Using GIS to Assess Sustainable Land Management; A case of Manyatta B, an Informal Settlement in Kisumu, Kenya

Research · November 2020

DOI: 10.13140/RG.2.2.35438.84803

1 author:

Franklin Ogwankwa
Maseno University

MASENO UNIVERSITY

SCHOOL OF PLANNING AND ARCHITECTURE

DEPARTMENT OF URBAN MANAGEMENT

TITLE:

Using GIS to Assess Sustainable Land Management; A case of Manyatta B, an Informal Settlement in Kisumu, Kenya

FRANKLIN KEBUNGO OGWANKWA

PA/00539/016

PGS 426 RESEARCH PROJECT

A RESEARCH REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN GEOSPATIAL INFORMATION SCIENCE OF MASENO UNIVERSITY

DECLARATION

This Research Project is my own independent work and has not been submitted to any other university for examination

Student

Name: Franklin Kebungo Ogwankwa

Reg. No. PA/00539/016

This Report has been submitted for examination with my permission

Supervisor

Prof. George M. Onyango

School of Planning and Architecture

Maseno University

ACKNOWLEDGEMENT

My sincere gratitude goes to Prof George Mark Onyango; my supervisor, for his continued and unreserved support at every stages of doing this research. I am thankful to all the respondents, and the individuals who I interviewed in Manyatta B during the data collection exercise. My special appreciation goes my fellow students and friends who provided me support and encouragement. The support, love and care I always get from my beloved parents are always appreciated and remain to have important role for my success. Thank you.

Table of Contents

List of Figures

List of tables

List of Abbreviations

ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
EM	Electromagnetic
ESRI	Environmental Science Research Institute
GCP	Ground Control Points
GIS	Geospatial Information Systems
LULC	Land Use Land Cover
NIR	Near Infrared
RS	Remote Sensing
SDG	Sustainable Development Goals
SLM	Sustainable Land Management
SPSS	Special Package for Statistical Studies
SWIR	Short Wave Infrared
TM	Thermal Mapper
USGS	United States Geological Survey

ABSTRACT

Sustainable land management is a knowledge based mechanism through which land is managed to ensure that land as a resource is optimally utilized taking into consideration the current users and users while ensuring that the future generations are taken into consideration. In this research, the focus was on sustainable land management in the informal to help us understand the practices of managing land developments, the changes in land use land cover and how sustainable they are. The use of Geospatial Information Science and Remote Sensing has been used to help in monitoring and evaluating the land use land cover change as well as assess the sustainability of these changes with respect to the factors that have contributed to these changes. The study area for this research was Manyatta B, an informal settlement with Kisumu County Kenya. Landsat satellite imageries of three different time periods, 2000, 2010 and 2020 were acquired by United States Geological Survey (USGS) earth explorer site and quantify the changes in the study area from 2000 to 2020 over a period of 20 years. Supervised classification methodology was employed using maximum likelihood technique in ArcGIS Desktop 10.2.2 Software. The images of the study area were categorized into four different classes namely vegetation, trees, bare land, and built-up areas. The results indicate that during the last two decades, built-up land had been increasing by 0.85% annually over the years; there was no relative average change in tree cover while bare land and vegetation have decreased by 0.65% and 0.3% respectively. Data from the questionnaires showed that these changes have been influenced by different factors like a various in the weather patterns, localization of development through the County government and population increase.

CHAPTER ONE

1.0 Introduction

This chapter introduces this research with: the background of the study, statement of the problem, study objectives, significance of the study, scope and delimitations of the study and justification of the study.

1.1 Background of Study

The concept of Sustainable Land Management (SLM) was an outcome of the United Nations Conference on Environment and Development held (Brown, 1992). SLM is considered as the use of resources including soils, water, animals and plants for the production of goods and services to meet the changing needs of the human beings while on the other hand ensuring that these resources are not overexploited hence the long term productivity potential and maintenance of the environmental factors. It involves knowledge-based procedures that help integrate land, water, biodiversity and environmental factors to meet the rising human demands without exhausting the resources (Tengberg, 2014). This entails the preserving and enhancing the productive capabilities of land as well as actions to stop and reverse degradation.

Land is a very important resource to human survival. The efficient allocation and optimum use of land ensure that there is proper functioning of society and the economy depends upon its. The economic benefits attached to land depend on how properly land is used as a resource. Efficiency and effectiveness in the use of land is in turn dependent on how well the land market work and the efficient dissemination of and access to information about it. The representative bodies of key players in the land market agree that the management of land resources properly and the efficient working of the land market are hindered by a lack of good quality information (Land Resource Economics and Sustainable Developement, 2014).

Land is geographical feature that cannot be changed or moved hence being a fixed resource. Unlike other forms of resources like labour and capital, a single unit of land cannot be directly substituted for another unit because each unit is unique at least in terms of its geographical location. Consequently the aspect of location of land and property information is of essential

importance. Herein is the importance of systems like Geospatial Information System that are able to handle the locational characteristics of land information and that can relate that information to standard land management data sets (Peter Wyatt, 2003).

Land is a diverse resource ranging from rural land through to urban and residential land uses and infrastructure for transport and service delivery. It is unsurprising that the management of land involves a similarly diverse range of activities. Unfettered access to accurate and comprehensive information is vital to good land management decision making.

1.2 Statement of Problem

Most of the developments that are done are land related which makes it the core component on the survival of the human population. Data about location of the land portions, the status and conditions of these land portions as well as the characteristics like the soil type, the land use land cover are needed for proper planning, policy formulation and implementation.

Land is geographical and there is need to understand the dynamics and trends that are developing through the different human activities that are carried out on this land. These activities influence the use of land and what covers that particular portion of land. Data about land and its characteristics can be acquired through satellites and then the processed information about this can be structured and stored in an organized database where it can be retrieved, analyzed as well as manipulated to study the trends of land and be used to advice on making informed decisions.

1.3 Study Objectives

1.3.1 Main Objective

Using Geospatial Information Science (GIS) to assess Sustainable Land Management in the informal Settlement; A case of Manyatta B, Kisumu County

1.3.2 Specific Objectives

1. To perform land use land cover change analysis.

2. To investigate those factors that has contributed to the change in land use land cover within the study area.

3. To determine how sustainable are the changes in the land use land cover.

1.4 Scope

This study is limited to assessing the sustainability in the management of land by use of GIS and Remote Sensing, a case of Manyatta B in Kisumu County. It focused on land use land cover changes throughout the years 2000 to 2020 with a span of 10 years. This research does not cover the administrative aspect of land management.

1.5 Justification

The findings of this research will add to the relevant body of knowledge regarding sustainable land management in the informal settlement and especially Manyatta B in Kisumu County. The study can be used as a reference to further studies and in informing policy makers on sustainable land management. It can also be used to enlighten on the factors that contribute to the land use land change in the informal sectors and how they can be mitigated.

1.6 Definitions of Key Terms

False Colour is a mechanism that is used on images to display the colours that the eye can identify whereas representing what we would not see by our eyes within the visible light portion of the EM spectrum. An example, using Red colour to represent the Near Infrared rays.

Informal settlement is a region that experiences urban developments, but in one way or another, break the rules of the existing statutory or formal systems that guide the development.

Land Cover is defined as the attributes of the earth's land surface captured in the distribution of vegetation, water, and the immediate subsurface including living organisms, soil, topography, surface and ground water as well as those structures created by human activities such as settlements and agriculture.

Land use is the intended employment of and management strategy placed on the land cover by human agents or land managers to exploit the land cover and reflect human activities such as industrial zones, residential zones, agricultural fields, mining and forestry.

Land Use change is considered as to be the physical, biological and chemical change attributed to the management of land which may include conversation of a previously agricultural land to industrial development land or residential zoned land or improving the agricultural land through introduction of other management systems like irrigation for maximum utilization.

Land Management refers to the manipulation of the biological, physical and chemical properties of land to optimize its productivity for the well-being of human kind.

Sustainable Land Management is the knowledge based procedures that integrate the management of land water and biodiversity to meet the current needs human beings while avoiding overexploitation for reservation of future generations. Remote Sensing

Geospatial Information Science is a computer based system that is designed to collect, store, manipulate, integrate, visualize georeferenced data about features and objects.

Remote Sensing is the art and science of acquiring information about a feature or object without being in touch with it. This can be done using sensors mounted on platforms or cameras.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

. This chapter provides literature review in areas related to land use land cover mapping, the factors that contribute to land use land cover change and their respective impacts as well as sustainability in land management as well as sustainability in land management.

2.1 Assess land use land cover change

Land management is knowledge based on the current state of the land and how it is used as a resource. Understanding the land covers and how the land is being used, along with accuracy in monitoring the change over time, is vital to any person responsible for land management. Land use and land cover studies cross cut through different disciplines in nature. Besides, the facilitation of management of the land sustainably, LULC information may be used for planning, monitoring and evaluation of development, industrial activity or reclamation (Peter Wyatt, 2003).

The changes of Land use land cover (LULC) are widespread, in a fast rate and under very notable processes which are driven by human actions. These changes alter the availability of the different physical and biological resources on land which include soils, vegetation, water and others. Consequently LULC would lead to a decreased availability for human now and the generations to come.

Monitoring and identification of changes over a long period of time in land cover may show and depict possible reasons for the shift in the climatic conditions of an area and analyzing the basis of terrestrial global monitoring. In order to improve the economic condition of the area without further deteriorating the biophysical conditions and the biodiversity, each and every portion of the available land has to be used in the most appropriate way (Dawson, 1991).

Geographical Information System (GIS) and Remote Sensing technologies provide a modern incursion into the issues of ecosystem management (Mrinus G Bos, 2013). Land is a geographical phenomenon to which its characteristics can be identified and distinguished through satellite images that are acquired through remote sensing and then analysed in a geographical Information System to

distinguish the attributes of land. Over time through the different pressures exerted on land, like an increase in the population which influence people to use the land differently from its previous use or cover.

