EVALUATION OF URBAN EXPANSION AND ITS IMPLICATIONS ON LAND USE IN KIAMBU COUNTY, KENYA

BARBARA ESTHER NJIRU
REG NO C50/21485/2012

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF DEGREE OF MASTERS OF ARTS IN URBAN AND REGIONAL PLANNING IN THE SCHOOL OF HUMANITIES AND SOCIAL SCIENCES OF KENYATTA UNIVERSITY.

JUNE 2016
DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

Signature_________________________ Date____________________

Name: Barbara Esther Njiru
C50/21485/2012

Supervisors:
This thesis has been submitted for review with our approval as University supervisors.

Dr. Shadrack Murimi
Department Geography

Signature_________________________ Date____________________

Dr. Philomena Muiruri
Department of Geography

Signature_________________________ Date____________________
DEDICATION

To my father, Mr. Josphat Njiru and mother Mrs Justa Njiru and all my siblings for their continuous support throughout my studies.
ACKNOWLEDGEMENT

My gratitude goes to God Almighty for how far He has brought me. My profound gratitude goes to my supervisors, Dr. Shadrack Murimi and Dr. Philomena Muiruri for their tireless efforts, guidance, and support. My sincere thanks to Madam Belta Makato for her immense contribution towards realization of remote sensing and GIS procedures.

I also extend my sincere gratitude to AMS Properties Limited, the Estate manager at Four ways Junction, Migaa Estate, Edenville and Mr Chris Barron of Tatu City. The planning office at Kiambu sub-county, the Kiambu sub-county lands office and the Kiambu sub-county agriculture office.

My appreciation to my classmates: Charity Kageni, Ann Karonji, Jasper Kebati, and John Mathenge for being such an awesome team to work with and live among. Not forgetting also all the Staff of Department of Geography, Kenyatta University.

Finally, I want to express my special gratitude to my close friends Stella Munanie, George Barasa, and Martin Gitonga for their support and contributions. To those I have not mentioned by name, I value your support and reiterate my appreciation for your contributions.
TABLE OF CONTENT

DECLARATION ....................................................................................................................... i
DEDICATION ........................................................................................................................... ii
ACKNOWLEDGEMENT ........................................................................................................ iii
TABLE OF CONTENT ........................................................................................................ iv
LIST OF FIGURES ............................................................................................................. viii
LIST OF TABLES ................................................................................................................ x
LIST OF PLATES ................................................................................................................ xi
LIST OF APPENDICES ....................................................................................................... xii
ABBREVIATIONS AND ACRONYMS ................................................................................ xiii
OPERATIONAL DEFINITION OF TERMS AND CONCEPTS ............................................. xiv
ABSTRACT ........................................................................................................................... xv
CHAPTER ONE ................................................................................................................... 1
  1.1 Background to the study .............................................................................................. 1
  1.2 Statement of the problem ........................................................................................... 4
  1.3 General objective ....................................................................................................... 5
  1.4 Research questions ................................................................................................... 5
  1.5 Justification and significance of the study ................................................................. 5
  1.6 Scope and limitation of the study ............................................................................. 7
CHAPTER TWO ................................................................................................................... 8
LITERATURE REVIEW ....................................................................................................... 8
  2.1 Introduction ................................................................................................................ 8
  2.2 Global trends of urbanization, urban sprawl and expansion ...................................... 8
  2.2.1 Urbanization, urban sprawl and expansion trends in Kenya ............................... 10
  2.3 Urbanization and urban sprawl ............................................................................... 12
  2.4 Urbanization and peri-urban agriculture in Kenya .................................................... 13
  2.5 Effects of urban sprawl on agricultural activities ..................................................... 14
  2.6 Factors influencing land use changes in peri-urban areas ........................................ 16
2.7 Overview of land use planning response to urbanization ................................. 18
2.8.1 Land use planning in Kenya ........................................................................... 19
2.9 Application of remote sensing and GIS in urban planning .............................. 21
2.10 Conceptual framework ................................................................................. 23
2.11 Theories of urban growth and urban land use ............................................. 24
2.11.1 Bid-Rent theory ......................................................................................... 24

