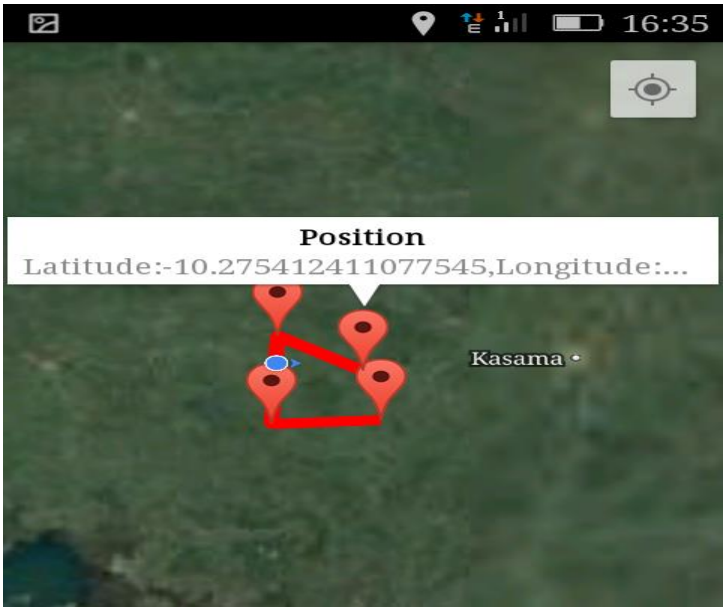


Figure 40: Mobile Land demarcation

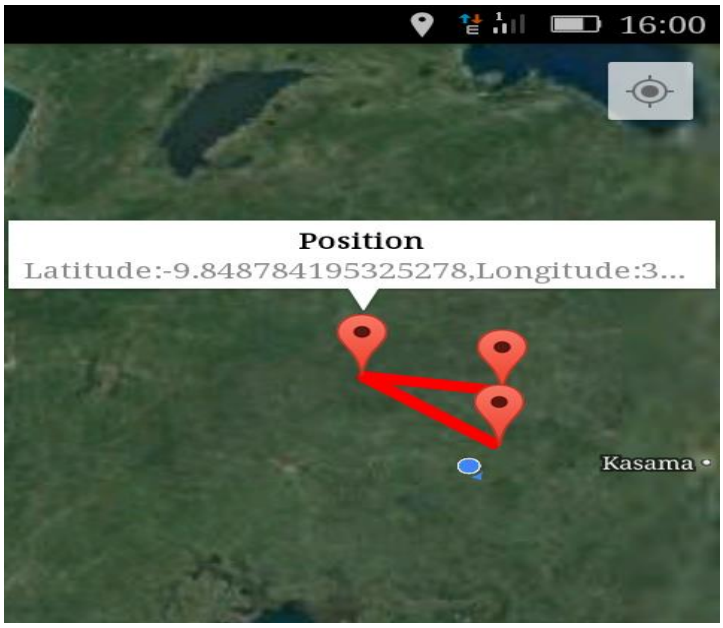


Figure 41: Mobile Land demarcation

5.3.6 Uploading window

Figure 42 shows the upload process where the residents will have an opportunity to upload their personal documents which will be attached to their piece of land.

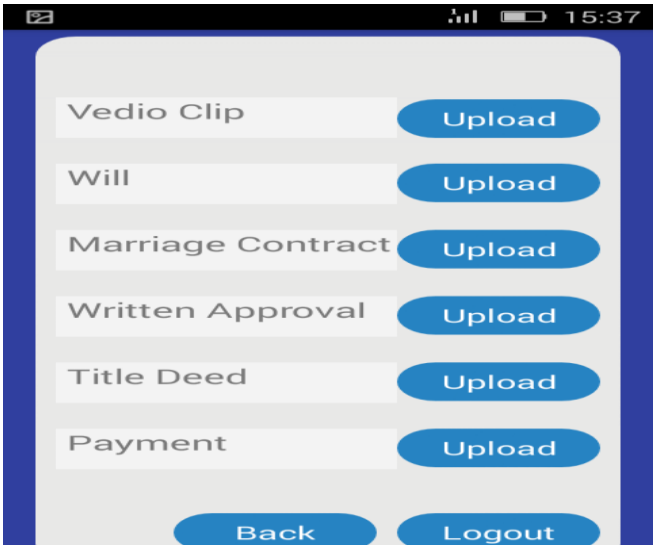


Figure 42: Mobile Upload menu

5.4 Summary

In this chapter, the mobile based customary land management information system was implemented, that allows residents to successfully register personal details and then perform land demarcation process with the committee members and document land parcels using a mobile phone.

CHAPTER SIX:
DISCUSSION AND CONCLUSION

6.1 Introduction

This chapter makes recommendations based on the result and analysis. I begin by discussing the results obtained, recommendations based on the results from the research, comparison with other similar works and finally the conclusion.

6.2 Discussion

This section discusses the results from the study conducted and the implementation of the proposed system in relation to the objectives of this study. The prevailing customary land conflicts such as family land disputes, communal land conflicts and chiefdom land conflicts necessitated the development of the mobile based customary land management system as a measure to safeguard the land rights and ensure security of tenure for the residents.

