UNIVERSITY OF NAIROBI

SCHOOL OF ENGINEERING

MAPPING OF DEFORESTATION USING MOBILE PHONE APPLICATION: A CASE STUDY OF UPLANDS, KINALE AND KEREITA FORESTS IN KIAMBU COUNTY.

BY

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Declaration

I, Florence Tuukuo, hereby declare that this project is my original work. To the best of my knowledge, the work presented has not presented in any other university.

FLORENCE TUUKUO ……………..... …………………

Name of student **Signature** **Date**

This project has been submitted for examination with our approval as university supervisor(s).

MR. JASPER N. MWENDA .... …………………

Name of supervisor **Signature** **Date**

Dedication

This work is dedicated to my late parents Mr. Simon Kosiom Tuukuo and Mrs. Agnes Njoki Kosiom

Acknowledgement

My sincere gratitude goes to the Lord, the giver and sustainer of life, for the strength and good health He bestowed unto me during the entire period. Secondly, I appreciate my supervisor Mr. Jasper Mwenda who has provided guidance to me during this research. I would also like to thank Higher Loans Education Board for the scholarship that funded my second year of the course. I am also so grateful to the Kenya Forest Service for providing the data needed for completion of this project. Finally, I would like to appreciate my entire family for moral and financial support throughout the period of my course.

Abstract

Deforestation and forest degradation monitoring is one of the central elements for Reducing Emission from Deforestation and Forest Degradation, sustainable management of forest, enhancement of forest carbon stock and conversion of existing forest carbon stock implementation. The current schemes for detecting and monitoring deforestation are based on remote sensing and field measurements. Monitoring being a periodic process of assessing the properties of forest stands with respect to some reference data. This project presents a conceptual framework and process that aims to simplify the forest monitoring capacities of local communities in developing countries in which mobile phone application is used based on a case study Kiambu County Kenya. The objectives of this research included: Provision a platform by identification of nature and extent of deforestation which can be used by Kenya Forest service. Testing and validation of mobile phone application as an efficient and fast method for monitoring deforestation. Assessment of forest change activities within the forest that lead to deforestation i.e. drivers of deforestation and determination of the usability of mobile application in assessing and monitoring deforestation.

Adopting the current schemes for implementing monitoring at national levels is a challenging task. Recent advancement of Information and Communications Technologies (ICT) and handheld devices has enabled local communities to monitor their forest in an efficient and cost-effective way. The GIS cloud mobile application in this study demonstrated the potential to be used for mapping deforestation and makes data collection easier as well as enables better forest management. It is able to integrate location-based services with digital orientation which makes wireless communication and remote sensing technologies for low-cost solutions for geospatial data collection and ground truthing. The results enabled the determination of major drivers of deforestation which include; Logging, infrastructural development, forest to agriculture land conversion and unplanned settlement. The mobile phone application was efficient for this research and this project recommends that the forestry sector should take it into account as it is effective within reachable means.

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List of Abbreviations

ALS	_	Airborne Laser Scanning System
AVHRR	_	Advanced Very High-Resolution Radiometer
CBM	_	Community Based Monitoring
DBH	_	Diameter, Breadth and Height.
FAO	_	Food and Agricultural Organization
GIS	_	Geographic Information Systems
GPS	_	Geographic Positioning System
IPCC	_	Intergovernmental Panel on Climate Change
KNBS	_	Kenya National Bureau of Statistics
LAN	_	Local Area Network
MDC	_	Mobile Data Collection
MODIS	_	Moderate-Resolution Imaging Spectroradiometer
MoEF	_	Ministry of Environment and Forestry
MRV	_	Monitoring, Reporting and Verification
NFMS	_	National Forest Monitoring System
NRS	_	Natural Resource Society
NRT	_	Near Real Time
PDA	_	Personal Digital Assistant
REDD+	_	Reduction of emissions from deforestation and forest degradation plus the sustainable management of forests
SAR	_	Synthetic Aperture Radar
TRS	_	Terrestrial Laser Scanning
UNFCCC	_	United Nations Convention on Climate Change

CHAPTER 1: INTRODUCTION

1.1 Background

Kenya's forests covered 7.4 % of the total land area as of 2017 (MoEF, 2018) and are of great value since they provide many goods and services such as wildlife habitat, biological diversity, water catchment, employment opportunities and livelihood sources (MENR, 2016). The government of Kenya has a goal of enhancing and maintaining forest cover at a minimum of 10 % of the land area by 2030, this is captured in the constitution of Kenya 2010, Forest Management and Vision 2030 documents. However, deforestation has continued to reduce the forest cover estimated at 5000 hectares per annum, these is a result of charcoal extraction, illegal logging, overgrazing and encroachment and improperly planned development activities.

"Remote sensing has proven to be very useful for deforestation monitoring at the global, national and subnational scale" (Pratihast 2014a).This can be attributed to the wide range of capabilities of remote sensing platforms which makes satellite imagery efficient for capturing the reduction of forest cover. However, Frantz (2016) notes that despite Remote sensing being the only feasible means of monitoring forest change, there is no retrospectively available remote sensor that meets the demand for monitoring forests with the required spatial detail and guaranteed high temporal frequency. Remote sensing techniques are useful for forest monitoring but they have to be combined with field measurements and observations as ground truth data in order to validate the acquired data, satellite imagery provide time series data, conversely these datasets are not real-time hence inefficient in provision of data for adequate deforestation assessment.

According to Pratihast (2014b) "community-based monitoring is an emerging alternative method for forest change monitoring that promises to be cheaper than conventional monitoring methods". Mobile phone applications for instance; cloud GIS mobile application are able to provide up to date information as its mobility enables users to record measurements in the system during their time of occurrence including forest changes and human activities affecting forest cover. Mobile GIS involves integration of GIS technology with other technologies including Geographic Positioning Systems (GPS), wireless communication and database which are able to access, use and maintain geo-data in the field. Data acquired using the mobile devices is used as input for analysis of deforestation as the dataset is used to update satellite data.

Changes occurring within Kiambu county and Kenya at large include Forest degradation, deforestation, prolonged drought seasons, flood and generally climate change. Verbesselt (2012) records that near-real time monitoring of ecosystem distribution is critical for rapidly assessing and addressing effects of biodiversity and socio-economic processes. To be able to attribute effects of forest change to their actual causes, timely information about forest change activities occurrence and their spatial extent is essential.

This research applies the use of mobile phone application which is cheaper and is able to signal new changes with high accuracy which makes the technique more efficient as compared to other forest monitoring techniques. The mobile phone application is applied to acquire data in the field to complement what has been captured by remote sensing in this case Landsat 8 satellite imagery of the area of study. The research is therefore steered towards determination of deforestation within Kiambu County using a mobile phone application which captured up-to-date data for effective forest monitoring. The mobile phone application used in this study is user friendly and anyone can collect data using it even without major knowledge in Forestry.

1.2 Problem Statement

Monitoring of deforestation in Kenya is carried out by use of data acquired from satellites such as Landsat and this data is acquired after sixteen days which is the interval in between two repeat cycles. This leads to inconsistency of the data, information about forests remains limited and unevenly distributed. This has over the years led to poor forest management and it is time consuming. The lack of a system for the continuous monitoring of the forest cover, including forest inventory or geographical information system to periodically update the changes in land use, deforestation, prevent obtaining actual figures regarding the disappearance of woodlands. "To the above, are added controls inefficient and little or no supervision over the damage to the forest cover by total and selective harvesting, authorized annually; therefore, there are no updated figures on the extent of commercial forest loss and total deforestation" (FAO ,1995).

Up-to-date information on deforestation remains a challenge as the current remote sensing techniques require that data obtained from satellites be complimented with field measurements and observations. This proves to be expensive and time consuming in turn providing data that is not real-time due to the long pre-processing procedure. Mobile devices come in handy to solve the short comings of remote sensing due to various appealing characteristics including; mobility, sustainability, they are cost effective as compared to remote sensing methodologies and have high potential of signalling forest changes both in area dimension and type of disturbance. The hand-held devices also reduce uncertainties of forest inventories. Mobile phones will assist in data collection, monitoring, evaluating, mapping and transmitting data, they provide information which would otherwise not be available or would take vast amounts of time to acquire. Without up-to-date accurate data on deforestation, Kenya forest Service is unable to act on time. The current status of forest cover in Kenya can be attributed to lack of timely data to help the forest managers to identify forest change as it occurs and to capture the perpetuators. Therefore, this research is meant to provide a way out for the service to identify and solve such cases. It can also help in distribution of newly recruited rangers in areas where much of such deforestation occurs hence improving service delivery and consequently increase forest cover.

1.3 Objectives

Overall objective:

The overall objective of this study was to provide a platform by identification of nature and extent of deforestation which can be used by Kenya Forest Service to acquire up to date information in Kiambu county and Kenya at large.

Specific objectives;

1. To test and validate mobile application as an efficient and fast method for monitoring deforestation.
2. To identify activities within the forest that lead to deforestation i.e. drivers of deforestation.
3. To determine the usability of mobile application in mapping deforestation.