CHAPTER THREE ........................................................................................................... 28

METHODOLOGY .......................................................................................................... 28

3.1 Introduction ........................................................................................................ 28
3.2 Description of the Study Area ......................................................................... 28
3.2.1 Location and size ....................................................................................... 28
3.2.2 Climate ........................................................................................................ 28
3.2.3 Geology and soils ...................................................................................... 29
3.2.4 Population size and distribution .................................................................. 29
3.2.5 Socio-economic activities ......................................................................... 32
3.2.6 Land use and land cover ............................................................................ 32
3.3 Research design ............................................................................................... 32
3.3.1 Sampling methods and techniques ............................................................. 33
3.3.2 Site reconnaissance .................................................................................... 33
3.4 Data collection and techniques ....................................................................... 34
3.4.1 Source and types of data ........................................................................... 34
3.5 Land use/cover classification ......................................................................... 36
3.5.1 Image pre-processing ................................................................................ 36
3.5.2 Image classification ................................................................................... 37
3.5.3 Training data acquisition ........................................................................... 38
3.5.4 Accuracy assessment ................................................................................ 39
3.5.5 Change detection analysis ........................................................................ 41
3.6 Data analysis ..................................................................................................... 41
3.7 Ethical considerations ....................................................................................... 41
CHAPTER FOUR .............................................................................................................. 43
RESULTS AND DISCUSSION ......................................................................................... 43

4.1 Introduction .............................................................................................................. 43
4.2 Land use and land cover change between 1986 and 2014 ...................................... 43
4.3 Location of change in built-up land ........................................................................ 52
4.4 Change detection analysis ...................................................................................... 54
4.5 Factors contributing to declining agricultural land .................................................. 62
  4.5.1 Population growth .............................................................................................. 64
  4.5.2 Demand for real estate ...................................................................................... 65
  4.5.3 Low producer prices ........................................................................................ 66
  4.5.4 Proximity to major urban centres ....................................................................... 67
  4.5.5 Access to improved infrastructure ..................................................................... 68
  4.5.6 High costs of inputs .......................................................................................... 69
  4.5.7 Lack of organized marketing structures .............................................................. 70
  4.5.8 Lack of public participation ................................................................................. 71
4.6 Implications of changing land uses in Kiambu County ............................................ 72
  4.6.1 Declining agricultural production ..................................................................... 73
  4.6.2 Loss and creation of employment ....................................................................... 79
  4.6.3 Increasing land values and housing costs ............................................................ 81
  4.6.4 Uncontrolled developments .............................................................................. 84
  4.6.5 Pressure on existing infrastructure ..................................................................... 86
  4.6.6 Changing social interaction .............................................................................. 86
  4.6.7 Provision of houses ............................................................................................ 88
4.7 Perception towards land use/cover change .............................................................. 89
4.8 Measures taken to mitigate the effects of land-use and land cover changes ............. 90
CHAPTER FIVE ......................................................................................................................... 97
SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS ........... 97

5.1 Introduction ....................................................................................................................... 97
5.2 Study objectives and methodology ................................................................................. 97
5.3 Summary of key findings ................................................................................................. 98
5.4 Conclusion ........................................................................................................................ 99
5.5 Recommendations ......................................................................................................... 101
5.6 Further research ............................................................................................................ 103

REFERENCES .................................................................................................................. 105

LIST OF APPENDICES ................................................................................................. 114
Figure 4.20: Zoning map of Kiambaa Sub County ................................................................. 95

Figure 4.21: Zoning map of Kiambu Municipality Sub County ........................................... 96
LIST OF TABLES

Table 2.1: Percentage of African Population Residing in Urban Areas by Region ............... 10
Table 2.2: Nairobi versus Kenya Population size trends .............................................. 11
Table 3.1: Population Projections by Urban Centres .................................................. 30
Table 3.2 Characteristics of satellite images ............................................................... 35
Table 3.3: Land use land cover classification scheme .................................................... 38
Table 3.4: Producer's and User's accuracy for individual land-use/land-cover classes ........................................... 40
Table 3.5: Overall accuracy and Kappa (K^) statistics for the classifications .................... 40
Table 4.1: Land-use/land-cover for years 1986, 2002 and 2014 .................................... 43
Table 4.2: From-to area change matrix (ha) from 1986 to 2002 .................................... 55
Table 4.3: From-to area change matrix (ha) from 2002 to 2014 .................................... 57
Table 4.4: From-to area change matrix between 1986 and 2014 .................................... 59
Table 4.5: Land-use/Land-cover class conversion to Built-up area in hectares .................. 62
Table 4.6: Population trend 1989-2009 ........................................................................ 65
LIST OF PLATES