The aim of the research focused on the use of ICT tools in the management of existing customary land tenure information in order to improve land tenure security for the rural populace. In order to meet the research aim relevant questions were to be asked in relation to the objectives of the research. Table 6 below summaries the research questions, objectives, methods and the results of the study.

Table 6: Research Objectives

	Research Question	**Objective**	**Methodology**	**Result**
1.	What are some of the methods used by developing countries in customary land tenure management?	To carry out a literature review of various methods used in customary land management in traditional African setup and other developing countries.	Surveying literature in Land Management Systems and the integration of ICT tools. Information was obtained from published Journals, reports and websites.	Talking Titler Model, Social Tenure Domain Model (STDM)
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?	To carry out a survey to establish the method and type of information used in customary land management in Zambia	Questionnaire, face to face and oral interview	The research, showed that the study area lacks documentation and proper land demarcation process leading to several land conflicts. 97.1% respondents agreed that personal details are kept in the membership book and the residents do not have any supporting documents of land ownership. 54.9% respondents agreed to having had family disputes, 41.2% respondents agreed the selling of

				communal land by chief or headmen and 3.9% experienced communal land disputes.
3.	How can a model for customary land management in Zambia be develop?	To develop a model based on the findings from the survey in question and objective (1) in customary land management and administration.	Customary Land Architecture	The development of the customary land management system will supplement the existing land demarcation system that uses ancient trees, ant hills and streams, with latest mapping technologies and enhanced documentation of land records.
4.	Is it possible to automate the land management system based on the model in (3)?	To automate the process of customary land management by using mobile applications.	Agile Software Development • Java SDK • MySQL	The mobile based customary land application prototype was designed and developed.

6.2.1 Baseline study

The first objective was to establish the methods and type of land information used by chiefs and headmen to document customary lands parcels for their subjects in Zambia. The results revealed that the residents of the study area occupied land ranging between two (2) hectares to sixty (60) hectares with 66.7% being dominated by males while 33.3% is allocated to female residents. The residents are not provided with any documentation pertaining to their individual land that they possess. However, the village headman captures the resident's details such as their names, age and specific area of stay in the membership. The results shows that 98% of the residents personal and land data is captured in the membership book. The study also revealed that 61%

of the respondents agreed that the land is demarcated by trees, while 29% said the land was demarcated using ant hills and 10% residents had their land demarcated through use of streams. The study area encounters land disputes ranging from family boundary disputes, communal boundaries disputes and selling of land by chiefs and headmen as a result of lack of proper demarcation and documentation of land parcels. The study shows that 54.9% of the residents had family disputes, 41.2% residents witnessed the selling of communal land by chief or headmen and 3.9% experienced communal land disputes. The family boundary disputes are rampant because of a non-coordinated and systematic land demarcation system supported with proper land ownership evidence.

It is evident that the current methods been used to administer and manage customary land are not adequate to ensure security of tenure.

6.2.2 Customary land management model

The second objective was to design a customary land management model for management of customary land. The designed model involves all the residents in the demarcation process of the customary land using the latest technologies of PGIS, GPS and the use of internet. All the land coordinates captured by all stakeholders involved are stored securely on the server. The use of a firewall ensures that all personal and land related information are secure. All users and administrators need authentication before permission to the system is granted. The whole process of the customary land management model is shown in Figure 22 in Chapter 4.

6.2.3 Development of the mobile based customary land management information system

The fourth objective was to develop a mobile based customary land management information system using latest mapping technologies based on the model in Objective 3.The study revealed that the majority of the resident's personal information such as name, age, date of birth is kept in the membership book and that the access to the book is restricted to the Village headman and the Chief. The mobile application stores personal details in the database and the residents have full access to their personal data.

The mobile application captures land coordinates such as the latitude and longitude of the area and the information is stored securely in the database. The mobile application also has the capability of appending personal records such as wills, marriage certificates and videos to the land information. This provides proof of customary land ownership, thereby reducing the family and communal land boundary conflicts and the selling of land by the Chiefs and Village Headmen.

The mobile based customary land management system has the capability of harmonising land boundary coordinates for family and communal land and integrate with ownership details.

The developed mobile application would be used both by the residents and the chief in all land matters in the most effective manner. The mobile application was developed using Java and MySQL.

6.2.4 Comparison with Other Similar Works

There exists a number of land management systems developed by different organizations and individuals across the globe. Different Countries have designed and developed land systems depending on their specific requirements, mostly cultural values. The most important factors in designing a customary system is simplicity, robustness and security. These factors must be assessed before a land system is developed to ensure it is accepted by the stakeholders. Some of the related systems reviewed include:

- Nigerian web based customary Land tenure information system based on the Talking Titler model
- Social Tenure Domain Model (STDM) – Uganda
- Ghanaian Land Administration project
- Land Management Paradigm
- Lesotho's mobile GIS Land Administration system
- Open Tenure System-Cambodia
- FAO SOLA Open Source Software for land administration
- Open Data Kit – Brazil

The mobile based customary land management information system has an advantage of mobility compared to other related system as it can be operated from the mobile devices. The use of a firewall ensures security to the application as it only allows access to authorised users.