1.4 Justification for the Study

Deforestation has led to reduction of forest cover in Kenya, this can be attributed to the fact that there are very few systems that provide up to date information on the accurate rates of deforestation and forest cover change. This research looked into a method that can be used by the forestry sector to acquire up to date information on the type of forest change that happens, the nature and extent of drivers of those changes and hence provide data that will improve on monitoring of forest status. It is necessary to carry out a study on an efficient and fast data acquisition system to curb the current rate of deforestation being experienced in Kenya. Currently, the sector sorely depends on remote sensing techniques to acquire data about forest change, this is not efficient as it takes a long period between data collection and analysis so that action can be effected.

1.5 Scope of work

The study area is located in Kiambu county which consists of seven forest stations. It is a county in Central Highlands Conservancy in Kenya. It is adjacent to the northern border of Nairobi County and has a population of 1,760,692 according to 2013 population projections (KNBS, 2015). The seven forest stations are under the management of Kenya Forest service, which is mandated by the government to conserve forests both public and private. Of these forests, the study was conducted at Kinale, Kereita and Upland forests. Data will be collected using the mobile phone application to investigate the rate of deforestation. These data shall be used to update the satellite data for improved accuracy on monitoring deforestation.

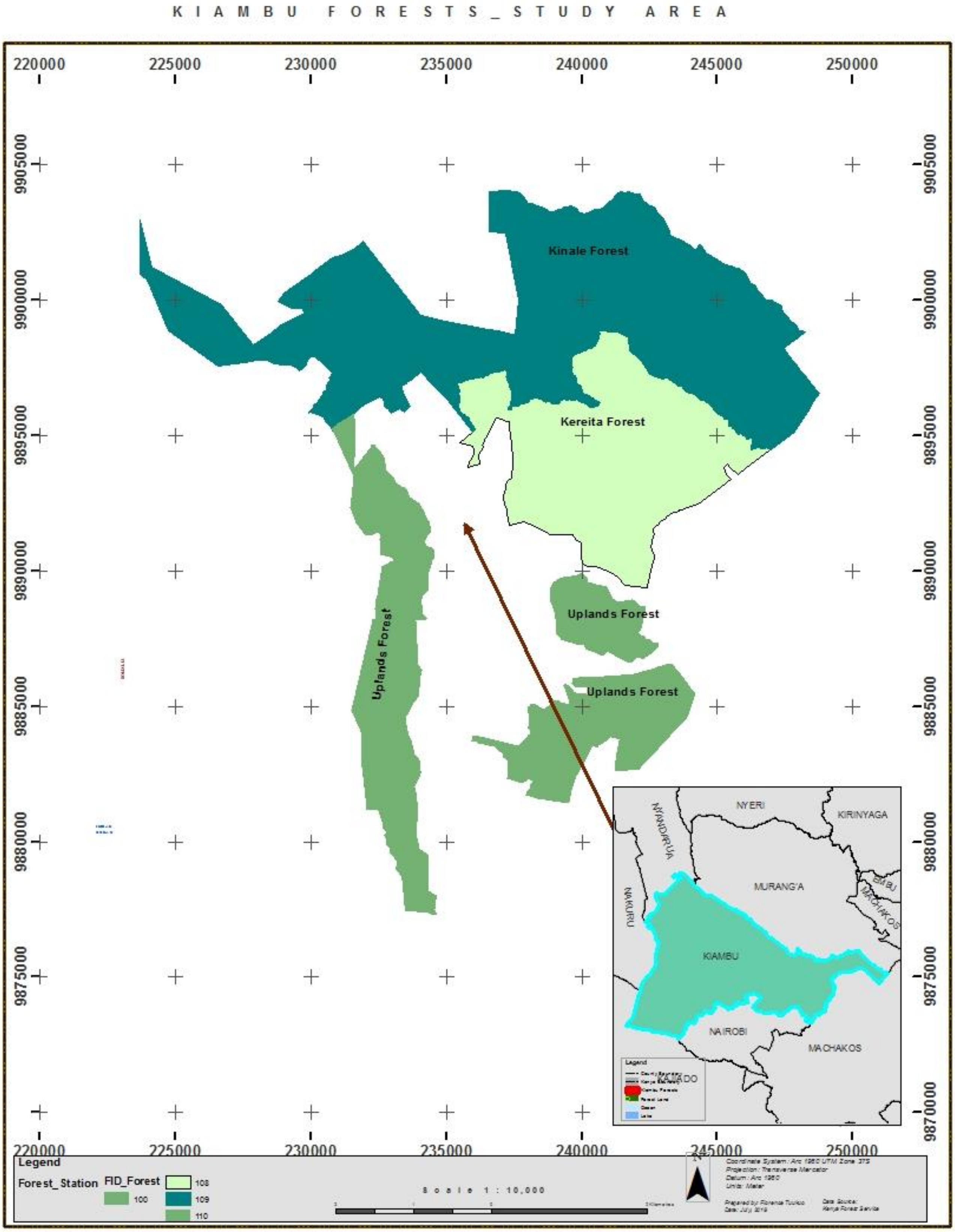


Fig 1.1 Map of the forest within Kiambu county in which the study was conducted.

1.6 Limitations

Field data collection in terms of survey was challenging due to unwillingness of some forest officers to give information on the areas of exact forest change activities making it a complex task to locate the areas by studying large areas. Remote sensing platforms acquire data on forest cover change inconsistently, although the mobile phone application used in this research is supposed to complement the satellite imagery, limited number of imagery makes it challenging because the mobile phone application cannot be used exclusively without satellite imagery.

1.7 Organization of the Report

This research is organized into five chapters; The first chapter entails introduction where a background study was carried out to identify the current status of forests in Kenya. This was followed by identification of methods applied currently in mapping this status of forests in the country and it was found out that remote sensing is the major methodology that is used in mapping changes of forest cover. The above factors led to development of the problem statement which highlighted the inadequacy of remote sensing techniques in providing up-to-date information on disappearance of woodlands given the time required to acquire data. This informed on formulation of objectives that were to be met at the end of this research. Selection of the area to carry out the research was done based on the preconditions of forest change in the area.

Chapter 2 comprises of literature review on the topic of study which divulged into similar works that have been carried out in previous researches. Here, various aspects were looked into, including; deforestation in Kenya and how the rate of forest cover has been changing over the years. The monitoring system applied in forest cover mapping including the traditional methods that were used to map forest cover change and the current techniques applied. The next section in this chapter comprise of the potential the mobile phone application has in complementing the data acquired through remote sensing techniques. In chapter 3, materials and methodology applied in carrying out this research are detailed. This involved data collection by both primary and secondary methods included reconnaissance survey, field survey, actual data collection and data analysis. Chapter 4 comprises of results and discussion, this were drawn from the methodology applied in the research, the drivers of forest change were captured at the point of occurrence which is detailed in this chapter from which maps were created to visualize this. Finally, Chapter 5 describes the conclusion and recommendations that were made based on results of the research.

CHAPTER 2: LITERATURE REVIEW

2.1 Deforestation

Kenya which historically has had a viable industrial plantation-based forest sector (MoWF,2013), gazetted reserves of natural forests has over the last 3 decades experienced unprecedented losses of forest cover through a number of mechanisms which have led to both deforestation and forest degradation (GOK, 2010). Over the past 25 years there has been massive destruction of forests due to excision, settlement establishment, illegal logging, encroachment and unsustainable grazing (MoEF, 2018). Forestry is also facing overwhelming threats due to natural resource depletion, soil erosion, forest degradation, habitat degradation, water imbalance, unbalanced human interference and illegal poaching (Jiban, 2016). Forests that were once common, have now become very rare due to deforestation and forest degradation in Kenya and other parts of the world. The current leasing system is seen as one of the major threats to sustainable management of the area, as it encourages maximum exploitation, and marginalizes the local community. Settlements have been done without following due process leading to clearing of vast amounts of forests.

Deforestation is regarded as complete removal of trees and conversion of forests into other land uses (Hosonuma et al 2012).Johnson (2008) noted that Africa is facing a huge deforestation problem where the rate of deforestation is higher than any other continent.
Management of forest ecosystems to sustain desired benefits requires knowledge of how forests change over time in response to both artificial and natural disturbances and management activities. Disturbances are both stresses and destructive agents such as invasive species of both plant and animal pests, natural and artificial fires, climate change and serious weather events such as drought, floods and ice storms, both air, water, and soil pollution, real estate development of forest lands and timber harvest. As indicated by Ochego (2003) combating deforestation requires factual information on what is going on in our forests. "Deforestation and forest degradation are the second leading sources of greenhouse gas emissions which accounts for over 17% of global carbon dioxide emissions" (Margono, 2012) Kenya's forest cover has been reducing 0.3 % p.a due to population pressures, wood fuel, building materials and prioritization of other land uses.

2.2 Forest Monitoring System.

Forests play important roles in survival and wellbeing of species by providing food, water and stabilizing climate (Pratihast, 2016) However, deforestation reduces or completely removes tree cover which affects the global climate by increasing greenhouse gas emissions due to reduction of carbon stocks. Forest monitoring focuses of forest cover change activities such as logging, encroachment and overgrazing. Pratihast (2014) notes that forest change is a dynamic process hence monitoring needs to be carried out on a regular basis in support of Monitoring, Reporting and Verification (MRV) requirements.