2.2 Factors contributing to the change in land use land cover

Land use and land cover change is a dynamic process that may result from the land conversion which is essentially the change of the previous use or cover of that portion of land to another type of cover or use, land modification which occurs when the structures and functions of land undergo some form of alterations without fully changing the whole context on the type of land use or land cover as well as the maintenance of land in its current state to sustain the current needs hence preventing it from the expected changes (Munich, 2019).

Land use land cover change is influenced by a variety of environmental and socio-demographic factors that operate on several geographical and time-based levels and acting in detailed connections of place and time specific relationships. At the level of individual land unit, relevant biophysical factors include local climate and weather, topography, bedrock and soil type, surface water and ground water (Pratt, 2009). The choice of land use and the decision to change it are influenced by household size, age brackets, sex, educational levels, economic status of the household, culture and personal behaviours of household members, site specific conditions; how easy it is to access the area, what are the land values and neighborhoods; as well as by transport cost, profits, parcel size, competition, cost of production, product prices, public or private financial support, land management practices, land tenure (Hailu, 2020).

Land-use change occurs initially at the level of individual land parcels when land managers decide that a change towards another land-use/land-utilization type is desirable. Aggregately, individual land-use decisions produce land-use/cover changes at higher spatial levels. Land managers respond, however, mostly to internal and external influences on the land-management unit, and their decisions are influenced by their personal traits and local environmental conditions as well as by the immediate and broader environmental, socio-economic, institutional, and political settings within which the land unit is embedded (Yongyut Trisurat, 2011).

A first distinction, thus, emerges between those factors that are pertinent to the level of the individual land parcel (the micro-level) and those that apply to higher spatial/organizational

levels (the macro-level). At both the micro and macro- levels, the factors influencing land-use and land-cover change are broadly distinguished further into biophysical and societal, depending on their origin. Biophysical and societal factors at the micro and the macro levels are intricately interrelated and interdependent. Local weather conditions are affected by and affect the regional and global climate. Local soil and ecosystem types are determined by and determine regional soil and ecosystem types. The decisions of individual land managers are influenced, sometimes strongly, by decisions of persons or organizations at higher levels so that, in essence, local land-use change is often the result of higher level decisions as Blaikie and Lewis have demonstrated. Land-use and land-cover changes produce environmental and socio-economic impacts that frequently feedback and modify the biophysical and societal factors causing them. Thus, new rounds of change come up as the ensuing discussion will demonstrate

Turner et al distinguishes the macro-level societal factors further—according to the role they play in the process of change—into human driving forces, human mitigating forces, and proximate sources of change. Human driving forces are those fundamental societal forces that are the essential, deeper causes of land-use change, bringing about changes in population, technology, and socio-cultural and economic organization that lead to land-use change. Human mitigating forces are forces that counteract the negative effects of human driving forces such as all forms of formal and informal regulation, market adjustments, technological innovations; mitigating forces may become driving forces of land-use change to cope with the adverse effects of past land-use change. Proximate sources of change are human actions that directly affect land cover. They refer to the immediate land management strategies employed that convert land cover from one type to another or that modify an existing land-cover type, under the influence of the underlying driving forces.

2.3 GIS in Sustainable land management

Geographic information provides the common language and reference system to establish linkages and balance between economic, environmental and social capital in order to improve upon the basis for societal response. Access to geographically referenced data, and the regulations that govern that access, are important in informing policies, programmes and projects. Geographical information forms core part of the knowledge available in the current

technological based world. It helps governments and communities plan for resource management and allocation, ensure critical infrastructure are given the required priority, protect the environment as well as the daily human decision making (Tahsin Yomralioglu, 2017).

The use of GIS has been greatly adopted in Land and Property Management to ensure that the different challenges that are experienced in the management of land and property are addressed. Disputes over land are very common in the legal making processes in many countries, preventing social and economic development. Land tenure systems present both policy makers and residents with major challenges. Many empirical responses have evolved which command social validity, even if they lack full legal authority. Planning standards, legislations and management procedures for registering, developing and transferring land rights put a lot of influence over the equity and efficiency of land markets (Maina J, 2020). These practices are generated by experienced and skilled persons but have proven not effective. For example, official minimum plots sizes are too often based on aspirations and not realities which result to costs that are unaffordable, forcing them into various forms of unauthorised development which result to the urban informality trend.

The administrative procedures, total costs required to register and develop land hinders many people from following to official practices and is a widespread source of irregularities. New techniques, like the 'One-Stop-Shops', have improved the overall land management. Mixed land use land cover practises enhance social interaction and economic development which are key for the future of successful cities. On the other hand, many spatial plans seek to hinder this in favour of peripheral forms of order. Smaller towns adjacent to major cities have increased transport expenses and encroached on extensive areas of productive rural land, suggesting that greater focus should be given to developing more compact poly-centric cities (Panwar, 2017).

The completion for land has intensified and this has made it inevitable for it now to dominate the public conversation and the global media attention. Fortunately, land markets are an excellent means for achieving this wider goal since the governments have put considerable influence over land and are therefore qualify in claiming a reasonable proportion of the surplus generated for allocation in the public interest. There have been many innovative, practical ways of achieving this. Land and Property data is very broad. For cadastre to be comprehensive it required a variety of data sets that may include the Spatial characteristics of the parcels of land; size, shape,

location within the earth's surface; the morphological characteristics of the land that includes the soil types, the soil structures and the ground structures; the topographical that includes among many the gradient and altitude of the different land parcels and properties.

Geospatial Information Systems (GIS) being a computer based system provides an interface through which data can be easily updated in cases of changes. Land and property data is very dynamic as it changes from now and then through instances of subdivision of land, change of use of a property or the land use itself, change of ownership of the properties or the land parcels. As population is increasing the demand for land as well as property is increasing which in turn result to people acquiring new land parcels, making major developments on the land as well as changing the use of the land that has been in existence. GIS allows for the administrators to work on these vast of data within a single platform and make informed decisions and policies on how the land is used (Sensing, 2017).

The challenge of political economy of land is addressed through these capabilities of GIS. This is done by the fact that land data is geographical data and GIS does utilise geographical data by integration location to the characteristics attributed to the locations. Land is a resource and for the resource to be optimally utilised in that appropriate policies are made and implemented accordingly, there should be a way in which these data is processed to arrive at informed decisions. GIS provides this ability whereby different datasets about land are put into one interface through which it is processed from a one point and evidence based solutions is arrived at.

Land is a sensitive resource as it is prone to frauds and mismanagement. This has been a major issue with the use of the analogue forms of land management whereby documentations that are in paper format may be altered to fit a fraudster's intentions. The use of GIS has been crucial in ensuring that there is accountability in the way land and property is managed. GIS as well is used to model and forecast the possible outcomes of any developments on the land. Through this people are encouraged to invest on land and property as it is always an appreciating resource.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter focuses on the research methodology. According to Kothari (2011), research methodology is a technique used to systematically solve the research problem, and can also be understood as the science of studying how research is done in a scientific manner. Specifically, it will deal with the: study area, research design, study population, data collection methods and tools and validity.

3.1 Study Area

Manyatta B is located between 0º 4´ –0º 7´ S longitudes and 34º 46´ –34º 47.5´ E latitudes. The area borders ShauriMoyo Kaloleni Estate to the West, Migosi Estate to the North, Kolwa Central to the East and Nyalenda Informal settlements to the South. It covers an area of 3.21 square kilometers with a population size of approximately 5007 and 1391 households (Statistics, 2019). The annual precipitation varies from 350 to 1,500 mm with a mean annual temperature of 26 C.