6.2.5 Possible Application (s)

The major use of the mobile based customary land management information system is in land administration. The system can be used by the Ministry of Local Government and Housing, Ministry of Chiefs and Traditional Affairs as well as Ministry of Lands for the purpose of land surveying and documenting customary land. The system has the ability of integrating with other existing systems such as the Zambia Integrated Land Management Information System (ZILMIS) under Ministry of Lands. The system has the capability of harmonising the land demarcation process and documenting all personal land records thereby assisting the residents to have security of tenure for their land.

6.3 Conclusion

ICT has played a major role in land administration in both developing and developed Countries. A mobile based customary land management system if implemented in Zambia would reduce the prevailing customary land disputes among the residents, thereby ensuring security of customary tenure. The mobile application has proven to be cheaper than other method of surveying which are currently being used in Zambia. The participation of the residents during the demarcation process ensures total ownership and responsibility of the whole process.

6.4 Future Works

The mobile based customary land management system could be further enhanced with capabilities of reducing the accuracy level attributed to the use of the mobile device. This was not taken into consideration. The automation of the application and encryption of the information as it is being transmitted could also be some of the future works to be undertaken.

6.5 Summary

This study proposed the design and development of a mobile application for customary land management and administration for Munkonge chiefdom in order to reduce the prevailing customary land conflicts. The mobile application can also be used by other chiefdoms across the Country in management of customary land. The peri-urban towns can also utilise the application as was the case with Namibia. Mobile based customary land systems are now the latest technological solution for land demarcations as they can be operated with minimal expert, thereby ensuring that most customary land is secured by the rightful owners. This will reduce the land conflicts earlier noticed from the previous chapters.

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Appendix

CODE LISTING

A.1: LAND DEMARCATION CODE

Land Demarcation Process

Layout Activity

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:weightSum="1">
  <TextView
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:text="Get Current Location and City Name"
    android:layout_weight="0.20"
    android:gravity="center"
    android:textSize="20sp" />
  <EditText
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:layout_weight="0.33"
    android:id="@+id/editTextLocation"
    android:editable="false">
    <requestFocus></requestFocus>
  </EditText>
  <LinearLayout
    android:id="@+id/layButtonH"
    android:layout_height="wrap_content"
    android:layout_width="fill_parent"
    android:gravity="center"
    android:layout_weight="0.15">
    <Button
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text="GetLocation"
      android:id="@+id/btnLocation"></Button>

    <Button
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
```

```
        android:text="MappCordinates"
        android:id="@+id/btnmap"                                    />
    </LinearLayout>
    <LinearLayout
      android:id="@+id/layloadingH"
      android:layout_height="wrap_content"
      android:layout_weight="0.20"
      android:layout_width="fill_parent"
      android:gravity="center">
      <ProgressBar
        android:layout_width="wrap_content"
        android:id="@+id/progressBar1"
        android:layout_height="wrap_content"></ProgressBar>
    </LinearLayout>
</LinearLayout>
```

Mappng.java

```
1. package com.kce.zdiko;
   import android.app.ProgressDialog;
   import android.content.Intent;
   import android.graphics.Color;
   import android.os.AsyncTask;
   import android.os.Bundle;
   import android.support.v4.app.FragmentActivity;
   import android.util.Log;
   import android.view.View;
   import android.widget.Button;
   import android.widget.EditText;
   import android.widget.ImageButton;
   import android.widget.Toast;
   import com.google.android.gms.maps.GoogleMap;
   import com.google.android.gms.maps.OnMapReadyCallback;
   import com.google.android.gms.maps.SupportMapFragment;
   import com.google.android.gms.maps.model.LatLng;
   import com.google.android.gms.maps.model.LatLngBounds;
   import com.google.android.gms.maps.model.MarkerOptions;
   import com.google.android.gms.maps.model.PolylineOptions;
   import org.apache.http.HttpEntity;
   import org.apache.http.HttpResponse;
   import org.apache.http.NameValuePair;
   import org.apache.http.client.HttpClient;
   import org.apache.http.client.entity.UrlEncodedFormEntity;
   import org.apache.http.client.methods.HttpPost;
   import org.apache.http.impl.client.DefaultHttpClient;
   import org.apache.http.message.BasicNameValuePair;
   import org.json.JSONObject;
```

```
import java.io.BufferedReader;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.util.ArrayList;
import java.util.List;
/**
 * Created by Annie Mporokoso i5 on 2/1/2016.
 */
public class Mapping extends FragmentActivity implements OnMapReadyCallback {
    String id;
    InputStream is=null;
    String result=null;
    String line=null;
    int code;
    // this is all
    private EditText statusdate;
    // Progress Dialog
    private ProgressDialog pDialog;
    String insertcordinates = "http://www.properschool.com/zdiko/index.php";
    private Button statusbtn;
    String ids , lat, lng,zom, id2;
    int x =1;
   // JSONParser jsonParser = new JSONParser();
    private GoogleMap mMap;
    ArrayList<LatLng> points;
    // Create a LatLngBounds that includes Australia.
    private LatLngBounds AUSTRALIA = new LatLngBounds(
            new LatLng(-12.871593, 20.980588), new LatLng(-12.451796, 34.609365));
    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.mapping);
        points = new ArrayList<LatLng>();
// Obtain the SupportMapFragment and get notified when the map is ready to be used.
SupportMapFragment mapFragment = (SupportMapFragment)
getSupportFragmentManager().findFragmentById(R.id.map);
mapFragment.getMapAsync(this);
//button listener
Button reg = (Button)findViewById(R.id.imageButton);
reg.setOnClickListener(new View.OnClickListener() {
    @Override
    public void onClick(View v) {
        // TODO Auto-generated method stub
        Intent nxt = new Intent(getApplicationContext(), MediasClass.class);
        startActivity(nxt);
    }
```