Satellite technology is useful in tropical deforestation determination due to inaccessibility of many areas and the impracticability of air-craft based methods (Townshend, 2000). These technologies encompass Advanced Very High-Resolution Radiometer (AVHRR), and Landsat using 80m Multi-Spectral Scanner and 30m Thematic Mapper (Tucker, 1984); in addition, imaging radar has been suggested given its capability to penetrate clouds. Measuring the aerial extent of deforestation for other than localized areas requires use of satellite data which is acquired by optical and radar satellites.

Remote sensing involves acquisition of information about an object, an area or phenomenon through the analysis of data acquired by remote devices (Kieffer, 1994), analysing these datasets from different epochs enables detection and monitoring of forest destruction (Kumar, 2010). Remote sensing data have been used to provide information at different scales for surveys of forest ecosystems but information about understorey remains a challenging task (Luxia Liu, 2017). Some of the techniques used to overcome this include Airborne Laser Scanning (ALS) and Terrestrial Laser Scanning (TLS).

Remotely sensed images from Landsat family of satellites have spectral, spatial and temporal properties ideal for identifying ecological change at landscape scales (Hughes, 2017). Nevertheless, remote sensing techniques encounter challenges due to persistent cloud cover, seasonality and relatively low resolution also inadequate coverage in certain areas due to data acquisition constraints and lack of local Landsat data receiving stations for real-time data. In order to improve efficiency, harmonization of wireless networking and web GIS/ web services allows mobile phone GIS users to stream large amounts of geographical information as a base-map hence eliminating processing costs and data processing time (Lwin, 2014)

2.3 Traditional and Modern Forest Monitoring System.

Earlier field data collection methods involved pen-and-paper based techniques which tend to be time consuming and cumbersome (Lwin, 2014). The tasks included preparation of basemaps, ancilliray data collection which was not practical in real-time information collection. This was followed by GIS applications which Biuk-Aghai (2004) defines as software applications that reside on high performance work stations and servers equipped with the necessary resources i.e large amounts of primary and secondary memory, fast CPUs and graphic processors and large screens for displaying the data.

These method can be solved by mobile devices which reduce logistical burden, costs and rate of error of paper based methods of data collection. Mobile devices such as smart phones and personal digital assistants (PDAs) have shown great potential to increase local community's participation in data collection processes (Pratihast 2012). In addition, mobile devices have the potential to signal recent forest changes such as logging and forest clearance for infrastructural development which cause deforestation and other disturbances.

The outstanding features include:

i. Flexibility- a hand-held device is more efficient and data accuracy is high.
ii. Users are able to validate data in real-time which reduces errors and improves communication protocols.
iii. Offline data storage, network connectivity and multimedia capabilities.
iv. Creating and sharing information and knowledge to improve institutional performance.
v. Signals of new changes which takes less time as compared to remote sensing techniques.

Online geospatial technology solves challenges in data collection by removing paper-based surveys and achieving real-time access to collected GIS information. Greg Newman (2012) points out that new and existing technologies will improve the rate and quality of data collection through location-based real-time mapping services. Integration of remote sensing data and mobile phone collected data shall enhance data accuracy while capturing changes as they occur within the forests. Lwin (2014) indicates that accurate field data collection is necessary for adequate spatial data analysis and proper decision making hence there needs to be a strategy to monitor global forests on a daily basis to allow authorities to act quickly to stop activities that reduce forest cover.

2.4 Mobile phone application

Mobile devices such as mobile phones, palm-top computers and tablet computers have remarkable advances in terms of technological innovation improved by upgrading in network which has increased data transmission, bandwidth and coverage area (Moe, 2004). “Recently, the use of mobile communication devices, such as smartphones and cellular phones, is increasing in field data collection due to the emergence of embedded GPS and wireless networking technologies” (Lwin, 2014). Hickey (2009) indicates that Mobile phones are on the verge of becoming powerful tools to collect data on many issues, ranging from global health to the environment this can be attributed to the appealing features of mobile devices including affordability, logistical efficiency, cost reduction and low processing time. In addition, the availability of built-in GPS in mobile phone and the development of locational services based on the wireless networking environment means field data collection is more accurate than before as getting locations from the field is no longer critical work (Lwin et al, 2014)

The advent of mobile technology including mobile phones, GIS and convergence of data over wireless networks for instance 3G, wireless LAN have led to an explosion of a wide range of mobile application (Moe, 2004). The GIS cloud mobile application in this study has the capability to be used for forest inventory which is currently pen-and-paper based, this will make data collection easier as well as enable better forest management. As Freirea (2014) indicates, integrating location-based services, digital orientation makes wireless communication and sensing technologies low-cost hardware solutions for geospatial data collection directly into a digital environment in turn boosting field data collection in more efficient ways hence refining data processing and availability also transfer and storage in databases.

2.5 Forest monitoring form and attributes

2.5.1 Forest inventory form

This form contains measurement of forest inventory data such as Geo-location, Date-time, DBH, tree species and photographs.

Table 2.5.1. Forest monitoring form

Forest Monitoring Form and attributes		
Forest Inventory form	Geo_ location	
	Date	
	DBH	
	Tree species	
	Photographs	

2.5.2 Forest Change Activity monitoring form

This form allows the user on capturing forest activities such as small-scale degradation, deforestation and reforestation.

The form facilitates the user to store the location, photographs and description of the activity.

Table 2.5.2. Forest Change Activity Form

Forest Change Activity Form		
Forest Change Activity	Geo-location	
	Date/Time	
	Change Activity	
	Photographs	
	Comments	

CHAPTER 3: MATERIALS AND METHODS

3.1. Data collection

The present study is in view of both primary and secondary information. The primary information was gathered through the poll review, organized and unstructured meeting with key witnesses, direct field perception and dialogs with the common individuals of the study area. Secondary data for this study was collected from free available materials from non-governmental organization, distributed and unpublished sources such as reports, articles, diaries, day by day daily papers, records, maps.

Reconnaissance survey

Reconnaissance survey was done at the starting level of the study. Firstly, boundary was delineated by available resources to understand the extent of the study. A short field observation for primary documentation was then carried out under the primary observation field introduction, objectives identification, previous survey evidence query, scope identification was instituted.

Field survey

This study focused on field survey as the main source of data. Field survey helped to understand the natural sitting of the study area as well as to understand the perception of the local people relevant to this study. During the field survey, data was collected using the mobile device and this was the main input for the mobile phone application, the information captured included forest change activities. These data shall be stored asynchronously and transferred later over Wi-Fi or USB cable.

Data collection procedure

- Getting coordinates from built-in GPS or Wi-Fi Access point
- Locate points on a map
- Input survey items
- Create new, edit, delete and update the records
- Records view.

Description of GIS cloud Mobile data collection Application.

GIS cloud mobile data collection application was used in this research, it is a tool for users and mobile devices which allows collection of data in real-time, it contains custom design forms in offline mode and more. The data forms were customized to include the attributes relevant to the study including photos, audio as well as standard text, number or choice inputs. The application is efficient as it is linked to Mobile Data Collection (MDC) portal which was accessed on http://mdc.giscloud.com.