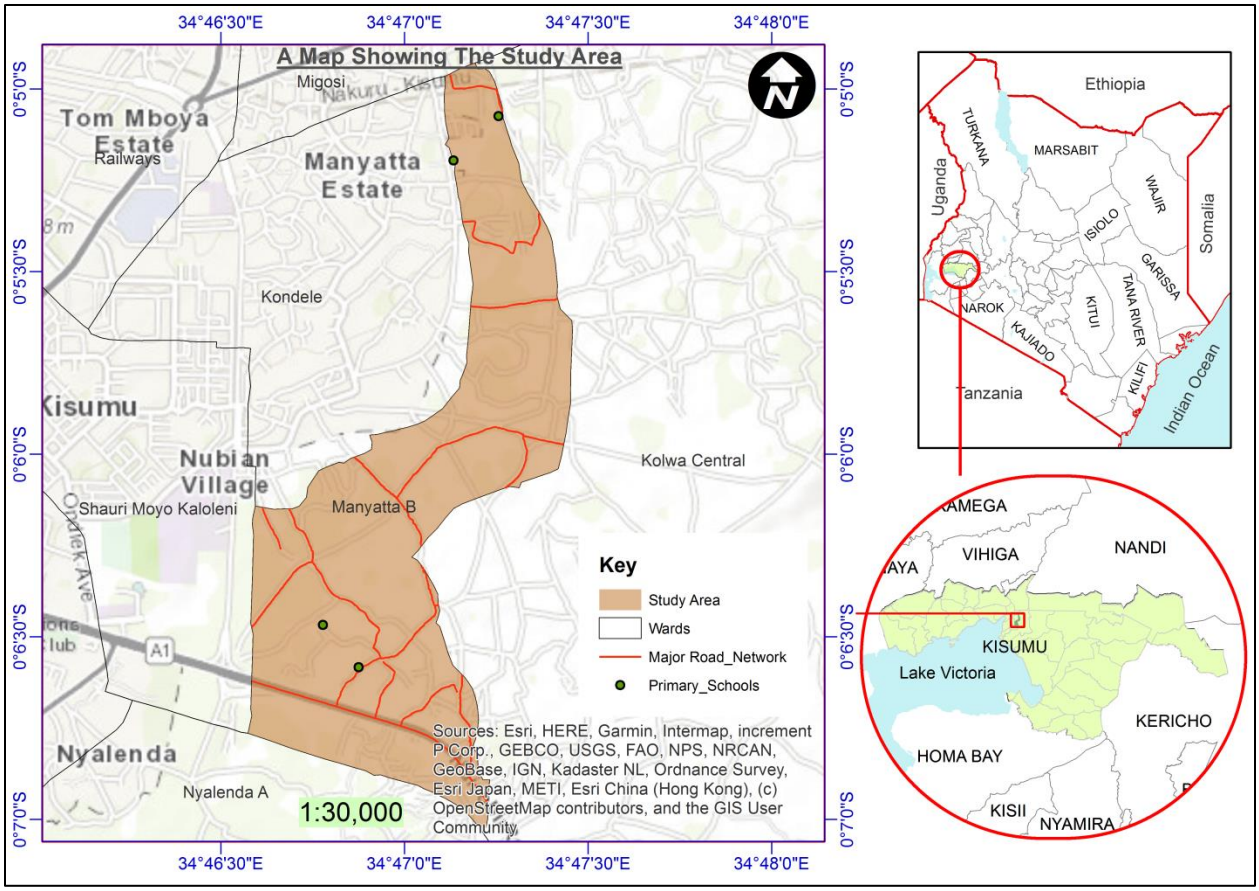

Figure 1: Study area Map of Manyatta B

3.2 Research Design

Research design is a comprehensive plan to obtain the question being evaluated and to manage some of the trouble found during research process. The study will employ a case study research design through studying in details the spatial temporal aspects in Sustainable Land management.

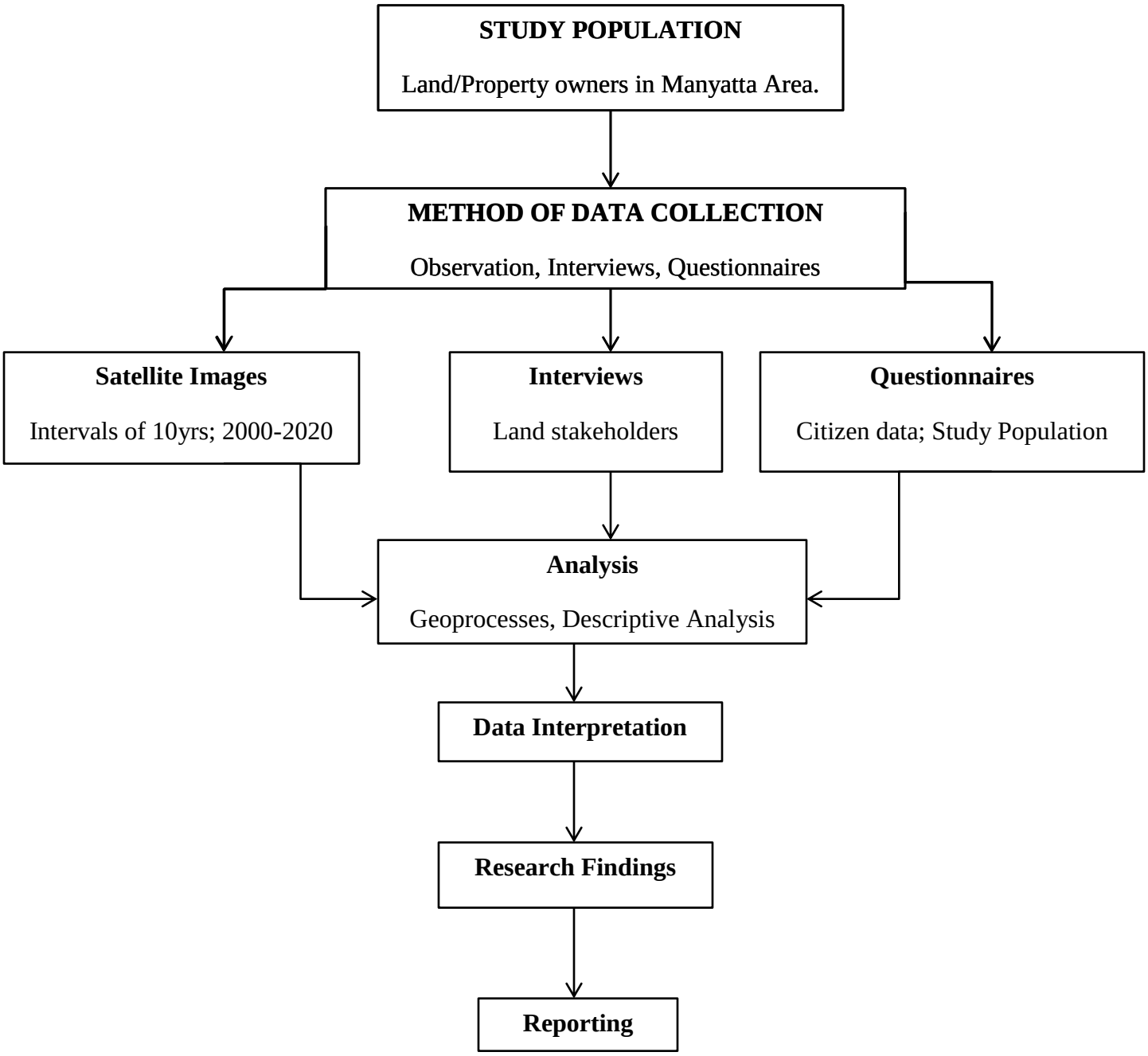

Figure 2: Illustration of the Research Design

3.3 Study Population

A study population is the entire set of cases in which a study is interested. It is the full set of individual or of objects having some common characteristics. In this study the population was all the land and property owners in Manyatta Area.

3.4 Sampling

Sampling involves a process of selecting a sub-section of a population that represents the entire population in order to obtain information regarding the phenomenon of interest. A sample is a sub-section of the population, which is selected to participate in a study. A simple random sampling technique was employed in the sampling process.

3.4.1 Sample procedure

The sampling for this research was done using the Taro Yamane formula with a 90% confidence level and an accuracy of 0.1. The formula was used as follows.

$$n = \frac{N}{1+N(e)^2} \text{ where,}$$

n is the sample size

N is the total household number

e is the accuracy level and for this case is 0.1

Hence;

$$n = \frac{1391}{1+1391(0.1)2}$$

= 94 households.

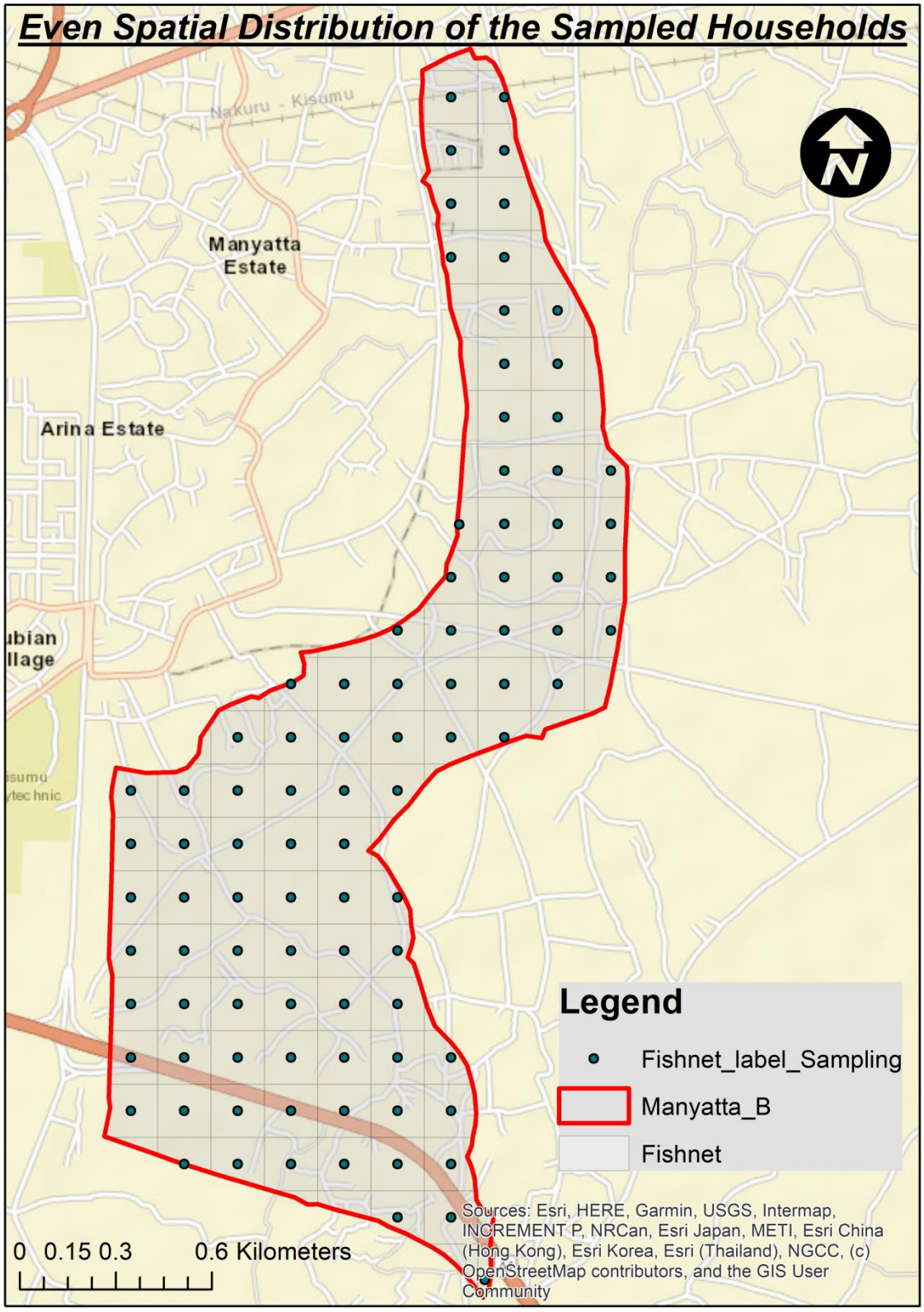

Figure 3: Map showing even spatial Distribution of the sample population of study

3.5 Data Collection Methods

3.5.1 Questionnaires

Data needed for the research was collected with questionnaires. A questionnaire is a collection of pre-formulated items from which a respondent is expected to react in writing (Kothari, 2004). They can also be defined as pre formed written items which respondents are expected to respond orally or written form. The semi structured questionnaires was used to collect information according to the study objectives. The structured questionnaire was chosen because it's easy to administer, record even though the instrument results have already been readily analyzed, and data is collected in the field. The items on the questionnaire were established based on the study goals.