```
        });
        //button listener
        ImageButton Btnlockation = (ImageButton)findViewById(R.id.buttonView);
        Btnlockation.setOnClickListener(new View.OnClickListener() {

            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                Intent nxt = new Intent(getApplicationContext(), Landdts.class);
                startActivity(nxt);
            }
        });

        //Start plotting button listener
        ImageButton Btnstartplot = (ImageButton)findViewById(R.id.buttonCurrent);
        Btnlockation.setOnClickListener(new View.OnClickListener() {

            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                Toast.makeText(getApplicationContext(), "Please Move around the property to
start picking cordinates",
                        Toast.LENGTH_LONG).show();
                Intent nxt = new Intent(getApplicationContext(), GetCurrentLocation.class);
                startActivity(nxt);
            }
        });

        //Savebutton listener
        ImageButton Btnsaverenderstopplotting = (ImageButton)findViewById(R.id.buttonSave);
        Btnlockation.setOnClickListener(new View.OnClickListener() {
            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                /*Intent nxt = new Intent(getApplicationContext(), Landdts.class);
                startActivity(nxt);*/
                //Stop mapping

                // save cordnates
                // check if array not empty
                if(!points.isEmpty()) {
                    id = "1";
                    lat = points.toString();
                    lng = points.toString();
                    zom = "not available";
                } else{id = "1";
```

```
                lat = "0.123";
                lng = "32.012";
                zom = "not available";}

            plottinginsertTask ins = new plottinginsertTask();
            ins.execute();

            //plot saved cordinates on the map
        }
    });
}

class plottinginsertTask extends AsyncTask<String, String, String> {
    private Exception exception;
    @Override
    protected void onPreExecute() {
        super.onPreExecute();
        pDialog = new ProgressDialog(Mapping.this);
        pDialog.setMessage("Saving Land Plot..");
        pDialog.setIndeterminate(false);
        pDialog.setCancelable(true);
        pDialog.show();
    }
    protected String doInBackground(String... urls) {
      // Toast.makeText(getBaseContext(), "cordinates",
Toast.LENGTH_SHORT).show();//points.toString()+
        ArrayList<NameValuePair> nameValuePairs = new ArrayList<NameValuePair>();
        //Partner_ID, OrgName, Address, Phone, Email, Website
        nameValuePairs.add(new BasicNameValuePair("id",Integer.toString(2)));
        nameValuePairs.add(new BasicNameValuePair("lat",lat));
        nameValuePairs.add(new BasicNameValuePair("lng",lng));
        nameValuePairs.add(new BasicNameValuePair("zom",zom));
        try
        {
            HttpClient httpclient = new DefaultHttpClient();
            HttpPost httppost = new
HttpPost("http://www.properschool.com/zdiko/index.php");
            httppost.setEntity(new UrlEncodedFormEntity(nameValuePairs));
            HttpResponse response = httpclient.execute(httppost);
            HttpEntity entity = response.getEntity();
            is = entity.getContent();
            Log.e("pass 1", "connection success ");
        }
        catch(Exception e)
        {
            Log.e("Fail 1", e.toString());
```

```
            Toast.makeText(getApplicationContext(), "Invalid IP Address",
                    Toast.LENGTH_LONG).show();
        }

        try
        {

            System.out.print(result.toString());
            JSONObject json_data = new JSONObject(result);
            // Building Parameters
            List<NameValuePair> params = new ArrayList<NameValuePair>();
            params.add(new BasicNameValuePair("lat", lat));
            params.add(new BasicNameValuePair("lng", lng));
            params.add(new BasicNameValuePair("zom", zom));
            JSONParser jsonParser = new JSONParser();
            JSONObject json = jsonParser.makeHttpRequest(insertcordinates,"POST", params);
            code=(json_data.getInt("code"));

            if(code==1)
            {
//                Toast.makeText(getBaseContext(), "Inserted Successfully",
//                        Toast.LENGTH_SHORT).show();
              //  System.out.print("Sucess insert");
            }
            else
            {
//                Toast.makeText(getBaseContext(), "Sorry, Try Again",
//                        Toast.LENGTH_LONG).show();
             // System.out.print("Try Later");
            }
        }
        catch(Exception e)
        {
            Log.e("Fail 3", e.toString());
        }

        try
        {
            BufferedReader reader = new BufferedReader
                    (new InputStreamReader(is,"iso-8859-1"),8);
            StringBuilder sb = new StringBuilder();
            while ((line = reader.readLine()) != null)
            {
                sb.append(line + "\n");
            }
            is.close();
```