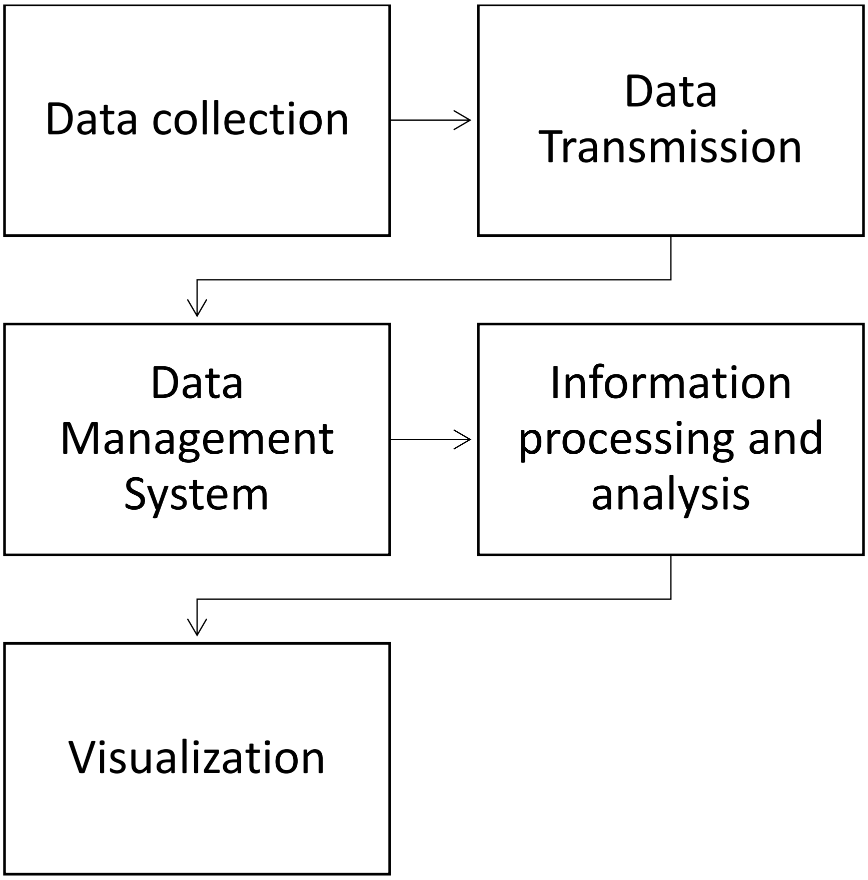


Fig 3.1 Flow chart of mobile data collection process

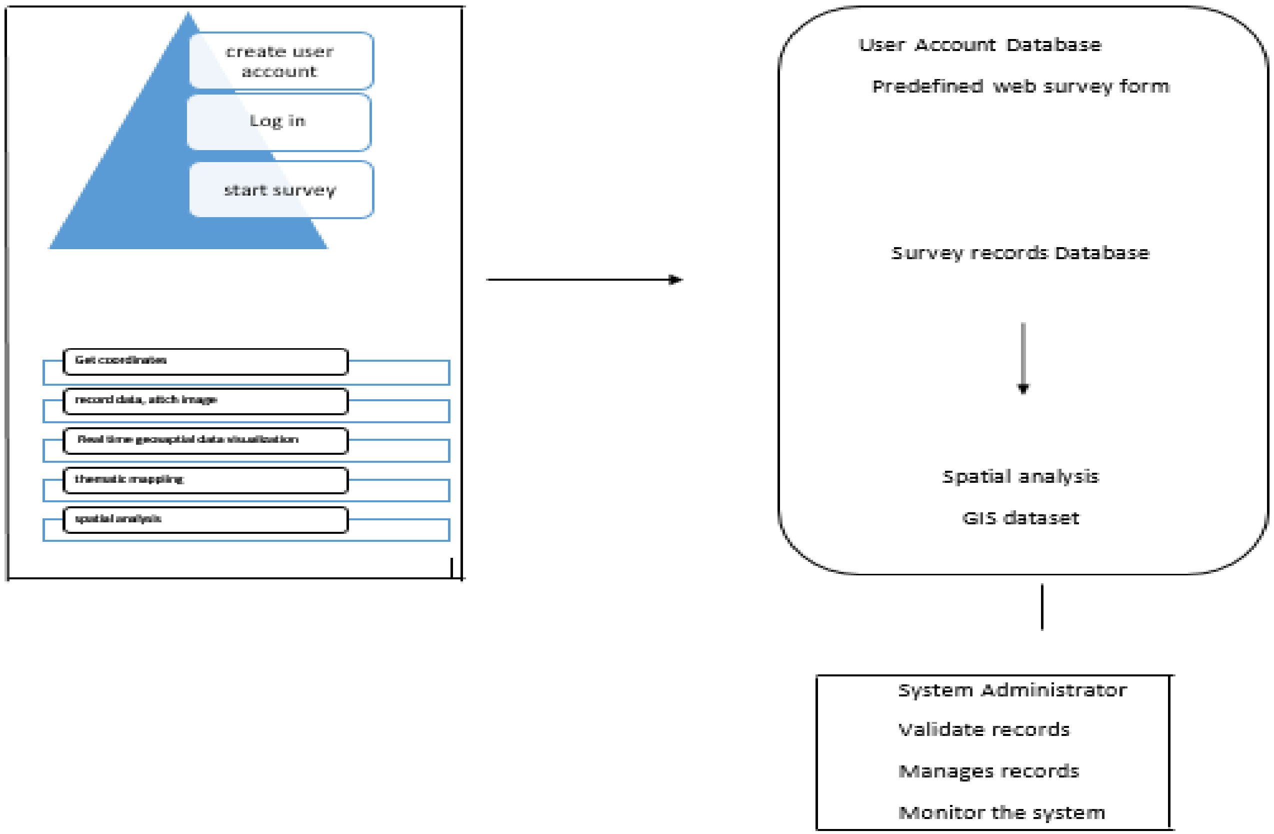


Fig 3.2 Real-time geospatial data collection, processing and Analysis

Data was acquired from satellite imagery and mobile phone application then the data was combined to detect forest change within the study area informed by change activities which have been undertaken causing deforestation.

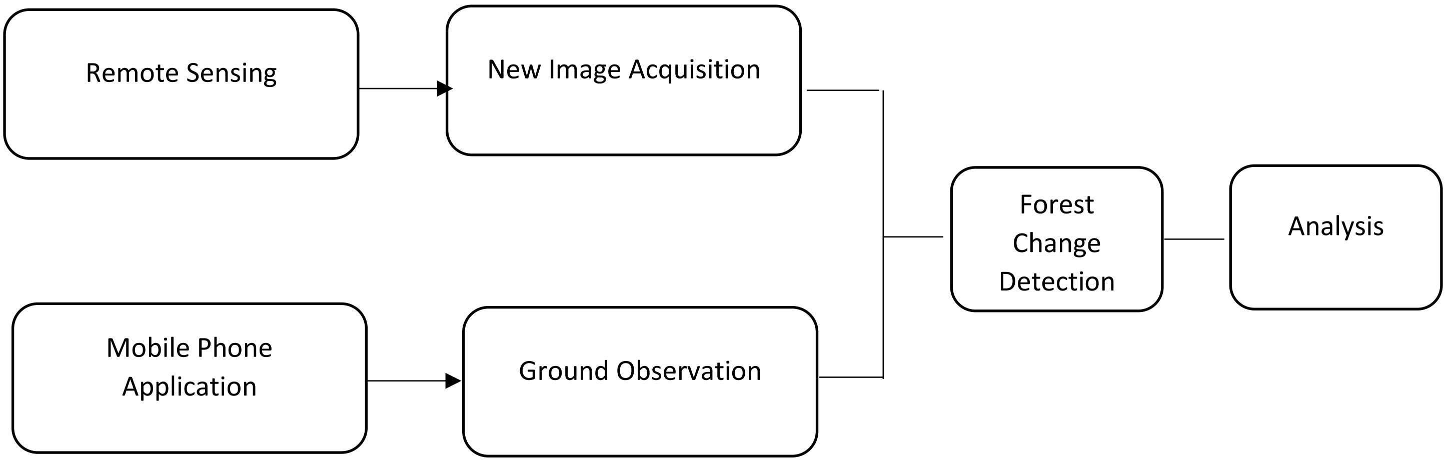


Fig 3.3 Flow chart of applied methodology

Secondary data collection

Base maps for this study area and available land use map of the study area. Main Base map was collected from Forest Information Centre based in Kenya Forest Service. After collection, an overlay analysis was done to understand the relativity of the two- to the delineated area.

3.2 Data Acquisition

3.2.1 Remote sensing

This section outlines the current procedure that is applied by Kenya Forest Service to establish areas of deforestation, it is done using remote sensing imagery as described below:

Data selection criteria

- Sensor_ Landsat collection 1 leve1- Landsat 8 OLI/TIRS C1 Level 1
- Date _ 01/01/2018 to 05/31/2018
- Cloud cover _ Less than 20 %
- Path and Row- 168/ 61

These criteria resulted to two scenes within the area of interest which was prepared for classification. The downloaded scene was processed to deliver an image that is later classified to show forest cover change that occurred within an area.