The first part of the questionnaire gave data on certain personal and socio-economic characteristics of the respondents, while the second part had information related to the study objectives. Closed ended questions were used to collect quantitative data, while open-ended questions were used to collect qualitative data. The questionnaires was used to collect data from the land owners and managers, and administered to the respondents by the researcher himself.

The second part of data collection will involve the semi structured interview. According to (Kothari, 2004), an interview involves collecting data from performing oral-verbal stimuli, which is replied by oral-verbal answers. They will be semi structured interviews, administered using an interview schedule by the researcher to collect data from: Kisumu County official, land administrators and surveyors.

Within the questionnaire, Ground Control points (GCPs) were collected for purposes of ground truthing. Besides these, field observation was made to have better information about the nature of the different land use and land cover classes within the area.

Validity

Validity is referred to as the extent to which a test measures what it is supposed to measure, and the results obtained will represent the phenomenon being studied (F N Mvumbi, 2015). The questionnaires were tested to check: content validity to ensure that the content of the questionnaire had an adequate sample that it is supposed to represent, face validity that deals

with readability and legibility aspects like: printing clarity, font size and type, adequacy of workspace, and language appropriateness among others, finally the construct validity will be used to determine the psychological construct or characteristics nature being measured by the instrument.

3.5.2 Observation

Observation is a method that is widely used especially in studies that relate to behaviors and understanding them. In a way we all observe things around us, but this sort of observation is not scientific observation. Observation becomes a scientific tool and the method of data collection for the researcher, when it serves a formulated research purpose, is systematically planned and recorded and is subjected to checks and controls on validity and reliability.

The main advantage of this method is that subjective bias is eliminated, if observation is done accurately. Secondly, the information obtained under this method relates to what is currently happening; it is not complicated by either the past behavior or future intentions or attitudes. Thirdly, this method is independent of respondents' willingness to respond and as such is relatively less demanding of active cooperation on the part of respondents as happens to be the case in the interview or the questionnaire method.

However, observation method has various limitations. Firstly, it is an expensive method. Secondly, the information provided by this method is very limited. Thirdly, sometimes unforeseen factors may interfere with the observational task.

3.5.2.1 Satellite Image

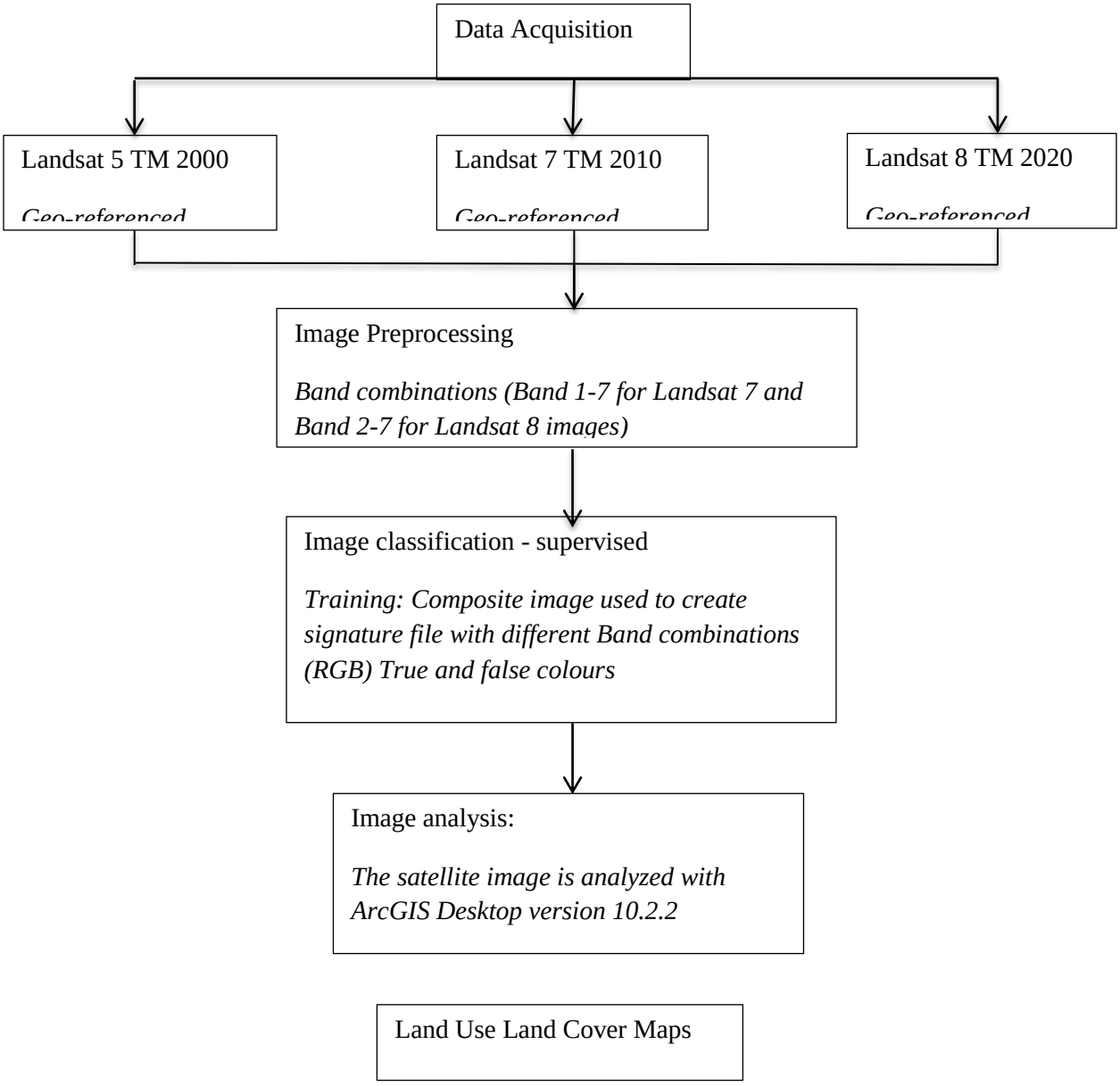

Figure 4: Workflow of satellite image processing

Landsat Images were used to analyze the land use land cover of the study area for a period of 20 years at intervals of 10 years. Supervised classification was chosen over unsupervised classification because the research has predefined results from field exercise through the survey of the study area which in turn would result to a more accurate image analysis. This was achieved at the training phase of supervised classification by correctly defining pixels with the actual land uses on the ground. The following steps were followed.

I Satellite image preprocessing

The satellite images were downloaded in different bands whereby I used Band 1 to Band 7 images. By using ArcGIS software I combined the different images to form a composite image for the supervised classification purposes. The use of the seven bands was important for the training and image processing purposes as Landsat provides the Band combination for the different land use as shown below.

Landsat 8

Table 1: Table showing Landsat 8 7 Bands Combination

LandSat 8 Image Band Combinations		
	Band Combination	Output
True Colour	Bands 4, 3, 2 (RGB)	Natural Color
False Colour	Bands 7, 6, 4(SWIR 2, SWIR 1, R)	Urban (Built up)
False Colour	Bands 5, 4, 3(NIR, R, G)	Vegetation
False Colour	Bands 6, 5, 2(SWIR 1, NIR, B)	Agriculture
False Colour	Bands 5, 6, 2(NIR, SWIR 1, B)	Healthy Vegetation
False Colour	Bands 5, 6, 4(NIR, SWIR 1, R)	Land/Water
False Colour	Bands 7, 5, 3(SWIR 2, NIR, G)	Natural with atmospheric removal
False Colour	Bands 7, 5, 4(SWIR 2, NIR, R)	Shortwave
False Colour	Bands 6, 5, 4(SWIR 1, NIR, R)	Vegetation Analysis

Table 2: Appearance of various surfaces and features in the different band combinations

	True Colour: RGB (Bands 4,3,2)	False Colour: (Bands 5,4,3)	SWIR (Bands 7,5,3)
Trees and bushes	Olive green	Red	Shades of green
Crops	Medium to light green	Pink or red	Shades of green
Wetland and vegetation	Dark green to black	Dark red	Shades of green
Water	Shades of blue and	Shades of blue to grey	Black to dark blue

	green		
Urban areas	White to light blue	Blue to grey	Lavender
Bare soil	White to light grey	Blue to grey	Magenta, lavender or pale pink
Clouds	white	white	White-pink-lavender