```
            result = sb.toString();
            Log.e("pass 2", "connection success ");
        }
        catch(Exception e)
        {
            Log.e("Fail 2", e.toString());
        }


        return id2;
    }

    protected void onPostExecute(String feed) {
        // TODO: check this.exception
        // TODO: do something with the feed
        pDialog.dismiss();
    }

}

@Override
public void onMapReady(GoogleMap googleMap) {
    mMap = googleMap;
    mMap.setMapType(GoogleMap.MAP_TYPE_HYBRID);

    //mMap.moveCamera(CameraUpdateFactory.newLatLngBounds(AUSTRALIA, 0));
   /* if (ActivityCompat.checkSelfPermission(this,
Manifest.permission.ACCESS_FINE_LOCATION) !=
PackageManager.PERMISSION_GRANTED && ActivityCompat.checkSelfPermission(this,
Manifest.permission.ACCESS_COARSE_LOCATION) !=
PackageManager.PERMISSION_GRANTED) {
        // TODO: Consider calling
        //    ActivityCompat#requestPermissions
        // here to request the missing permissions, and then overriding
        //   public void onRequestPermissionsResult(int requestCode, String[] permissions,
        //                                          int[] grantResults)
        // to handle the case where the user grants the permission. See the documentation
        // for ActivityCompat#requestPermissions for more details.
        return;
    }*/
    mMap.setMyLocationEnabled(true);
    // Setting OnClick event listener for the Google Map
    mMap.setOnMapClickListener(new GoogleMap.OnMapClickListener() {

        @Override
        public void onMapClick(LatLng point) {
```

```
            // Instantiating the class MarkerOptions to plot marker on the map
            MarkerOptions markerOptions = new MarkerOptions();

            // Setting latitude and longitude of the marker position
            markerOptions.position(point);

            // Setting titile of the infowindow of the marker
            markerOptions.title("Position");

            // Setting the content of the infowindow of the marker
            markerOptions.snippet("Latitude:" + point.latitude + "," + "Longitude:" +
point.longitude);

            // Instantiating the class PolylineOptions to plot polyline in the map
            PolylineOptions polylineOptions = new PolylineOptions();

            // Setting the color of the polyline
            polylineOptions.color(Color.RED);

            // Setting the width of the polyline
            polylineOptions.width(10);

            // Adding the taped point to the ArrayList
            points.add(point);

            // Setting points of polyline
            polylineOptions.addAll(points);

            // Adding the polyline to the map
            mMap.addPolyline(polylineOptions);

            // Adding the marker to the map
            mMap.addMarker(markerOptions);

        }
    });
    mMap.setOnMapLongClickListener(new GoogleMap.OnMapLongClickListener() {
        @Override
        public void onMapLongClick(LatLng point) {
            // Clearing the markers and polylines in the google map
            mMap.clear();

            // Empty the array list
            points.clear();
        }
```

```
        });
    }
}
```

A.2: DIRECTIONS CODE

```
package com.kce.zdiko;
import com.google.android.gms.maps.model.LatLng;
import org.json.JSONArray;
import org.json.JSONException;
import org.json.JSONObject;

import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;

public class DirectionsJSONParser {

   /** Receives a JSONObject and returns a list of lists containing latitude and longitude */
   public List<List<HashMap<String,String>>> parse(JSONObject jObject){

      List<List<HashMap<String, String>>> routes = new
ArrayList<List<HashMap<String,String>>>() ;
      JSONArray jRoutes = null;
      JSONArray jLegs = null;
      JSONArray jSteps = null;

      try {

         jRoutes = jObject.getJSONArray("routes");

         /** Traversing all routes */
         for(int i=0;i<jRoutes.length();i++){
            jLegs = ( (JSONObject)jRoutes.get(i)).getJSONArray("legs");
            List path = new ArrayList<HashMap<String, String>>();

            /** Traversing all legs */
            for(int j=0;j<jLegs.length();j++){
               jSteps = ( (JSONObject)jLegs.get(j)).getJSONArray("steps");

               /** Traversing all steps */
               for(int k=0;k<jSteps.length();k++){
                  String polyline = "";
                  polyline =
(String)((JSONObject)((JSONObject)jSteps.get(k)).get("polyline")).get("points");
```

```
            List<LatLng> list = decodePoly(polyline);

            /** Traversing all points */
            for(int l=0;l<list.size();l++){
              HashMap<String, String> hm = new HashMap<String, String>();
              hm.put("lat", Double.toString(((LatLng)list.get(l)).latitude) );
              hm.put("lng", Double.toString(((LatLng)list.get(l)).longitude) );
              path.add(hm);
            }
          }
          routes.add(path);
        }
      }

    } catch (JSONException e) {
      e.printStackTrace();
    }catch (Exception e){
    }


    return routes;
  }


  /**
   * Method to decode polyline points
   * Courtesy : http://jeffreysambells.com/2010/05/27/decoding-polylines-from-google-maps-direction-api-with-java
   * */
  private List<LatLng> decodePoly(String encoded) {