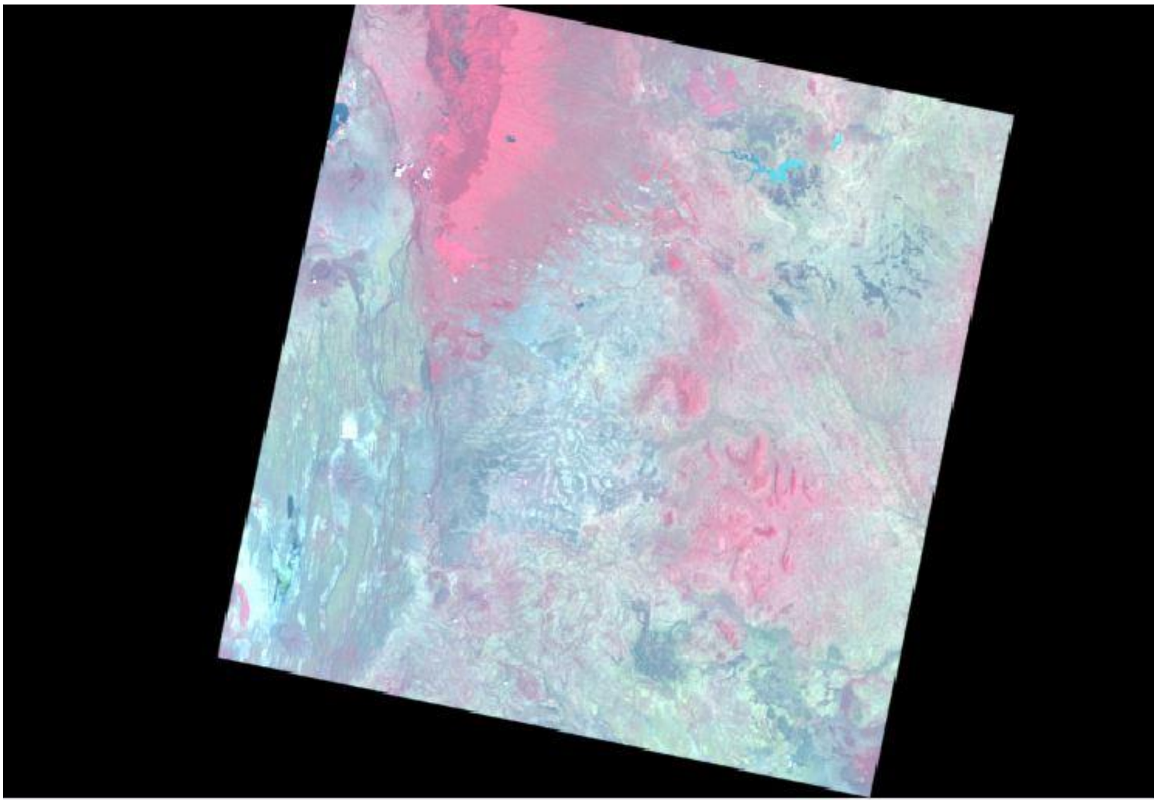


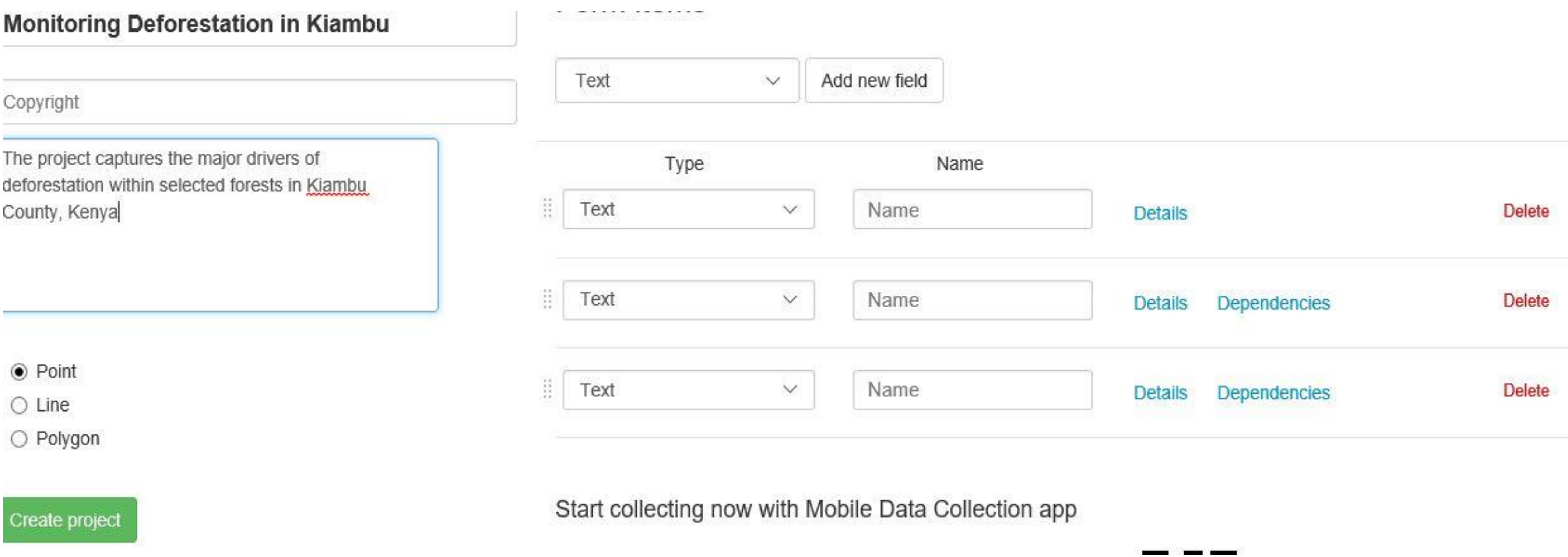
Fig 3.4 Landsat Scene 168061 acquired from https://earthexplorer.usgs.go

3.2.2 Mobile Phone Data Collection

GIS cloud mobile data collection application provides the user with the opportunity to create, upload, author, publish and manage geospatial data, the user can also collect, inspect and manage field data.

The mobile phone application was customized as shown below;

Fig 3.5: Customization of the mobile phone application for project description



The figure below shows an overview of the application;

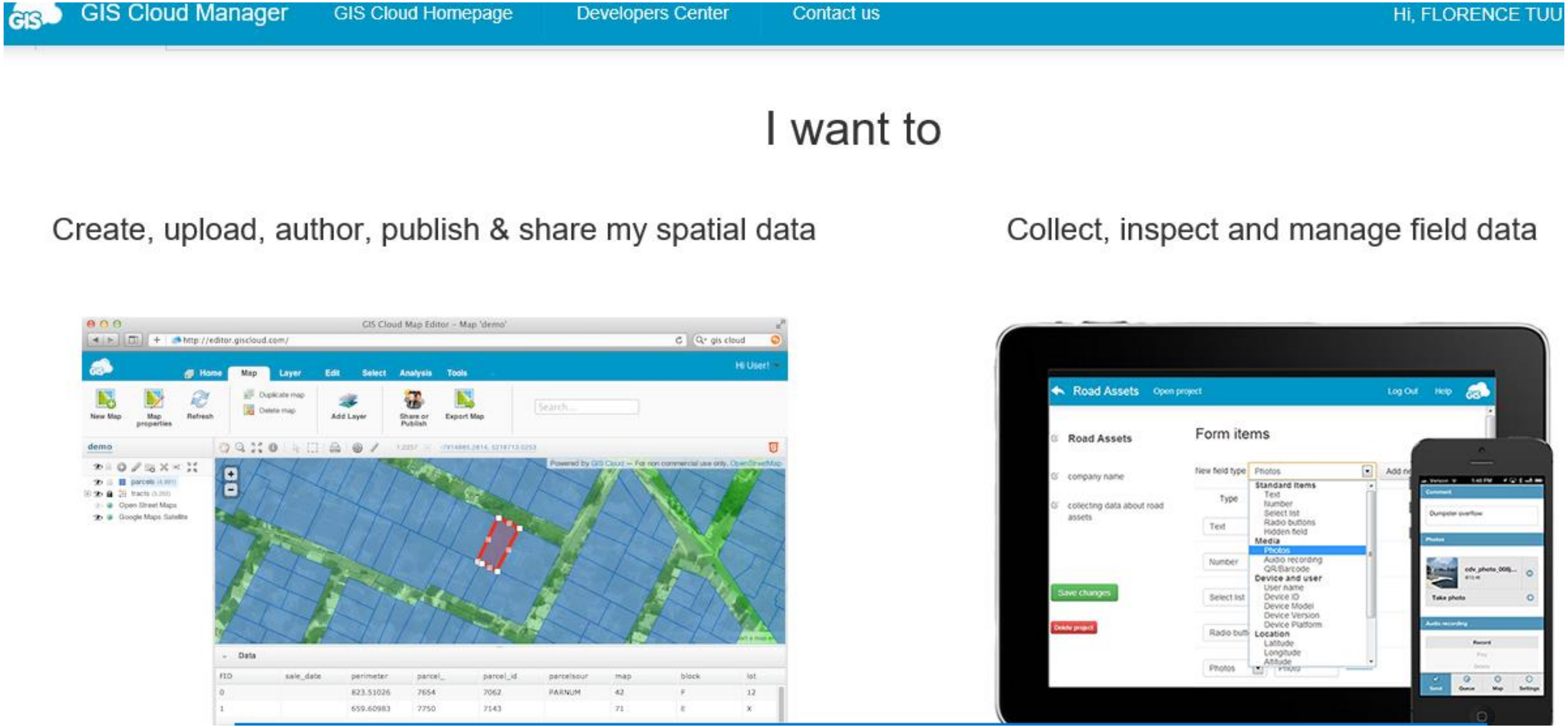


Fig 3.6 Outline of GIS cloud mobile data collection application

After uploading the data into the mobile phone application, the data was queued to be sent later at a place where internet connection was available. The uploaded data

Table 3.1 Data collected in the field using the mobile phone application

Monitoring Deforestation in Kiambu | Map | Data | Share | Report | To CSV

	ID	Conservancy	County	Forest Change /	Forest_Name	Pictures	Username	Longitude	Latitude
lete Edit	4	Central highla...	Kiambu	Logging	Kereita		Florence_Sialo	36.6361	-0.98309
lete Edit	5	Central Highl...	Kiambu	Logging	Kereita		Florence_Sialo	36.644824	0.936271
lete Edit	6	Central Highl...	Kiambu	Overgrazing	Kereita		Florence_Sialo	36.642889	-0.93690
lete Edit	7	Central Highl...	Kiambu	Fuel wood ext...	Kereita		Florence_Sialo	36.642889	-0.93830
lete Edit	8	Central Highl...	Kiambu	Logging	Kereita		Florence_Sialo	36.658309	0.973132
lete Edit	9	Central Highl...	Kiambu	Farming	Kinale		Florence_Sialo	36.614511	-0.92847
lete Edit	10	Central Highl...	Kiambu	Logging	Kinale		Florence_Sialo	36.615286	-0.92829
lete Edit	11	Central Highl...	Kiambu	Infrastructure...	Kinale		Florence_Sialo	36.6152	-0.92668
lete Edit	12	Central Highl...	Kiambu	Farming	Kinale		Florence_Sialo	36.61576	-0.92410
lete Edit	13	Central Highl...	Kiambu	Logging	Kinale		Florence_Sialo	36.616486	-0.92950

tps://mdc.giscloud.com/rest/1/layers/2407579/features/5/pictures/mdc_photo_mdc_30c944_20180628_142346_153098164110

The mobile data collection portal enables data to be downloaded as .csv a format that is usable with ArcGIS.