Table 3: A table showing the 7 Band combinations of Landsat 7

LandSat 7 Image Band Combinations		
	Band Combination	Output
True Colour	Bands 3, 2, 1(RGB)	Natural Color
False Colour	Bands 7, 5, 3(SWIR 2, SWIR 1, R)	Urban (Built up)
False Colour	Bands 4, 3, 2(NIR, R, G)	Vegetation
False Colour	Bands 5, 4, 1(SWIR 1, NIR, B)	Agriculture
False Colour	Bands 4, 5, 1(NIR, SWIR 1, B)	Healthy Vegetation
False Colour	Bands 4, 5, 3(NIR, SWIR 1, R)	Land/Water
False Colour	Bands 7, 4, 2(SWIR 2, NIR, G)	Natural with atmospheric removal
False Colour	Bands 7, 4, 3(SWIR 2, NIR, R)	Shortwave
False Colour	Bands 5, 4, 3(SWIR 1, NIR, R)	Vegetation Analysis

Table 4: Appearance of various surface features in different band combinations for Landsat 7

	True Colour: RGB (Bands 3,2,1)	False Colour: (Bands 4,3,2)	SWIR (Bands 7,4,2)
Trees and bushes	Olive green	Red	Shades of green
Crops	Medium to light green	Pink or red	Shades of green
Wetland and vegetation	Dark green to black	Dark red	Shades of green
Water	Shades of blue and green	Shades of blue to grey	Black to dark blue
Urban areas	White to light blue	Blue to grey	Lavender

Bare soil	White to light grey	Blue to grey	Magenta, lavender or pale pink
Clouds	white	white	White-pink-lavender

II. Supervised image classification

Once the band combinations have been done, supervised image classification of the Landsat images was done. Hence, the selected ground control points that included the major land use and land cover classes was sampled to create a signature file to help train the software to classify the entire study area. For accuracy purposes mixels were avoided rather pixels were used and an effort to include areas with relatively uniform in the same spectral pattern was made.

Based on the comparison of the different algorithms of supervised classification to monitor land use land cover, findings revealed that the maximum likelihood algorithm performed better than the other algorithms hence it was used.

3.5.3 Personal Interviews

Personal interview method requires a person known as the interviewer asking questions generally in a face-to-face contact to the other person or persons. The method of collecting information through personal interviews is usually carried out in a structured way.

With interviews, more information and that too in greater depth can be obtained. Interviewer by his own skill can overcome the resistance, if any, of the respondents; the interview method can be made to yield an almost perfect sample of the general population. There is greater flexibility under this method as the opportunity to restructure questions is always there, especially in case of unstructured interviews.

However, it is a very expensive method, especially when large and widely spread geographical sample is taken. There remains the possibility of the bias of interviewer as well as that of the respondent; there also remains the headache of supervision and control of interviewers. Certain types of respondents such as important officials or executives or people in high income groups may not be easily approachable under this method and to that extent the data may prove

inadequate. This method is relatively more-time-consuming, especially when the sample is large and recalls upon the respondents are necessary.

3.6 Description of Land Use and Land Cover Classes

Based on the field surveys and general historical information about the area, it was decided to focus on the following major land uses and land cover classes summarized below

Bare Land

The category of bare land denotes areas that are without vegetation cover at the time the satellite image was captured. These areas are not covered by any type of crop, vegetation or buildings. According to a classification scheme developed for woody biomass inventory and strategic planning project, bare land meant to include those areas with exposed sand or soil, salt flats and exposed rocks as well.

Vegetation cover

Vegetation cover is a category considered for a land that has been covered by the complex of living matter within the plant kingdom embracing all those plants capable of sustaining growth through photosynthesis.

Built up areas

Built up areas are areas that have undergone development and construction of features like buildings, warehouses as well as industries. These areas depict different spatial characteristics and are observed in different spectral reflectance depending on the band combinations for the satellite image.

Tree cover

Tree cover is distinguishable from vegetation as it forms an intense concentration of chlorophyll and is not adversely affected by the change in weather like high temperatures or heavy rainfall. This is not the case for vegetation, which dries up when the temperatures go high leaving the land bare or increasing during the rains and covering the land that was previous bare.

3.6 Data Analysis

Data analysis is the systematic organization and synthesis of the research data and the testing of research hypotheses, using those data. It also entails categorizing, ordering, manipulating and summarizing the data and describing them in meaningful terms (Brink, 1996).The satellite images were processed and analyzed in Environmental Systems Research Institute (ESRI) software package, ArcGIS Desktop version 10.2.2. The completed questionnaires were coded by the researcher using the Special Package for Statistical Studies (SPSS) computer program and the data analysed. The findings were then discussed and the data presented in the form of maps, frequency tables and bar graphs in chapter Four.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.0 Introduction

This chapter covers the findings and discussions of the data that was analysed from the data collection exercise. The data is presented in form of tables, graphs and maps.

4.1 Land User Land Cover of Manyatta B

An image of August 2020 was acquired from Landsat 8 Thermal Mapper since images over the same year most of them contained some cloud covers which would not allow for effective analysis except for the august image. The resolution of the image is 10 meters with a maximum cloud cover of 15% which is relatively low and hence would allow for ease of analysis.

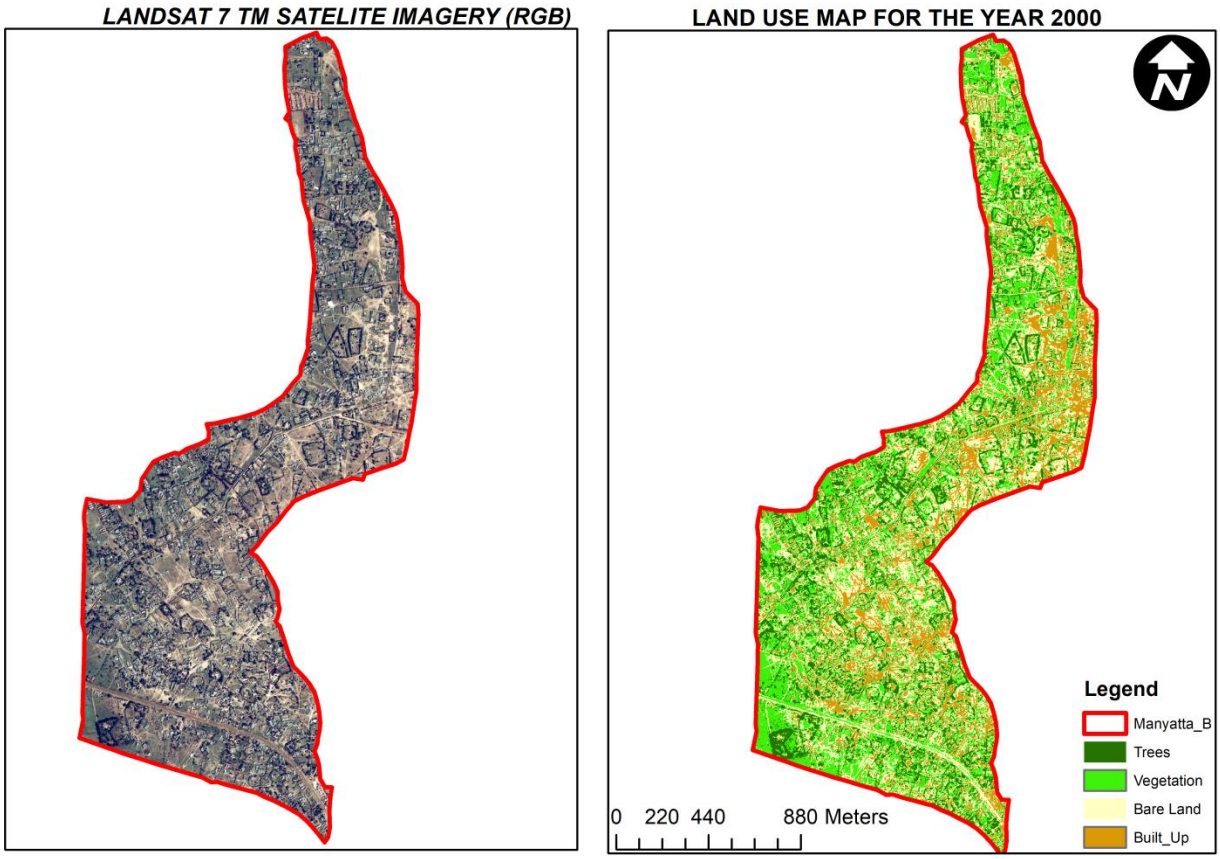

Figure 5: Land Use Land Cover map of Manyatta B for the year 2000

As can be seen on the land use land cover map of Manyatta B for the year 2000, the percentage proportion for the different land use land cover for the different classes are as follows; for the bult-up environment it was 18%, bare land at 32%, vegetation cover at 18% and the tree cover at 32%.