Plate 4.1: A neglected coffee farm ........................................................................................................... 71
Plate 4.2: Creation of Jobs .......................................................................................................................... 80
  a) Flower vases on sale along Kiambu road .............................................................................................. 80
  b) Bodaboda business that offers transportation service to Edenville estate ................................. 81
Plate 4.4: Houses built in coffee and maize farms ...................................................................................... 85
LIST OF APPENDICES

Appendix 1: Proposed Land uses in Nairobi Metropolitan Region .......................... 114
Appendix 2: Summary of Some Literature reviewed and gaps identified .................. 114
Appendix 3: Semi-structured interview guide for Landowners ................................. 115
Appendix 4: Semi-structured interview guide for Institutions Survey ..................... 116
Appendix 5: Semi-structured interview guide for Institutions Survey ..................... 117
Appendix 6: Semi-structured interview guide for Real Estate Developers ............... 118
### Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBD</td>
<td>Central Business District</td>
</tr>
<tr>
<td>ETM</td>
<td>Enhanced Thematic Mapper Plus</td>
</tr>
<tr>
<td>FCC</td>
<td>False Colour Composite</td>
</tr>
<tr>
<td>GCP</td>
<td>Ground Control Points</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Position System</td>
</tr>
<tr>
<td>Ha</td>
<td>Hectares</td>
</tr>
<tr>
<td>KNBS</td>
<td>Kenya National Bureau of Statistics</td>
</tr>
<tr>
<td>LUCC</td>
<td>Land Use /Cover Change</td>
</tr>
<tr>
<td>MLC</td>
<td>Maximum Likelihood Classifier</td>
</tr>
<tr>
<td>MSS</td>
<td>Multi spectral Scanner</td>
</tr>
<tr>
<td>NMR</td>
<td>Nairobi Metropolitan Region</td>
</tr>
<tr>
<td>RS</td>
<td>Remote Sensing</td>
</tr>
<tr>
<td>RUF</td>
<td>Rural-Urban Fringe</td>
</tr>
<tr>
<td>TM</td>
<td>Thematic Mapper</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>WGS</td>
<td>World Geodetic System</td>
</tr>
</tbody>
</table>
OPERATIONAL DEFINITION OF TERMS AND CONCEPTS

**Agricultural land**: refers to land suitable for agricultural production of both crops and livestock. In this study, it is limited to cropland or cultivable land.

**Geographic Information System**: a computer aided system, designed and assembled to capture, store, manipulate, analyse, manage, and present many types of geospatially-referenced data. GIS gives positional information pertaining to physical features for informed decision-making and for users to create interactive queries in order to analyse spatial information apply GIS tools and applications.

**Land use**: purposes for which humans exploit the land resources that involves the management and modification of natural environment.

**Land use conversion**: this refers to change in the overall classification of land cover through a complete replacement of one type of land cover by another type due to change in urban extent.

**Land use planning**: a process that is concerned with the preparation and actualization of spatial framework for orderly management of human activities.

**Peri-urban**: refers to the non-urban areas close to the cities and towns also referred to as rural-urban fringe, urban hinterland, or as the transition zone where urban and rural land uses mix and often clash.

**Remote sensing**: a process that involves the detection and measurement of radiation of different wavelengths reflected or emitted from distant objects or materials, which are identified and categorized by class/type, substance, and spatial distribution.

**Urbanization**: process driven by market forces and governmental policies that lead to simultaneous processes of change in livelihoods, land use, health and natural resources management.

**Urban expansion**: refers to the extension of urban landscapes to the surrounding areas mainly, peri-urban area resulting in the loss of agricultural lands, and natural beauty.