Table 3.2 Points data collected with the Mobile phone application

Conservancy	County	Forest Name	Latitude	Longitude	Forest Change Activity	Username
Central highlands	Kiambu	Kereita	-0.9831	36.6361	Logging	Florence_Sialo
Central Highlands	Kiambu	Kereita	-0.9369	36.64289	Overgrazing	Florence_Sialo
Central Highlands	Kiambu	Kereita	0.936271	36.64482	Logging	Florence_Sialo
Central Highlands	Kiambu	Kereita	-0.9383	36.64289	Fuel wood extraction	Florence_Sialo
Central Highlands	Kiambu	Kereita	0.973132	36.65831	Logging	Florence_Sialo
Central Highlands	Kiambu	Kinale	-0.92847	36.61451	Farming	Florence_Sialo
Central Highlands	Kiambu	Kinale	-0.9283	36.61529	Logging	Florence_Sialo
Central Highlands	Kiambu	Kinale	-0.92668	36.6152	Infrastructure Development	Florence_Sialo
Central Highlands	Kiambu	Kinale	-0.92411	36.61576	Farming	Florence_Sialo
Central Highlands	Kiambu	Kinale	-0.9295	36.61649	Logging	Florence_Sialo
Central Highlands	Kiambu	Kinale	-1.07323	36.69764	Infrastructure Development	Florence_Sialo

3.3. Data analysis

The total analysis was based on transforming ideas into maps. Temporal acquired dataset was analysed. A short generalization was done for proper planning. After analysing each dataset, the results were compared to evaluate the study findings. A detailed assessment of agents of deforestation was carried out followed by integration of several techniques identified the critical change areas.

Table 3.3. Sum of Frequency of Forest Change Activity Occurrences

	Sum of Frequency in Forest			
Forest Change Activity	**Kereita**	**Kinale**	**Uplands**	**Grand Total**
agriculture		**1**		**1**
Charcoal burning		**1**		**1**
Farming		**2**	**2**	**4**
Forest fires			**1**	**1**
Fuel wood extraction	**1**			**1**
Infrastructural development	**1**	**3**	**2**	**6**
Logging	**1**	**5**	**3**	**9**
Overgrazing	**1**	**1**		**2**
Grand Total	**4**	**13**	**8**	**25**

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 RESULTS

The anticipation of this study was that mobile devices would be useful in detecting and visualizing deforestation to aid Kenya Forest Service in effecting monitoring activities within Kiambu Forest and all forests within its mandate hence improve conservation and curb the current rate of deforestation. It was also expected that use the mobile phone application would provide an alternative method of ground truthing for satellite imagery including how to relay the data acquired to the headquarters while awareness of the surrounding community on their responsibility in forest conservation through Community Forest Associations would be achieved.

Photographs taken at the study area

Plate 4.1.1: Infrastructural development (Kinale) Year 2018

Plate 4.1.2: Tree harvesting for Charcoal extraction (Kereita) Year 2018

Plate 4.1.3: Farming (Kinale) Year 2018

Plate 4.1.4: Farming (Kinale) Year 2018

Plate 4.1. 5: Logging (Kereita) Year 2018

Plate 4.1.6: Logging (Uplands) Year 2018

Plate 4.1.7: Grazing (Kereita) Year 2018

Maps of different years

The procedure here involved uploading the point data i.e. XY data into ArcGIS to visualize the exact location of forest change activities on the ground as such., basic guidelines were adhered to for instance ensuring that both X and Y fields were appropriately configured also ensuring the correct coordinate system was selected.