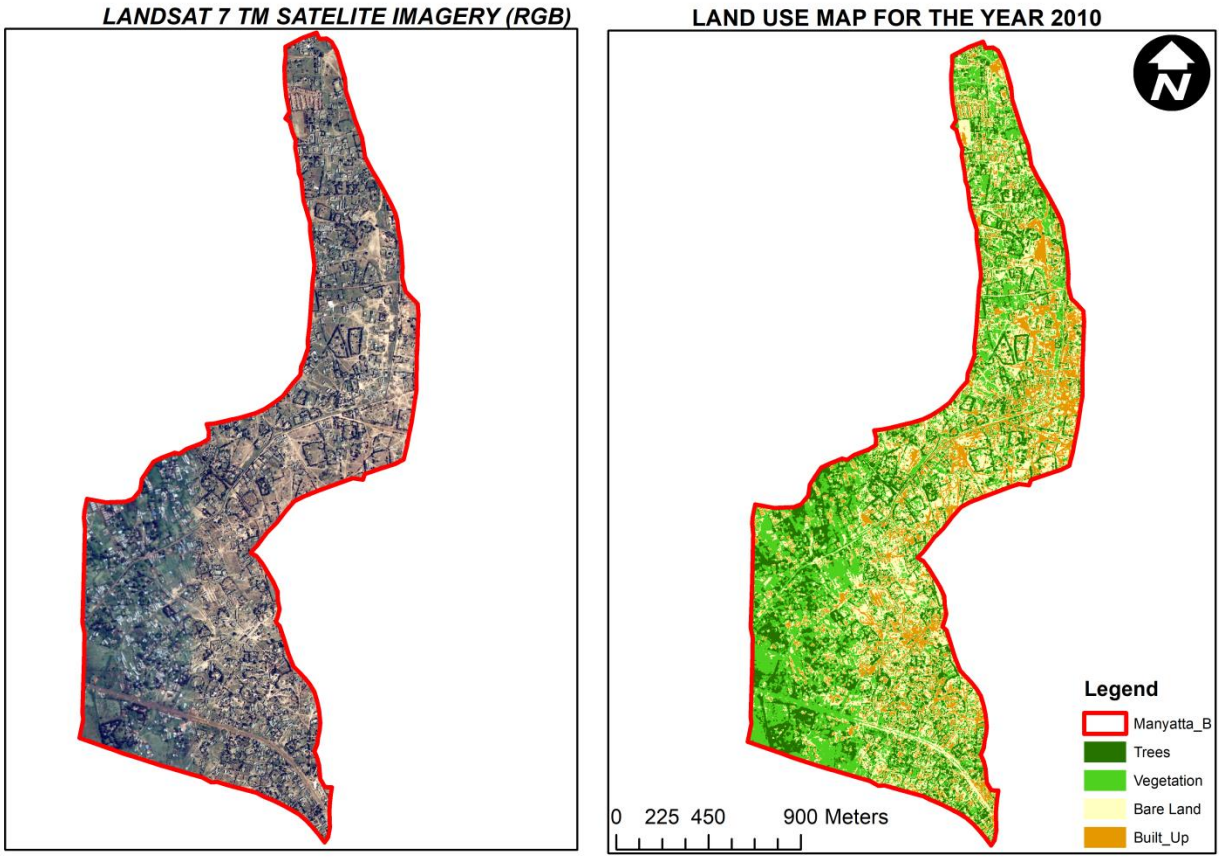

Figure 6: Land Cover map of Manyatta B for the year 2010

From the above Land Use Land Cover map of same area of Manyatta B for the year 2010, the following are the percentage proportions for the different land use classes; built up environment 25%, Bare land was at 25%, vegetation cover at 28% and the tree cover at 22%.

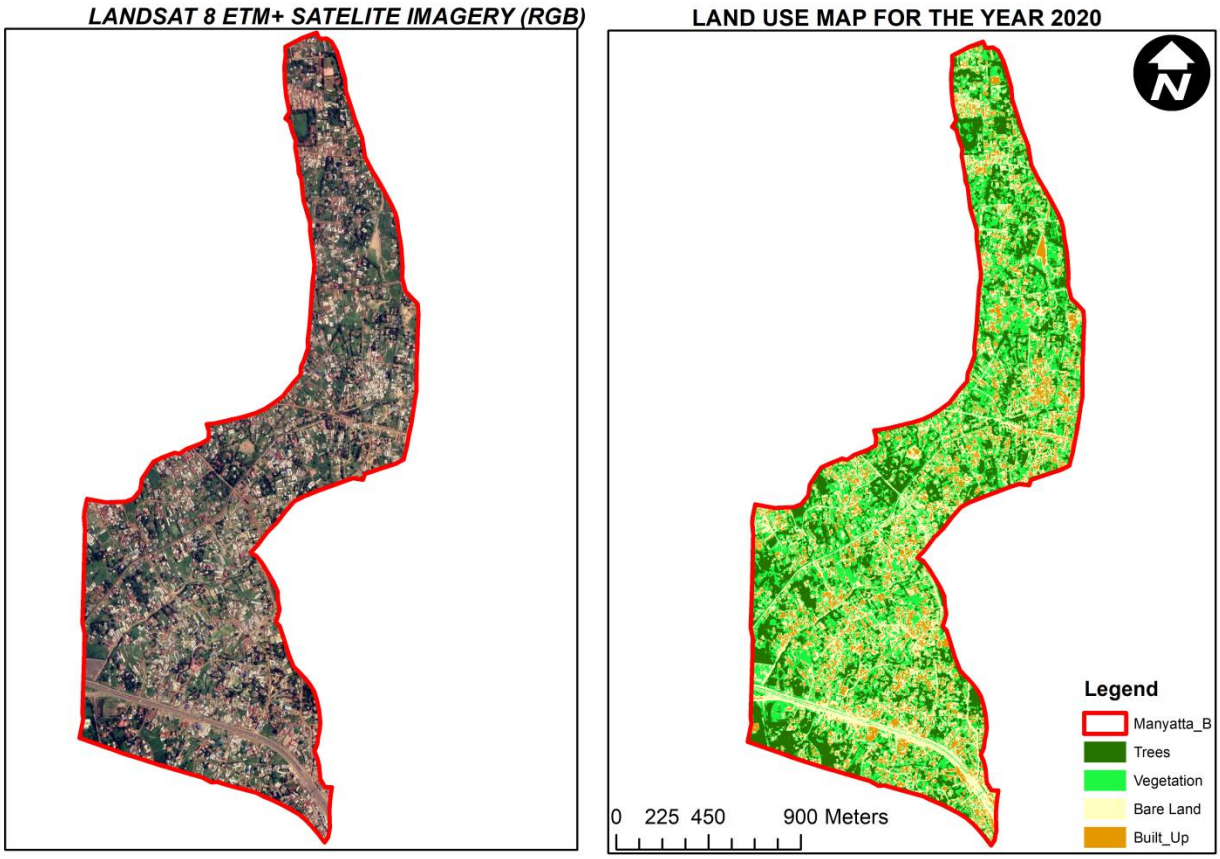

Figure 7: Land Cover map of Manyatta B for the year 2020

For the year 2020, the above land use land cover map of Manyatta B, shows that 35% of the total area is under built up environment, bare land covers a total of 19%, vegetation cover at 26% while tree cover takes a proportion of 20%.