      List<LatLng> poly = new ArrayList<LatLng>();
      int index = 0, len = encoded.length();
      int lat = 0, lng = 0;

      while (index < len) {
          int b, shift = 0, result = 0;
          do {
              b = encoded.charAt(index++) - 63;
              result |= (b & 0x1f) << shift;
              shift += 5;
          } while (b >= 0x20);
          int dlat = ((result & 1) != 0 ? ~(result >> 1) : (result >> 1));
          lat += dlat;

          shift = 0;
```

```
            result = 0;
            do {
                b = encoded.charAt(index++) - 63;
                result |= (b & 0x1f) << shift;
                shift += 5;
            } while (b >= 0x20);
            int dlng = ((result & 1) != 0 ? ~(result >> 1) : (result >> 1));
            lng += dlng;

            LatLng p = new LatLng((((double) lat / 1E5)),
                    (((double) lng / 1E5)));
            poly.add(p);
        }

        return poly;
    }
}
```

A.3 MEDIACLASS CODE

Mediaclass.java

```
package com.kce.zdiko;

import android.app.Activity;

import android.content.Intent;

import android.os.Bundle;

import android.view.View;

import android.widget.Button;

import com.kce.zdiko.R;


/**
 * Created by Annie Mporokoso i5 on 1/29/2016.
 */
public class MediasClass extends Activity {
    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.media);
```

```
Button reg = (Button)findViewById(R.id.button11);
reg.setOnClickListener(new View.OnClickListener() {

   @Override
   public void onClick(View v) {
      // TODO Auto-generated method stub
      Intent nxt = new Intent(getApplicationContext(), MainActivity.class);
      startActivity(nxt);
   }
});

Button reg1 = (Button)findViewById(R.id.button12);
reg1.setOnClickListener(new View.OnClickListener() {

   @Override
   public void onClick(View v) {
      // TODO Auto-generated method stub
      Intent nxt = new Intent(getApplicationContext(),  Landdts.class);
      startActivity(nxt);
   }
});

Button reg2 = (Button)findViewById(R.id.button5);
reg2.setOnClickListener(new View.OnClickListener() {

   @Override
   public void onClick(View v) {
      // TODO Auto-generated method stub
      Intent nxt = new Intent(getApplicationContext(), Upload.class);
      startActivity(nxt);
```

```
    }
});

Button reg3 = (Button)findViewById(R.id.button6);
reg3.setOnClickListener(new View.OnClickListener() {

    @Override
    public void onClick(View v) {
        // TODO Auto-generated method stub
        Intent nxt = new Intent(getApplicationContext(), Upload.class);
        startActivity(nxt);
    }
});

Button reg4 = (Button)findViewById(R.id.button7);
reg4.setOnClickListener(new View.OnClickListener() {

    @Override
    public void onClick(View v) {
        // TODO Auto-generated method stub
        Intent nxt = new Intent(getApplicationContext(), Upload.class);
        startActivity(nxt);
    }
});

Button reg5 = (Button)findViewById(R.id.button8);
reg5.setOnClickListener(new View.OnClickListener() {

    @Override
    public void onClick(View v) {
        // TODO Auto-generated method stub
```

```
        Intent nxt = new Intent(getApplicationContext(), Upload.class);
        startActivity(nxt);
    }
});

Button reg6 = (Button)findViewById(R.id.button9);
reg6.setOnClickListener(new View.OnClickListener() {

    @Override
    public void onClick(View v) {
        // TODO Auto-generated method stub
        Intent nxt = new Intent(getApplicationContext(), Upload.class);
        startActivity(nxt);
    }
});

Button reg7 = (Button)findViewById(R.id.button10);
reg7.setOnClickListener(new View.OnClickListener() {

    @Override
    public void onClick(View v) {
        // TODO Auto-generated method stub
        Intent nxt = new Intent(getApplicationContext(), Upload.class);
        startActivity(nxt);
    }
});

Button reg8 = (Button)findViewById(R.id.button11);
reg8.setOnClickListener(new View.OnClickListener() {

    @Override
```

```
        public void onClick(View v) {
            // TODO Auto-generated method stub
            Intent nxt = new Intent(getApplicationContext(), MainActivity.class);
            startActivity(nxt);
        }
    });
}
```

A.4 MAPSACTIVITY.JAVA

MapsActivity.java

```
package com.kce.zdiko;

import android.os.Bundle;
import android.support.v4.app.FragmentActivity;

import com.google.android.gms.maps.GoogleMap;
import com.google.android.gms.maps.SupportMapFragment;
import com.google.android.gms.maps.model.LatLng;
import com.google.android.gms.maps.model.MarkerOptions;

public class MapsActivity extends FragmentActivity {

    private GoogleMap mMap; // Might be null if Google Play services APK is not available.