**Zoning**: a method of land use control employed by local governments that imposes different land use controls in each zone.

**Urban sprawl**: refers to expansion of urban area to agricultural land caused by high population growth and rural urban migration.
ABSTRACT

Rapid urban population growth has led to not only an increasing demand for more land, more so for residential use. This land is not available within the city but at the peri-urban areas where parcels of fertile agricultural land are being converted into residential use at an alarming rate. This is because of the expanding urban area to its urban fringes that is accompanied by an increasing demand for land to accommodate the increasing urban developments. The specific objectives of the research were to, 1) investigate the dynamics of rural land lost to urban land uses in Kiambu County from 1986 to 2014. 2) assess the effects of urban land use changes on agricultural land use in Kiambu County and lastly, 3) to investigate the urban planning and management response to land use changes in northern area of Nairobi. Remote sensed data on land use/land cover change for the period of 1986-2014 together with any historical information and archived reference data used to compute spatial/temporal changes in the expansion of urban settlement and extent of land use/land cover changes. Change detection analysis was performed through GIS overlay operations. The study revealed a significant change of land-use/cover between 1986 and 2014 with the area experiencing rapid increase in urbanization (41.6%), Forest decreased by (10.3%), and a decrease in bare land (1.8%), water (0.22%) and agricultural area (29.3%). Agricultural land in a period of 28 years is losing rapidly to urbanization with the results indicating that 61.5 % of agricultural land converted to built-up land. Declining agricultural land, loss and creation of employment, changing social interaction and lifestyles, increasing land values and housing costs were some of the effects of rural land transformation. The measures put forward to control the rapid land use conversions included zoning for the various land uses. Findings provide a useful support for land-use planning and management. In addition, the results provide necessary inputs to decision makers that should balance trade-offs between the positive benefits of land-use change and potentially negative unintended consequences. The study calls for a combined approach, which involves participation of all the stakeholders in management and planning of land as a vital resource. This approach will protect the endangered land use, agricultural land, as well as controlling urban developments. Based on these results and some observations made in the study area, the study therefore recommends that, stakeholder participation should be given first priority in land use planning and management process, and a cost benefit analysis of land use conversions.
CHAPTER ONE

INTRODUCTION

1.1 Background to the study

In the last few decades, substantial growth of urban areas has occurred worldwide with population increase being one of the most obvious agents responsible for this growth (Araya and Cabral, 2010). The world urban population has increased from 0.73 billion in 1950; 1.51 billion in 1975 to 3.42 billion people in 2009, and is projected to double (6.29 billion) by 2050 (UNDESA, 2010). In Africa, the urban population is projected to be more than double its 2007 level of 373.4 million by 2030, and by 2050, there will be more than 1.2 billion African city dwellers (UN-HABITAT, 2008). Nairobi being Kenya’s principal economic and cultural centre is one of the largest and fastest growing cities in Africa. It has experienced a rapid growth over the last 40-year (Omwenga, 2008), in terms of population and spatial extent: In 1934, Nairobi was upgraded into a municipality, and it acquired city status in 1950. Initially Nairobi covered an area of 18 km2. However, there have been several boundary expansions since then. In 1927, the town area was extended to cover 78 km2. In 1963, it was extended to cover an area of approximately 690 km2 (UNDP, 1997), compared to other major cities in the region with the population increasing from 500,000 people in 1970 to 3.9 million (KNBS, 2009). As observed by Naab (2012), rapidly increasing urban population means changes in economic, social, spatial, and environmental issues for the improvement of society.

Urbanization leads to the outward expansion of cities and results in changes in land use and the dramatic effects are very clear in the cities and peri-urban areas.
As the cities expand, the main zone of direct impact is the peri-urban area (Nsiah-Gyabaah, 2000), which are characterized by diverse uses of land, that often vary in relation to their functional linkages to urban and to rural sectors. Aguilar and Ward (2003), notes that peri-urban areas are transitional in nature and they become progressively more agriculture in orientation as one recedes from the urban centre to the rural areas due to diverse land uses. The population here comprises heterogeneous groups including original residents, farmers, migrant residents, recreational land users, industrial users, natural resource users, investors, and speculators, developers, and builders (Thuo, 2010). Fringe zones associated with urban centres have become more numerous, larger and complex with rapid urbanization and the associated transition of large populations from rural to urban lifestyles. These complex fringe zones have strong interactions with the urban centre and characterized by similar physical, demographic, and occupational characteristics. A major difference is that in many cases, the fringe zone residents have varying access to urban services and facilities and more importantly, have only a limited voice in urban planning and development.