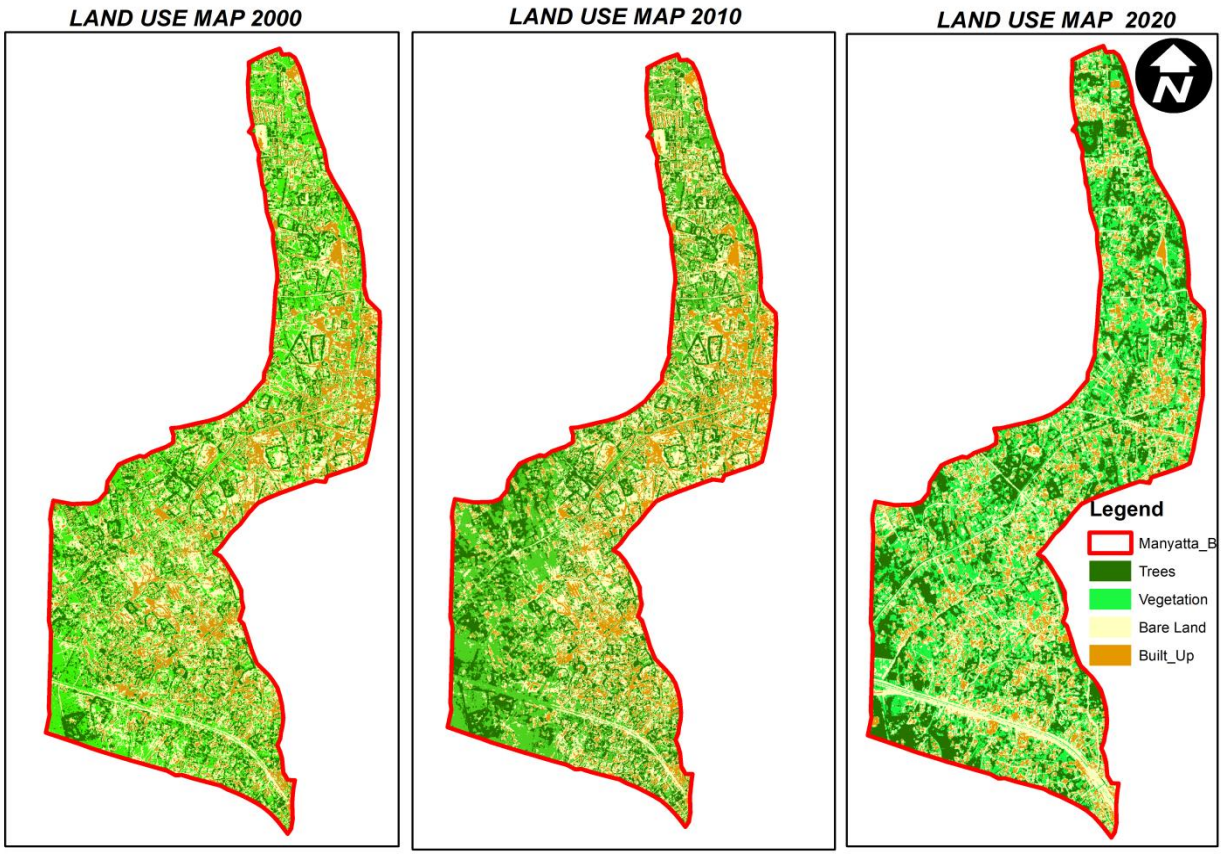

Figure 8: Land Cover maps of Manyatta B for the years 2000 to 2020

A graph showing land use change

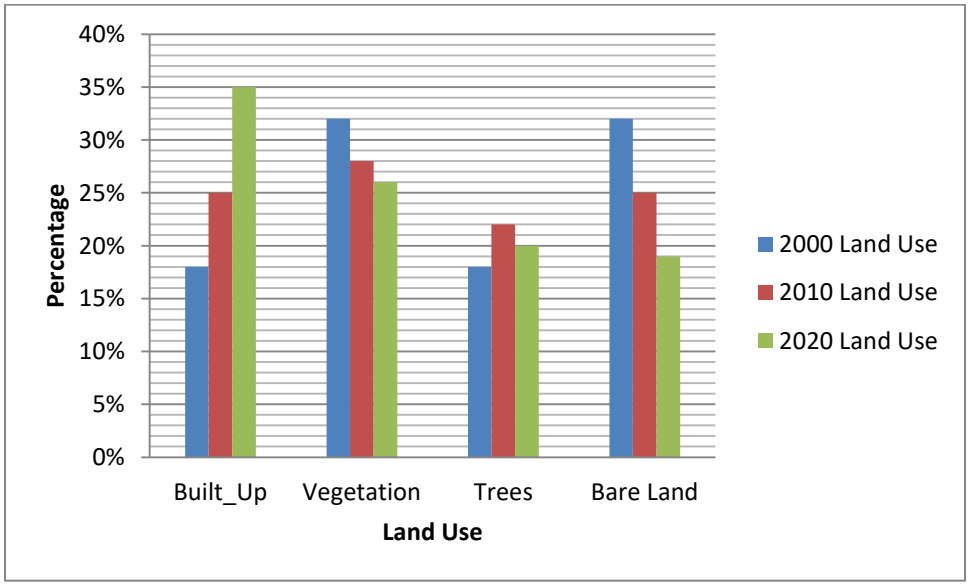

Figure 9: A graph showing land use change

From the above Map and graph which show the comparison of the different land use land cover classes, it shows that there has been a gradual increase in the total area of land that is under development which forms the built up environment. The vegetation cover depict an inconsistent trend in the proportion of coverage as it is dependent on some other factors which vary from year to year, which is the same case of for the tree cover of the area. The bare land proportion of the area that it covers shows that there has been a gradual decrease in its coverage over the 20 years under study.

4.2 Household characteristics

The total number of administered were 94, the completed questionnaires were 85. This formed a percentage of 90.43% response rate of the total number of respondents. Of the 85 respondent 37 were male while 48 were female.

Table 5: A table showing the general household characteristics of the respondents

Gender	Age Group	Number of Respondents	
Male	18-35	6	
	36-45	17	
	46-60	11	
	61 and above	3	**TOTAL: 37**
Female	18-30	9	
	31-45	15	
	46-60	18	
	61 and above	6	**TOTAL: 48**

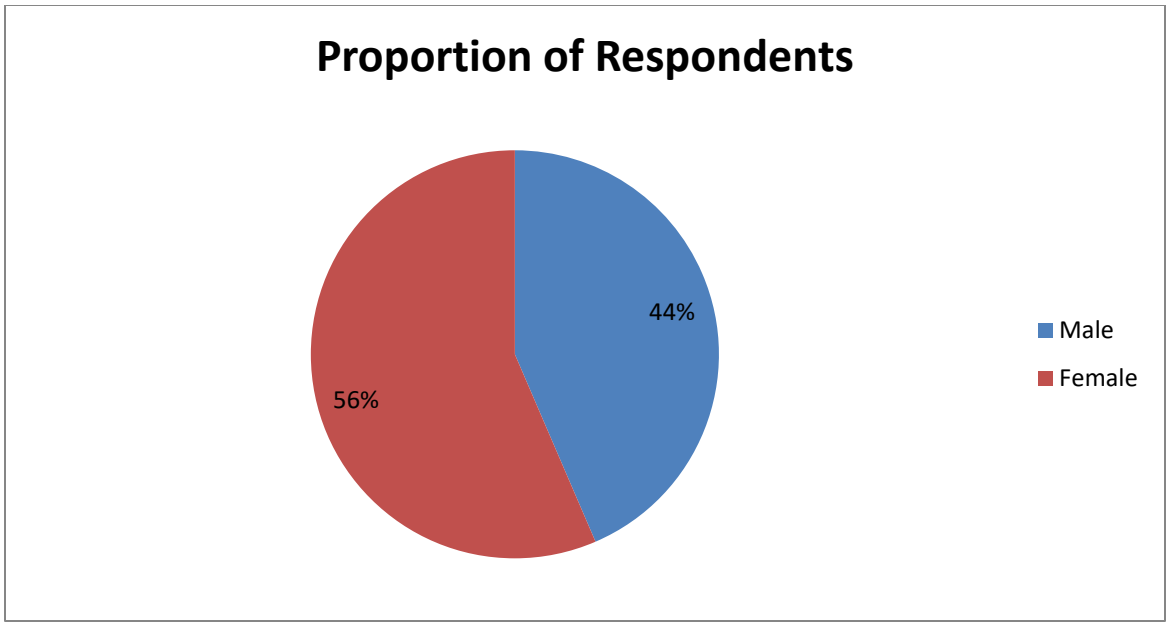

Figure 10: A pie chart showing the proportion of male to female respondents

Of the total number of respondents, 48 were female which formed a percentage of 56 of the total respondents while 37 were male which formed 44% of the total respondents. There was a high female response rate as most of them were stay at home mothers while their husbands go out during the day to do the informal and some doing formal jobs. From the male response, they were able to be reached since the data was collected from Friday through to the weekend which found a majority of the members of the households within their homesteads and houses.

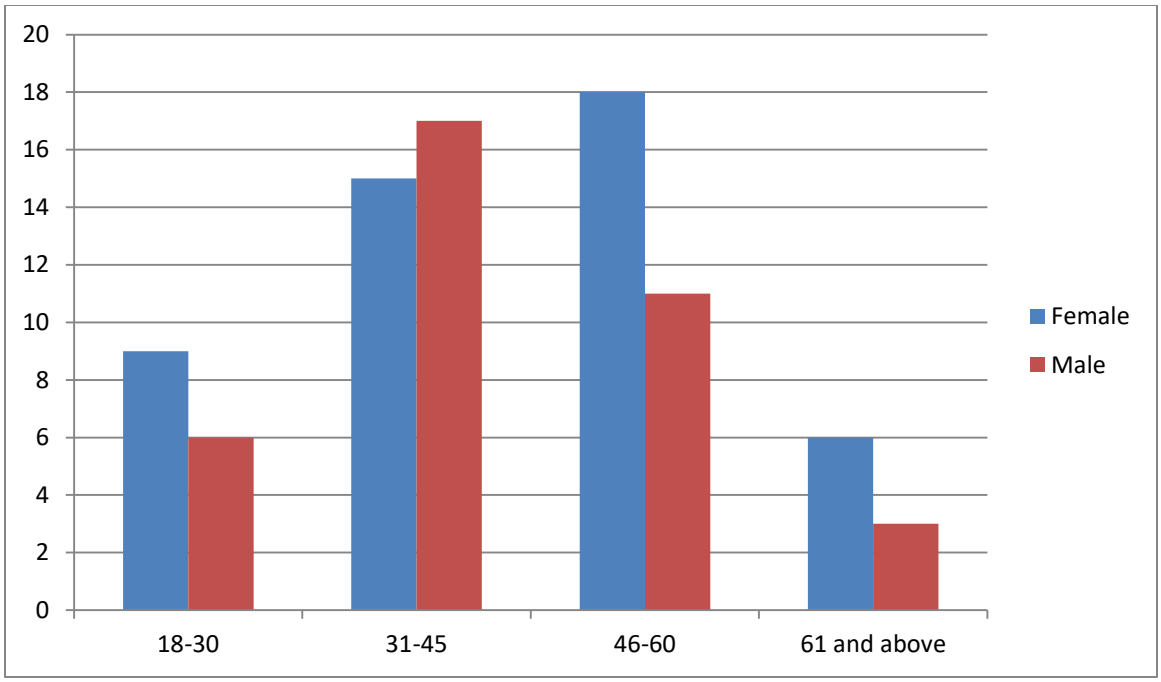

Figure 11: A bar graph showing the age distribution with respect to gender of the respondents

The figure above shows a bar graph with the age group distribution of the respondents. From the graph we can see that the age groups of 31-45 and 46-60 have the highest number of respondents as compared to the age groups of 18-30 and 61 and above.