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_maps);
        setUpMapIfNeeded();
    }

    @Override
    protected void onResume() {
        super.onResume();
        setUpMapIfNeeded();
    }

    /**
     * Sets up the map if it is possible to do so (i.e., the Google Play services APK is correctly
     * installed) and the map has not already been instantiated.. This will ensure that we only ever
     * call {@link #setUpMap()} once when {@link #mMap} is not null.
     * <p/>
     * If it isn't installed {@link SupportMapFragment} (and
```

```
     * {@link com.google.android.gms.maps.MapView MapView}) will show a prompt for the
user to
     * install/update the Google Play services APK on their device.
     * <p/>
     * A user can return to this FragmentActivity after following the prompt and correctly
     * installing/updating/enabling the Google Play services. Since the FragmentActivity may not
     * have been completely destroyed during this process (it is likely that it would only be
     * stopped or paused), {@link #onCreate(Bundle)} may not be called again so we should call
this
     * method in {@link #onResume()} to guarantee that it will be called.
     */
    private void setUpMapIfNeeded() {
        // Do a null check to confirm that we have not already instantiated the map.
        if (mMap == null) {
            // Try to obtain the map from the SupportMapFragment.
            mMap = ((SupportMapFragment)
getSupportFragmentManager().findFragmentById(R.id.map))
                    .getMap();
            // Check if we were successful in obtaining the map.
            if (mMap != null) {
                setUpMap();
            }
        }
    }

    /**
     * This is where we can add markers or lines, add listeners or move the camera. In this case,
we
     * just add a marker near Africa.
     * <p/>
     * This should only be called once and when we are sure that {@link #mMap} is not null.
     */
    private void setUpMap() {
        mMap.addMarker(new MarkerOptions().position(new LatLng(0, 0)).title("Marker"));
    }
}
```

A.5 MAPSACTIVITY.JAVA

MapsActivity2.java

```
package com.kce.zdiko;

import android.support.v4.app.FragmentActivity;
import android.os.Bundle;

import com.google.android.gms.maps.GoogleMap;
import com.google.android.gms.maps.SupportMapFragment;
import com.google.android.gms.maps.model.LatLng;
import com.google.android.gms.maps.model.MarkerOptions;

public class MapsActivity2 extends FragmentActivity {

    private GoogleMap mMap; // Might be null if Google Play services APK is not available.

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_maps2);
        setUpMapIfNeeded();
    }

    @Override
    protected void onResume() {
        super.onResume();
        setUpMapIfNeeded();
    }

    /**
     * Sets up the map if it is possible to do so (i.e., the Google Play services APK is correctly
     * installed) and the map has not already been instantiated.. This will ensure that we only ever
     * call {@link #setUpMap()} once when {@link #mMap} is not null.
     * <p/>
     * If it isn't installed {@link SupportMapFragment} (and
     * {@link com.google.android.gms.maps.MapView MapView}) will show a prompt for the
user to
     * install/update the Google Play services APK on their device.
     * <p/>
     * A user can return to this FragmentActivity after following the prompt and correctly
     * installing/updating/enabling the Google Play services. Since the FragmentActivity may not
     * have been completely destroyed during this process (it is likely that it would only be
     * stopped or paused), {@link #onCreate(Bundle)} may not be called again so we should call
this
     * method in {@link #onResume()} to guarantee that it will be called.
     */
```

```
    private void setUpMapIfNeeded() {
        // Do a null check to confirm that we have not already instantiated the map.
        if (mMap == null) {
            // Try to obtain the map from the SupportMapFragment.
            mMap = ((SupportMapFragment)
getSupportFragmentManager().findFragmentById(R.id.map))
                    .getMap();
            // Check if we were successful in obtaining the map.
            if (mMap != null) {
                setUpMap();
            }
        }
    }