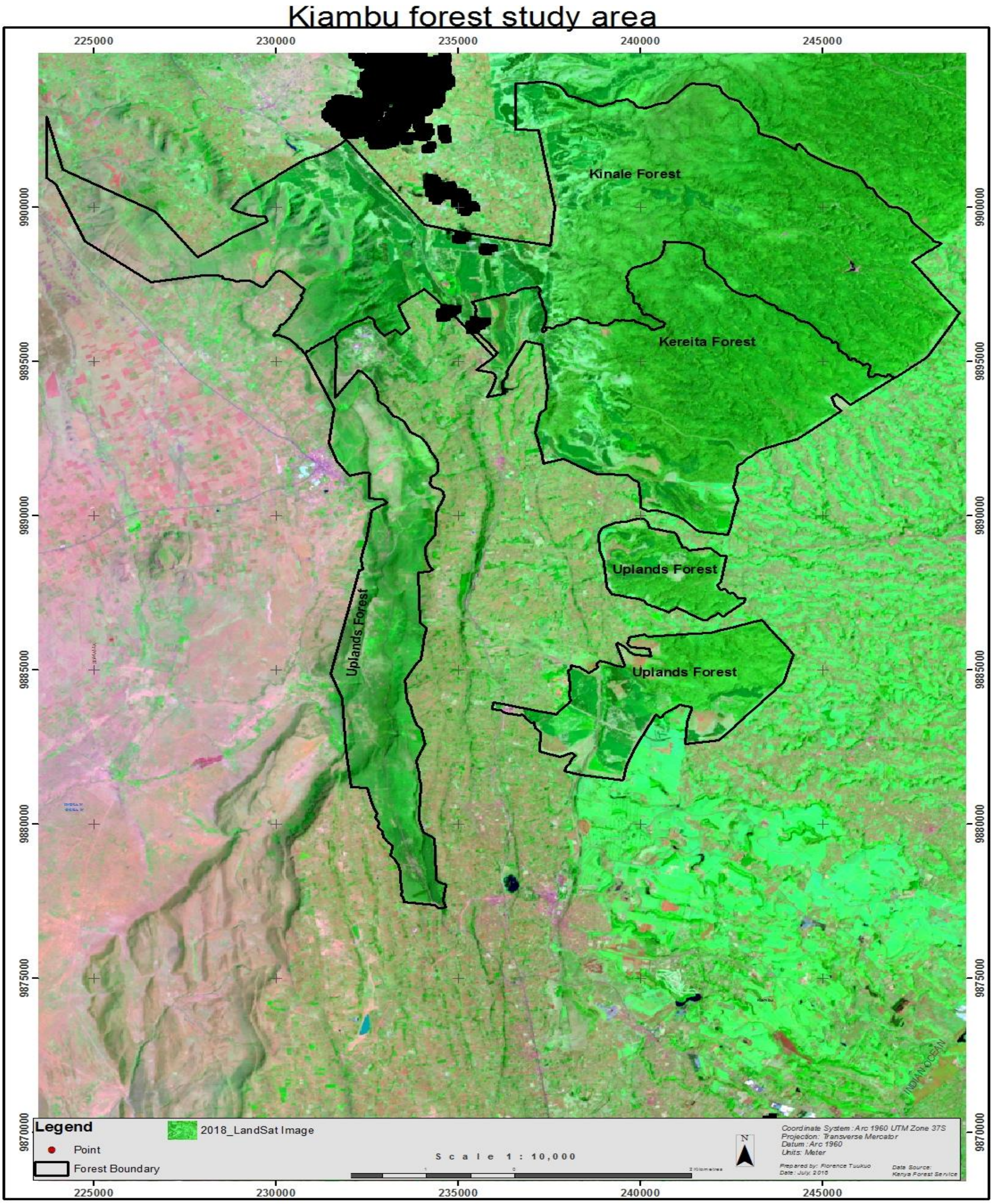


Fig 4.1 Map of the study area

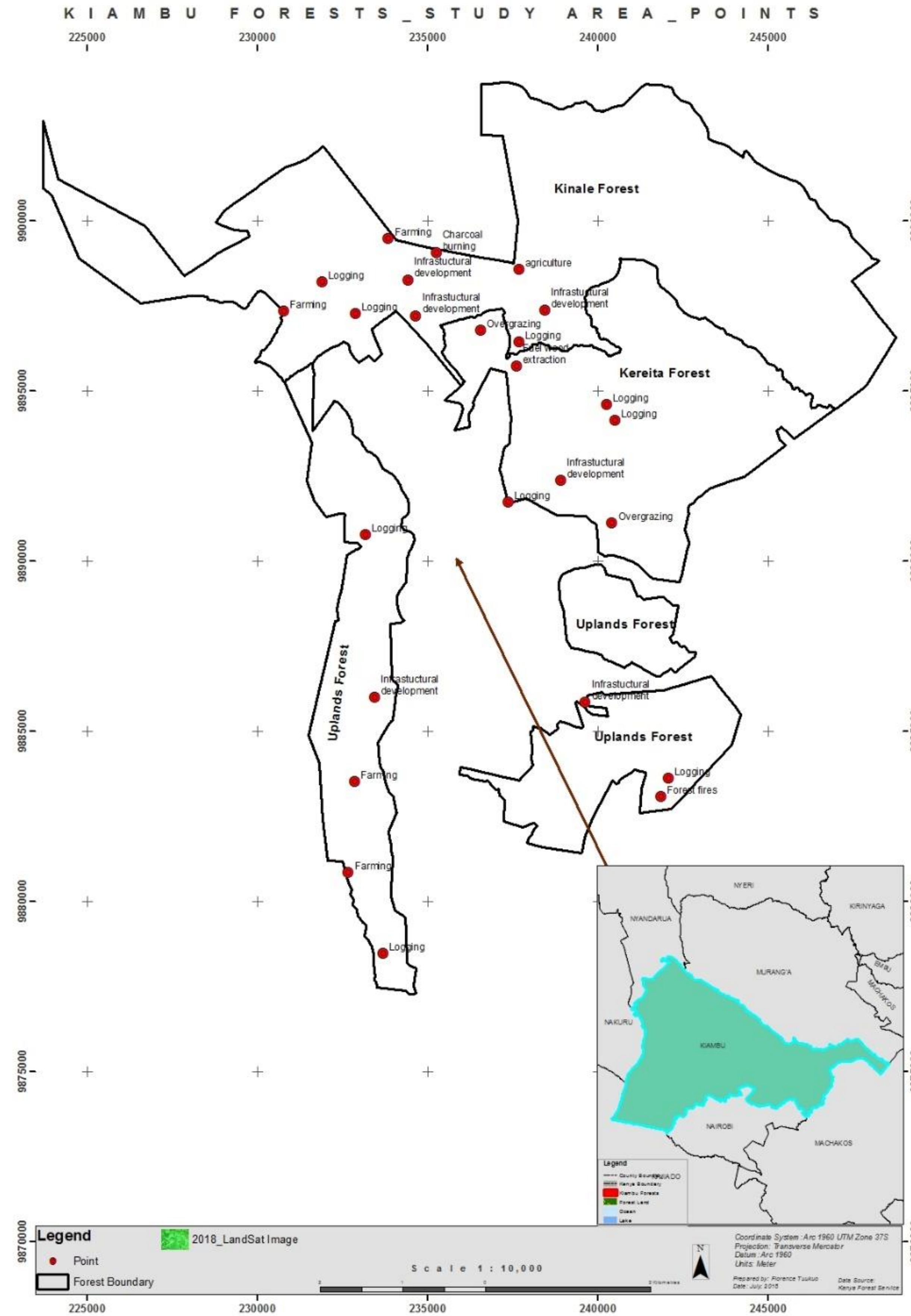


Fig 4.2 Map of the collected points

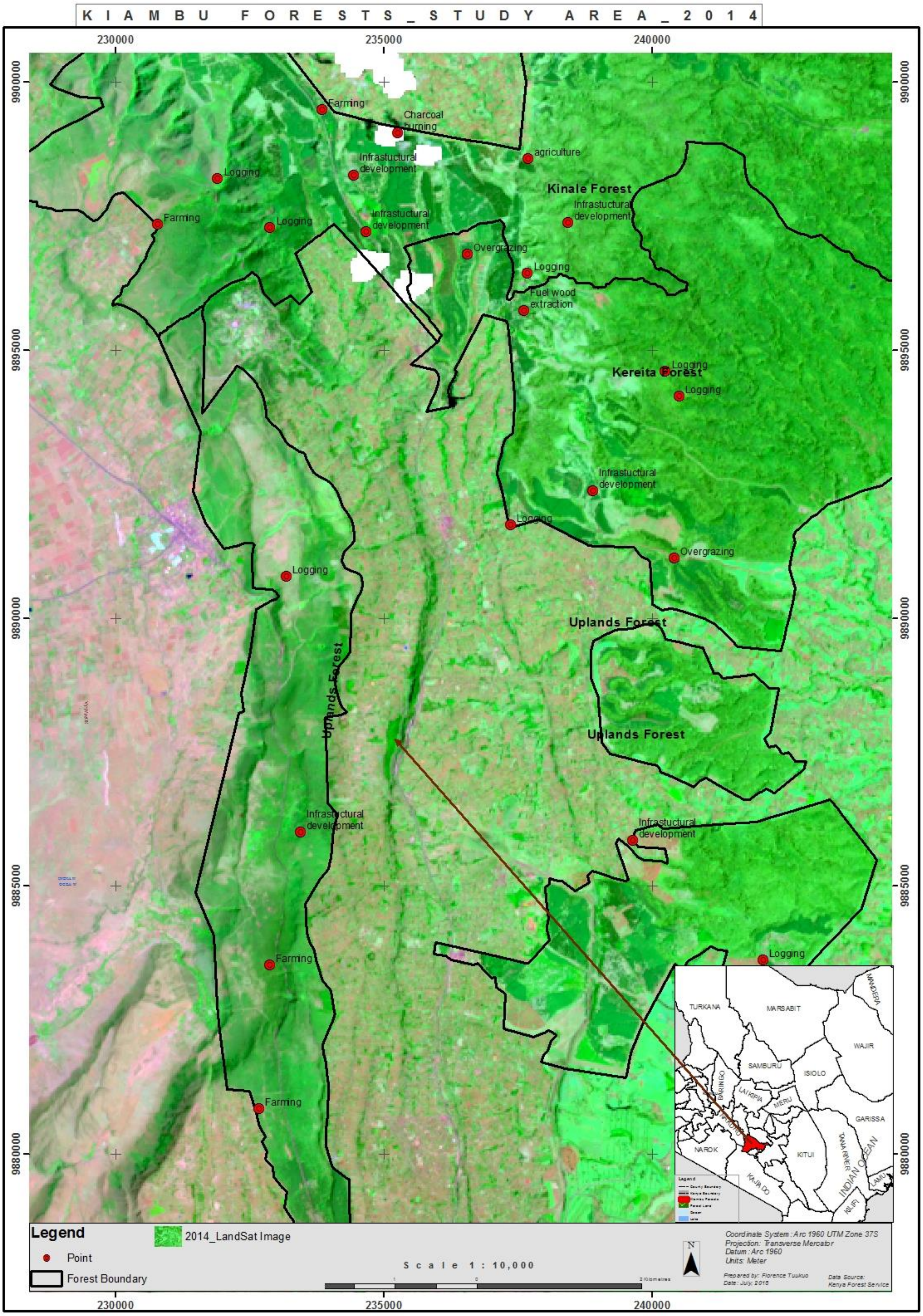


Fig 4.3 2014 image of the study area

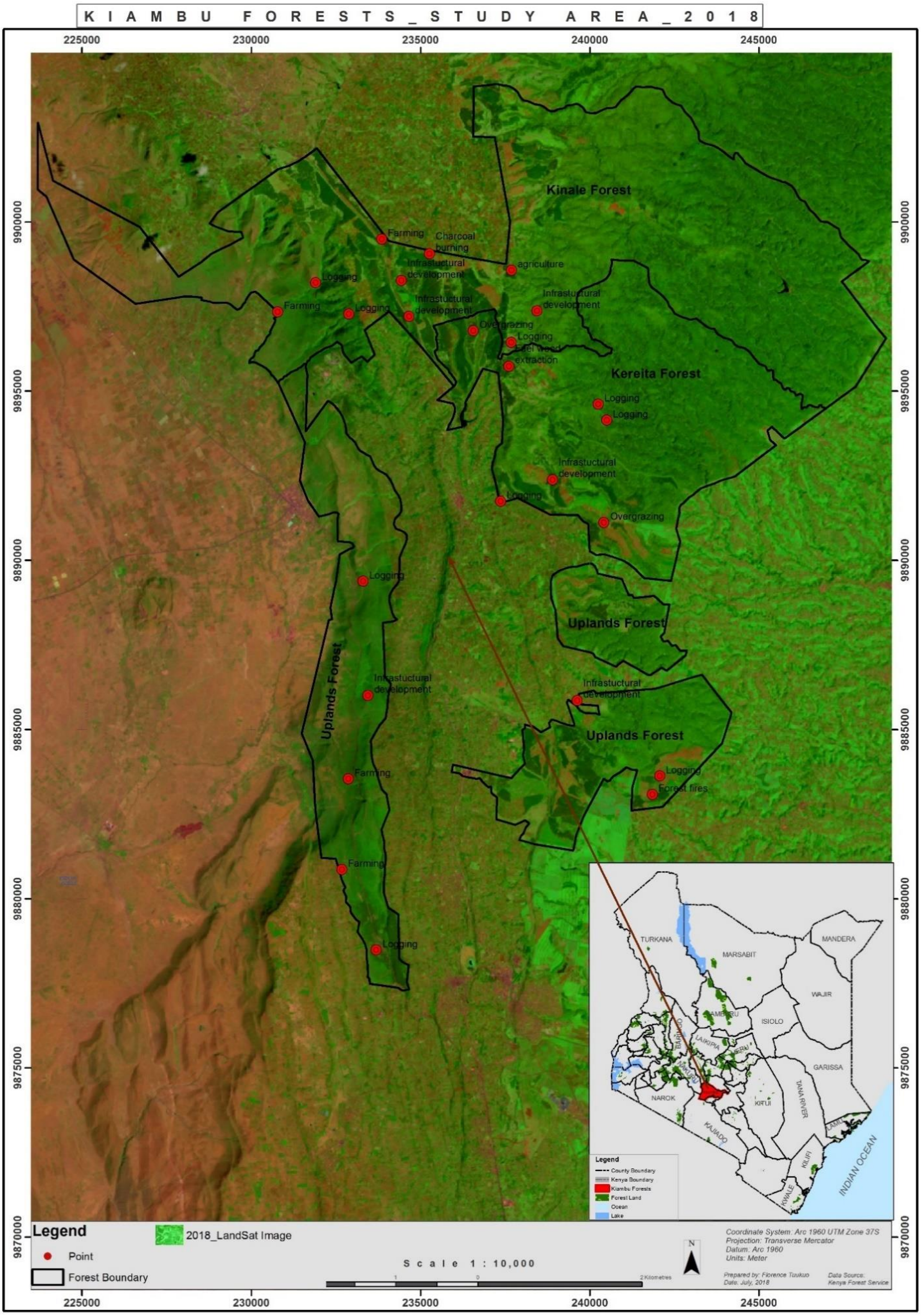


Fig 4.4 2018 image of the study area

4.2 DISCUSSION

A Landsat image of the year 2014 was obtained from the Information Centre at Kenya Forest Service which was overlaid with the points collected on the ground at the area of study, from the image, the forest cover was higher as compared to the 2018 Landsat Image acquired from USGS website as comparison of the two images was carried out.