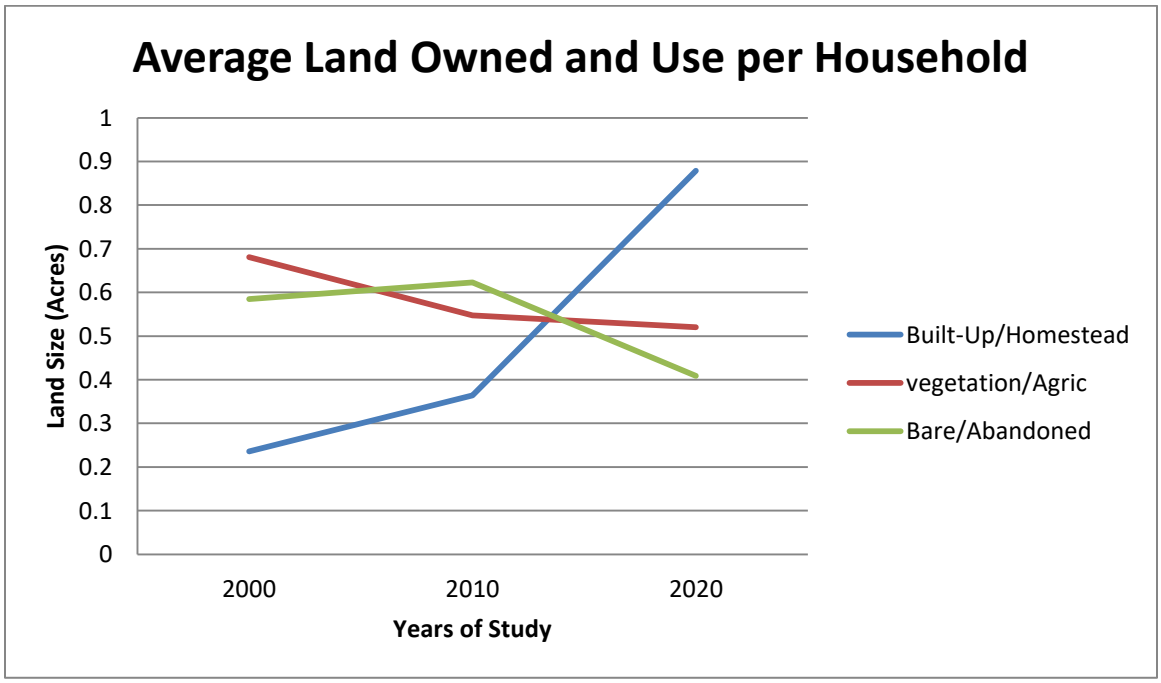

Figure 12: A line graph showing the average land sizes and their use per household

Over the years there has been a change in the different land uses and cover. The built up environment has been on the increase because there has been an increase in the population, the change in ownership whereby people from outside have come in to develop, settle as well as carry out commercial activities. Being that Manyatta B is an informal settlement, it depicts rural characteristics like ancestral land ownership rights while it has an urban standard of development due to it being within the Kisumu City jurisdictions. The vegetation has gradually decreased over the years since the land that was previously covered by vegetation is now under development which forms the built up environment. This is the similar case with the bare land.

4.3 Factors that have contributed to the change in land use land cover

Population

Table 6: Population size for Manyatta B for the years 2000, 2010 and 2020

Year	2000	2010	2020
Population of Manyatta B	1070	3452	5620

Source (KNBS)

There has been a gradual increase in the population of Manyatta B which has increased the occupancy levels of the area and as a result has seen the built up environment increasing over time from 2000 to 2020. This was projections from the Census reports for the years 1999, 2009 and 2019.

Trunk Infrastructure

The construction of the power line cutting through the study area which has let productive land and land which was previously covered by vegetation, the creation of land reserve for the construction of road networks through Manyatta B to open up the area for outside investors and people.

Change in weather patterns

Over the years there has been a change in the weather patterns precipitation to the temperatures of the study area and Kisumu at large. During the period 2017 to 2020 there has been a change in the weather pattern which has seen an increase in the rainfall. During the periods of 2010 to 2012 there were some prolonged dry seasons.

Table 7: Average annual rainfall for the years 2000, 2010 and 2020

	2000	2010	2020
Average annual Precipitation	101.68mm	99mm	108.9mm

Source (Average Weather)

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Remote sensing and GIS was used to process and analyse the images to determine the land use and cover as well as identify the changes that have taken place. Analysis of the satellite images for the years 2000, 2010 and 2020 showed that there has been change in the land use and land cover over those years. The results indicate that during the last two decades, built-up land had been increasing by 0.85% annually on average; there was no relative change in tree cover while bare land and vegetation have decreased by 0.65% and 0.3% respectively.

In Manyatta B, Tree cover increased in the first decade 2000 to 2010 then declined from 2010 to 2020 which vegetation cover increased gradually from 2000 to 2020. Data analysed from the questionnaire and personal interview showed that there has been a change in the weather patterns whereby in some years there has been very minimal rainfall while in some years there has been rainfall throughout the year. The increase in household size and the general population of the area has as well put pressure on the land that was previously bare or covered with vegetation into being built up.

5.2 Recommendations

1. In the face of the growing of the households and the general population, it will be imperative to promote planned and controlled development to ensure there are proper and planned developments that comply to the rules and regulations of the government, that is, the County government of Kisumu and the National government of Kenya

2. Designating interventions and activities like trunk infrastructures that directly benefit the population within the study area and can be synchronized with the land management within the study area being an informal settlement is very important, as an effort to improve the livelihood and promote planning developments.

3. The Ministry of lands through the County and National governments should provide individual land rights to the occupants and land owners within Manyatta B. This will help them have full control over their land units and with this they will be able to optimally use their land without fear of interventions from the administration.

REFERENCES

Land Resource Economics and Sustainable Developement. (2014). Vancouver: UBC Press.

Average Weather . (n.d.). Retrieved 11 3, 2020, from Weather and climate: https://weather-and-climate.com/

Brink, H. (1996). Research Methodology. *Qualitative Health Research*, 411-420.

Brown, I. (1992). International Conference on Sustainable Land Mnagement. *Land Policy*, 223-224.

Dawson, A. H. (1991). Land use change. *Land use policy*, 83-84.

F N Mvumbi, E. K. (2015). *Companion to Research Methology: Focus to humanities, Education and Social Science.* Nairobi: CUEA Press.

H Eswaran, S. B. (2011). *Sustainable Land Mnagement: Learning form the Past for the future.* Berlin: Springer.

Hailu, A. (2020). Dynamaics of Land use, land cover change trend and its drivers in Jimma Geneti District, Western Ethiopia. *Land Use Policy*, 105011.

KNBS. (n.d.). *KNBS Population and Housing Reports*. Retrieved 10 30, 2020, from Kenya National Bureau of Statistics: https://www.knbs.or.ke

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques (2nd Edition).* New Delhi: New Age International Publishers.

Maina J, W. S. (2020). Assessing land use land cover change Using GIS and Remote Sensing; A case of Kieni, Central Kenya. *Journal of Remote Sensing and GIS*.

Mrinus G Bos, A. V. (2013). *GIS and Remote Sensing Techniques in Land and Water Management.* Dordrwcht: Springer Netherlands.

Munich, Z. (2019). Monitoring Effects of Land Cover Change on Biophysical Drivers in Rangelands Using Albedo. *Land*, 33.

Nancy Davis Lewis, J. B. (1988). Land Degradation and Society. *Geographical Review*, 333.

P Blaikie, H. B., & Lewis, N. (1988). Land Degradation and Society. *Geographical Review*, 333.

Panwar, S. (2017). Evaluating Land Use/Land Cover Change Dynamics in Bhimtal Lake Catchment Area, Using Remote Sensing & GIS Techniques. *Journal of Remote Sensing and GIS*.

Peter Wyatt, D. M. (2003). *GIS in land and property Managment.* London: Taylor and Francis.

Pratt, A. C. (2009). Social and Economic drivers of land use change in the British Space. *Land Use Policy*, s109-s114.

Sarah Turner, T. P. (2015). "Nothing is like it was Before". The dynamics between Land Use and Land Cover and t he Livelihood Strategies in the Northern Vietnam Borderlands. *Land*, 1030-1059.

Sensing, R. (2017). Remote Sensing-Based Urban Land Use/Land Cover Change Detection and Monitoring. *Journal of Remote Sensing and GIS*.

Statistics, K. N. (2019). *2019 Population and Housing Census Report.* Nairobi: Kenya National Burea of Statistics.

Tahsin Yomralioglu, J. M. (2017). *Cadastre: Geo-Information Innovations in Land Administration.* London: Springer International Publishers.

Tengberg, A. (2014). Scalling up Sustainalbe Land Managment in the Western People's Republic of China: Evaluation of a 10-Year Partnership. *Land Degradation and Development*, 134-144.

Yongyut Trisurat, R. P. (2011). *Land Use, Climate Change and Biodiveristy Modelling: Perspective.* Information Science Reference.

APPENDICES

APPENDIX 1: QUESTIONNAIRE.

Questionnaire No:…

INTRODUCTION

This questionnaire is prepared to collect data about land use land cover, changes, their drivers, the general impact and the implications for the management of land within Manyatta B. It is expected to generate and provide helpful information for my research project on 'The use of GIS to assess Sustainable Land Management in Manyatta B". Your inputs will be highly appreciated and the information provided in this questionnaire will be treated as confidential and only for the use of this research project.

SECTION A: GENERAL BACKGORUND INFORMATION

NO	Question	Answer	
1.	Date of the Interview		
2.	Age of the interviewee	18-30	
		31-45	
		46-60	
		61 and above	
3	Position in the HH		
4	Total number of family members	Male:	Female:

5 a) Total Land owned in hectares: ……

5 b) Land tenure situations (Tick the most appropriate)

Private titled	
Traditional private rights	
Rented/leased	
Unofficial/squatting/still obtaining title deed	
Other/unknown	

5 c)

Type of land	Approximate size of each parcel			Underlying reasons
	Now	10 years ago	20 Years ago	
Homestead (Residential)				
Agricultural Land				
Abandoned Land				
Any other (Specify) ……				

SETION B: Land use change, drivers and impact

6. What major shift in land use that has occurred in the last 20 years?

Land use change	10 years ago to now *(In hectares)*	20-10 years ago *(In hectares)*
Agricultural – residential		
Abandoned land – residential		
Abandoned land – agricultural		
Agricultural – commercial		

7. What are the major factors that affect your decision related to land use or management in order of importance?

……
……
……
……
……
……

8. Describe land lost or additional land gained during the last 20 years and the associated factors to this.

……
……
……
……
……

9. Describe new practices and regulations that influence land management in this area at different points in time and their impacts

Last 10 years: ……

……

Between 10 to 20 years ago: …….

……

10. What are the major land use and management changes you have noted in this area over the past 20 years and the institutional changes that go along with these?

……
……
……
……
……....

11. Are there external factors that are out of your control in the management of your land?

Natural factors: ……....

……

Demographic factors: ……

……

Institutional factors: ……

……

Political factors: ……

……