    /**
     * This is where we can add markers or lines, add listeners or move the camera. In this case,
we
     * just add a marker near Africa.
     * <p/>
     * This should only be called once and when we are sure that {@link #mMap} is not null.
     */
    private void setUpMap() {
        mMap.addMarker(new MarkerOptions().position(new LatLng(0, 0)).title("Marker"));
    }
}
```

B.1 QUESTIONNAIRE

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
Designing an Information Communication Technology solution for Managing Customary Land Tenure Data in Zambia.

LAND TENURE QUESTIONNAIRE

Province……

District……..

Village……

I. Personal Data

1. Age:
[ ] Between 10 years and 20 years
[ ] Between 20 years and 30 years
[ ] Between 30 years and 40 years
[ ] Between 40 years and 50 years
[ ] Between 50 years and 60 years
[ ] Between 70 years and 80 years
[ ] Between 80 years and 90 years
[ ] Above 100 years

2. Gender:
[ ] Male
[ ] Female

3. Educational Background:
[ ] Tertiary Level
[ ] Secondary Level
[ ] Primary Level
[ ] No formal Education

4. Occupation: ……

5. Inheritance System practices:
[ ] Patrilineal
[ ] Matrilineal
[ ] Both
[ ] None

6. Nationality:
[ ] Zambian
[ ] Non-Zambian specify……..

7. Nativity:
[ ] Indigenous
[ ] Non Indigenous
[ ] Other Specify: …….....

8. How long have you lived in this Community?

……...

9. Do you have any children?
[ ] No
[ ] Yes
If **'Yes'** state number of:
Female……

Male……

10. What is your role / position in this community?
[ ] Chief
[ ] Head Man
[ ] Elder
[ ] Youth member
[ ] Does not have a specific role / position
[ ] Other Specify.....

II. Land Tenure Data

11. Do you have land?
[ ] Yes
[ ] No
If your answer to question 11 is **'No'**, skip to P**art III**

12. How did you acquire the land?
[ ] Through Inheritance
[ ] Gift
[ ] Purchase
[ ] Leased
[ ] Others Specify…….

13. Where is the land located? Specify the area……

14. What are you using the land for?
[ ] Commercial use
[ ] Residential use
[ ] Subsistence farming
[ ] Commercial farming
[ ] Other purposes, specify.....

15. What is the size of your land?

…….

16. How long have you lived on this land?
[ ] 1 year or less
[ ] Between 2 year to 10 years
[ ] Between 10 years to 20 years
[ ] Between 20 years to 40 years
[ ] Between 40 years to 60 years
[ ] Between 60 years to 80 years
[ ] Between 80 years and 100 years
[ ] More than 100 years

17 What evidences do you have that shows the land belongs to you?
[ ] Certificate of Title
[ ] Letter of Occupancy
[ ] Membership card
[ ] Membership book
[ ] Other specify……..

……

18. Do you have any documents that show the size of your land?
[ ] Yes
[ ] No

19. If **'Yes'**, state the document name……..

……

20. If **'No'**, why don't you have any documentation over your land?

……

21. How are land documents generated?
[ ] Manually, handwritten
[ ] Computer generated

22. Who is responsible for generation of the document stated in [21?]
[ ] Chief
[ ] Headman
[ ] Community Secretary
Others Specify……....

23. Is your land demarcated?
[ ] Yes
[ ] No

24. If ‘Yes” who demarcated your land?
[ ] Land Surveyor
[ ] Chief
[ ] Headman
Others specify…….……

25. How was your land boundary demarcated from those of your neighbouring land portions?

…….

…….

26. Did you participate in the demarcation process together with your neighbours?
[ ] Yes
[ ] No

27. If ‘Yes’ are there any documents provided as proof?

……..

28. Is there provision for appending signature on the document?
[ ] Yes
[ ] No

29. What happens to the land in case you move to a different location?

……..

III. **Land Tenure Security**

30. How do families or members of the community secure their land rights?

……

31. Has there been changes in the land tenure system in the community?
[ ] Yes
[ ] No.
If ‘Yes’ what are they?

…….

32. Have you registered your interest in land?
[ ] Yes
[ ] No

If 'No', what is the reason for non-registration of your land?

……..

33. Do you think you can lose your land to someone else?
[ ] Yes
[ ] No
If 'Yes', Give the reason……..

If 'No', Why? …….

……

……

34. If someone comes up to claim ownership of your land, how do you prove that the land is actually yours?
…….

35. Are you aware of land disputes in this community?
[ ] Yes
[ ] No

36. What are the common causes of land disputes in this community?
[ ] Chiefdom boundaries
[ ] Family boundaries
[ ] Communal land for animal grazing
[ ] Selling of communal land by Chiefs or Headmen
Other specify…….

……..

37. How often do land boundary disputes occur in the community?

……

……
.
38. How are the land disputes resolved?
……

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
An Information Communication Technology solution for Managing Customary Land Tenure Data in Zambia.

Informed Consent Form

Purpose of the study:

This is a study in customary land tenure conducted by Annie Mporokoso, Master's student at The University of Zambia, School of Engineering. The purpose of the study is to design and develop a management information system with latest technologies of web and mobile capabilities to manage existing customary land tenure information in order to improve land tenure security for the rural people in Zambia

What will be done:

You will complete a survey which will take 15-20 minutes. The Survey includes questions about the current method being used by Chiefs and other traditional leaders to document personal and customary land tenure. Other questions revolve around the land tenure security and dispute resolutions.

Benefits of the study:

You will be contributing to the knowledge on this subject and subsequently this will help in identifying the current methods being used by traditional leaders in documenting customary land data as well as the challenges being experienced with the current methods. This will aid in building a prototype Software System that will provide security to customary land. The proposed solution will be piloted in Kasama and Chibombo districts. It is expected that this will improve customary land tenure security by reducing land conflicts in the rural area. In addition, the key results from this study will be shared with the decision-making authorities in the Ministry of Lands, Natural Resources and Environmental Protection, Ministry of Chiefs and Traditional Affairs and the Ministry of Local Government and Housing.

Risks or discomforts:

No risks or discomforts are anticipated in this study.

Confidentiality:

Your responses will be kept completely confidential. All the information will be collected on an anonymous basis and no identifiable data will be collected in this survey.

How the findings will be used:

The results of the study will be used for scholarly purposes only. The results from the study will be presented in educational settings and at professional conferences, and the results might be

published in a professional journal in the field of customary land tenure. Kindly note that sensitive information will not be disclosed.

Contact Information:

If you have any concerns or questions about this study, please contact Annie Mporokoso on anniemporokoso@yahoo.com.

By beginning the survey, you acknowledge that you have read this information and agree to participate in this research.

Kindly tick the applicable.

I agree: ☐ *I do not agree:* ☐