According to Olima (2003), rapid urban population growth goes with a lack of equivalent growth in urban land supply i.e. land is fixed in supply and does not increase with the increasing population. The pressure exerted by this increasing population tends to deprive other sectors of the needed land. Agricultural lands are the most affected by this rapid urbanization, as other land uses such as residential and commercial tend to dominate agricultural lands in competition for more space. As noted by Owusu and Agyei (2007), a key challenge of the urbanization process is the rapid conversion of large amount of prime agricultural
land to urban land use (mainly residential, industrial, and infrastructural construction) in the urban periphery.

In majority of urban centres in Kenya, urbanization takes place either in radial direction around a well-established town or linearly along the highway. As a result, land development occurs in a haphazard manner resulting to urban sprawl and thus non-optimal use of land within the controlled areas (Mundia and Aniya, 2005). In order to estimate and understand the behaviour of urban sprawl, which is crucial for sound planning and resource management, the current study was undertaken in Karuri and Kiambu sub counties within the larger Kiambu County. The study areas like many other towns around Nairobi are satellite towns connected to the capital by both rail and road. The study area was originally a large-scale coffee-growing zone, however, majority of these coffee plantations have been cleared to pave way for urban land uses specifically, residential and commercial use. According to McGregor et al., (2006), managing the urban growth in rural-urban fringes is however complex and conflict ridden. It is particularly so in developing nations such as Kenya, where legal and policy framework on land use and ownership is weak. The conversion of agricultural land in the urban peripheries is a clear result of the haphazard developments and reflected in the numerous dormitory and satellite towns. In view of the trend of urbanization and its adverse effects on agricultural land use pattern, this study aimed at examining Nairobi’s expansion and its effects on agricultural land in a peri-urban area with a focus on land use conversions in the latter.
1.2 Statement of the problem

The increasing demand for land in Nairobi has seen the city expand to its rural fringes to cater for urban developments such as residential, commercial, industries, and recreational developments. According to the Nairobi Metro Strategy report (2008), 70% of new housing development in Kenya, more so in Nairobi, is occurring in peri-urban zones. These are parcels of fertile agricultural land being converted for urban developments, for principally, residential use at an alarming rate. The result is that urban development is expanding onto agricultural land, without due consideration to its effects on agricultural practices including cash crop and food production.

Kiambu County has been a predominantly in the production of coffee, tea, dairy farm products, maize and vegetables being consumed in Nairobi and its environs. However, production of coffee and other farm products has declined tremendously as result of agricultural land being converted for residential and commercial uses. However, there have been very limited detailed and comprehensive attempts (as provided) by Remote Sensing data and GIS tools to evaluate this status of changes over time with a view to detecting the rate of land use/cover change due to minimal monitoring of urban expansions attributed to ill-equipped land monitoring system. In view of this, there is the need to effectively and efficiently deal with land use conversion based on well-founded knowledge of the planning and management response to land use changes. Consequently, there is need to examine the causes, extent and rate to which urban expansion has affected agricultural land use in Northern area of Nairobi.
1.3 General objective

The general objective of the study was to assess urban expansion and land use conversions in Kiambu County by utilizing RS and GIS tools to detect, analyse, and map the extent of urban encroachment on rural land use for an understanding of the present situation.

Specific objectives were to:

3. Investigate the urban planning and management response to land use changes in Kiambu County.

1.4 Research questions

1. How has land use/land cover changed in Kiambu County from 1986, 2002, 2014?
2. What are the effects of urban land use changes on agricultural land use in Kiambu County?
3. How is urban planning and management responding to land use changes?