The objectives of this research were: to provide a platform by identification of nature and extent of deforestation which can be used by Kenya Forest Service to acquire up to date information in Kiambu county, to test and validate mobile application as an efficient and fast method for monitoring deforestation, to assess activities within the forest that lead to deforestation i.e. drivers of deforestation and to determine the usability of mobile application in assessing and monitoring deforestation.

From the results shown above, the objectives were achieved and the mobile phone application can used as a fast and cheap means of ground truthing because it is effective and efficient as demonstrated in this research. On drivers of deforestation, logging is the major forest change activity within the study area hence the Kenya Forest service should barn the activities or control it if deforestation rates are to be reduced. Kinale forest within Kiambu was the most affected by deforestation where logging is dominant, hence the forestry sector can be able to deploy more rangers in this specific forest to overcome or reduce the rates of forest cover reduction.

The mobile phone application used in this research was very efficient as data was relayed directly to the mobile data collection portal which is accessed from a computer, this application is better as compared to other applications in which data has to be downloaded using a USB cable while this application queues data which is sent conveniently when internet connection is available. Another appealing feature of GIS cloud mobile phone data collection application is that a user can upload data even without major knowledge in forestry hence the community surrounding the forests can participate in mapping forest changes as and when they occur in our forests. The mobile phone application is usable in assessing causes of deforestation within the study area and the user is able to validate data in real-time which reduces errors and improves communication protocols.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Forestry is facing overwhelming threats due to natural resource depletion, soil erosion, forest degradation, habitat degradation, water imbalance, unbalanced human interference and illegal poaching. Notably, deforestation has led to reduction of forest cover in Kenya, this can be attributed to the fact that a system to provide up to date information on the accurate rates of deforestation and forest cover change is not expensive and takes a lot of time to analyse data. This research sought to provide a way out for the forestry sector to acquire up-to-date information on reduction of forest cover.

The research was able to achieve the objectives by testing and validating it in the area of study whereby data was collected efficiently guided by forest change activity occurrence, the major drivers of deforestation were identified such as logging, infrastructural development, forest fires, charcoal and wood fuel extraction. This approach of mapping and assessing forest cover change would be appropriate for the forestry sector.

5.2 RECOMMENDATIONS

This research was carried out comprehensively and from the results obtained, the following recommendations were drawn;

I. Deforestation is a major threat to forest reduction in Kiambu county with the major driver being logging, it reduces forest cover slowly but gradually leads hence the drivers identified in this research are common for degradation.

II. The forestry sector should adopt the methodology of this research if forest cover reduction is to be attained in line with the constitution of 2010 and Vision 2030 since the approach is efficient and fast to use.

III. The mobile phone application used in this research is useful for the assessing changes in forest cover, forest sector stakeholders should determine the most appropriate method to curb reduction of forest cover this could include identifying a lead agency to be in charge of assessing such changes in forest cover

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APPENDICES

Appendix A: Forest Inventory Form

WOODLAND MANAGEMENT PLAN BIO-PHYSICAL DATA COLLECTION FORM			
			DATE. …………………………
A. PLOT INFORMATION			
PLOT No:			
GPS Coordinates: **Northings : Y** ___________________		**Eastings: X**___________________________	
1. County _________________________		Sub-County___________________	
Location ____________________		Village ___________________	
2. For slope tick appropriately			
Flat (0-10%)	Gentle(11-30%)	Steep (30-50%)	Very Steep (50>%)

3. Disturbances (tick where appropriate)

Damage	Severity	Description	tick
Erosion	No	No evidence of erosion	
	Light Erosion	Slight erosion where only surface erosion has take place	
	Heavy Erosion	Areas which have deep gullies, ravines, land slips etc	
Grazing	No Grazing	There is no evidence of grazing	
	Medium Grazing	Indicator of dung for cows abd browsers	
	High Grazing	Indicator of dung for cows abd browsers including livestock trails frequently used	
	Over-grazing	Complete loss of both herbaceous and shrubs in the plot	
Human Impact	No Impact	No cutting or other impact	
	Clear Felling	Removal of all trees has been carried out	1-5 years ☐ 5+ years ☐
	Silvicultural treatment	e.g prunning , planting, climber, weeding, boundary clearing, fire line construction	1-5 years ☐ 5+ years ☐
	Burning		1-5 years ☐ 5+ years ☐
	Charcoal Production		1-5 years ☐ 5+ years ☐
	Extraction of Medicinal herbs	Collecting of medicinal plants used in traditional medicine and/or for pharmaceutical companies	1-5 years ☐ 5+ years ☐
	Mining, sand collection	Mining and Land extraction activities	1-5 years ☐ 5+ years ☐
Others(specify)			

Appendix B: Activity Monitoring Form

Activity Monitoring Form					
FIELD NOTE for Remote Sensing Analysis					
No.	:	001	Date	:	
			Surveyor	:	
Category No.	:		UTM(X)/Lat	:	
			UTM(Y)/Long	:	
County	:		Elevation	:	
			Remark	:	
1. Forest land			Comments		
Type	:				
Height	:				
Density(Crown	:				
Remark	:				
2. Non-Forest Land					
Land use	:				
Remark	:				
Photo					
North :			South:		
East:			West:		

Appendix C. Forest Activity change data

	Conservancy	County	Forest Change Activity	Longitude	Latitude	Forest_Name	Username	
1	Central Highlands	Kiambu	Infrastructural Development	36.66041	-1.03186	Uplands	Florence_Sialo	
2	Central highlands	Kiambu	Logging	36.6361	-0.9831	Kereita	Florence_Sialo	
3	Central Highlands	Kiambu	Overgrazing	36.64289	-0.9369	Kereita	Florence_Sialo	
4	Central Highlands	Kiambu	Logging	36.64482	0.936271	Kereita	Florence_Sialo	
5	Central Highlands	Kiambu	Fuel wood extraction	36.64289	-0.9383	Kereita	Florence_Sialo	
6	Central Highlands	Kiambu	Logging	36.65831	0.973132	Kereita	Florence_Sialo	
7	Central Highlands	Kiambu	Grazing	36.56021	-0.9801	Kereita	Florence_Sialo	
8	Central Highlands	Kiambu	Tree Harvesting	36.6361	-0.9831	Kereita	Florence_Sialo	
9	Central Highlands	Kiambu	Logging	36.66838	-0.95698	Kereita	Florence_Sialo	
10	Central Highlands	Kiambu	Logging	36.65098	-0.93548	Kereita	Florence_Sialo	
11	Central Highlands	Kiambu	Infrastructure	36.65136	-0.92985	Kereita	Florence_Sialo	
12	Central Highlands	Kiambu	Logging	36.66612	-0.95272	Kinale	Florence_Sialo	
13	Central Highlands	Kiambu	Infrastuctural development	36.65398	-0.97291	Kinale	Florence_Sialo	
14	Central Highlands	Kiambu C(	Over grazing	36.6676	-0.98431	Kinale	Florence_Sialo	
15	Central Highlands	Kiambu	agriculture	36.6172	-0.91843	Kinale	Florence_Sialo	
16	Central Highlands	Kiambu	Farming	36.61451	-0.92847	Kinale	Florence_Sialo	
17	Central Highlands	Kiambu	Logging	36.61529	-0.9283	Kinale	Florence_Sialo	
18	Central Highlands	Kiambu	Infrastructural Development	36.6152	-0.92668	Kinale	Florence_Sialo	
19	Central Highlands	Kiambu	Infrastructure	36.61769	-0.91868	Kinale	Florence_Sialo	
20	Central Highlands	Kiambu	Charcoal burning	36.62769	-0.91189	Kinale	Florence_Sialo	
21	Central Highlands	Kiambu	Logging	36.59118	-0.92022	Kinale	Florence_Sialo	
22	Central Highlands	Kiambu	Farming	36.58012	-0.92817	Kinale	Florence_Sialo	
23	Central Highlands	Kiambu	Grazing	36.56021	-0.9801	Kinale	Florence_Sialo	
24	Central Highlands	Kiambu	Forest fire	36.66071	-1.08681	Uplands	florencetuukuo@gmail.com	
25	Central Highlands	Kiambu	Infrastuctural Development	36.6604	-1.03186	Uplands	Florence_Sialo	
26	Central Highlands	Kiambu	Charcoal extraction	36.6975	-1.07524	Uplands	Florence_Sialo	
27	Central Highlands	Kiambu	Forest fires	36.6851	-1.05334	Uplands	Florence_Sialo	
28	Central Highlands	Kiambu	Logging	36.6824	-1.05206	Uplands	Florence_Sialo	

THE BEST TECHNOLOGY IS OFTEN THE ONE WE ALREADY HAVE, KNOW HOW TO USE, CAN MAINTAIN AND CAN AFFORD.