1.5 Justification and significance of the study

Rapid urbanization has adversely affected development efforts in many cities due to decreasing agricultural land in favour of the provision of residential accommodation resulting in low agricultural productivity (Asamoah, 2010). The most pressing problem is the substantial loss of fertile agricultural land in many parts surrounding our main cities/urban areas. This poses a serious threat to the
economy bearing in mind that Kenya is predominantly an agro-economy. Ewing (1997) argues that suburbanization, as we know it is not the issue, but rather the wasteful form of development known as sprawl with which many critics have a problem. Nechyba et al (2004) list a plethora of ills related to sprawl: the loss of open space, urban decay, unsightly strip mall developments, the loss of a sense of community, patchwork housing developments in the midst of agricultural land, increasing reliance on the automobile, the separation of residential and work locations, and the spreading of urbanized developments across the landscape. The National Land Policy under section (3.4.1.3) states that the development of land in urban and peri-urban areas has been inhibited by poor planning, rapid growth of human settlements and activities, unmitigated urban sprawl and inadequate provision of infrastructure. Consequently, proper planning will facilitate coordinated development of urban and peri-urban areas in terms of housing, commercial, industrial and infrastructure development to accommodate changes in lifestyle and economic activities (GOK, 2009).

It is estimated that 1 to 2 million Ha of cropland are being taken out of production every year in developing countries to meet the land demand for housing, industry, infrastructure and recreation (UN-Habitat 2010). Understanding the consequences of urban expansion on land-use aimed at developing an approach for assessing land-use changes and their effects on land-use patterns and processes at the urban and peri-urban level is essential in land-use resource planning and management.

The results of the study will serve as baseline information on urban expansion in terms of its effects on land use patterns, the drivers/conditions that contribute to
the changing land use patterns in Kiambu County. The outcome of this research could be beneficial to local, sub-county, County and National Governments, as it will be useful in generating base line data for further studies and intervention, policy formulation, implementation, monitoring and evaluation, especially on issues relating to urban expansion and land use planning and management.

1.6 Scope and limitation of the study

Geographically, the study covered Karuri and Kiambu sub counties within larger Kiambu County, focusing on the effects of urban expansion to the changing land use pattern in the area. Further, the study sought to ascertain spatial and temporal changes in the land use pattern with a period from 1986-2014. The main limitation of the study was the inaccessibility of higher resolution images, hence the use of medium resolution images. Principally, the scarcity of information concerning land-use/cover change was a major limitation. However, appropriate measures were taken to address these problems; including extending time allocated for fieldwork so that information was eventually gathered through oral interviews and combining various types of images.
CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction
This chapter comprise of reviewed relevant literature on urbanisation and land use conversions patterns focusing on trends, concepts, process, and effects of urbanization, factors that influence land use conversions and responses of planning to urbanisation. The chapter also includes gaps identified from previous research.

2.2 Global trends of urbanization, urban sprawl and expansion
The face of the world is changing more rapidly now than at any time in history. The trend primarily responsible for the transformation is the rapid growth of the world population. People are moving into cities at a rate not seen since the industrial revolution filled the cities of the developed world more than a century ago (UN-HABITAT, 2006). In 2000, world population reached 6.1 billion. Currently about half of the world's population is urbanized, and this is expected to increase to 80-90 % in forty years’ time, growing at an annual rate of 1.2 % and it is projected to reach 8 billion by 2030. Urbanization is expected to continue rising in both the developed and the less developed regions so that, by 2050, urban dwellers will likely account for 86 % of the population in the developed regions and for 66% of that in the less developed regions. According to the expected result, 64.7% population in Asia and 61.6% population in Africa will have settled in urban regions by 2050. Similarly, 90.1% in North America, 88.8% in Latin America and the Caribbean, 84.3% in Europe and 74.8%
population in Oceania is expected to be urban by 2050 (UNDESA, 2010; UN, 2009).

Today, the largest and fastest-growing cities are located in developing countries of Africa, Asia, Central and South America. In regard to future trends, it is estimated that 93% of urban growth would occur in Asia and Africa and to a lesser extent in Latin America and the Caribbean (UN-HABITAT, 2006). Currently, Africa is the least urbanized region and has the highest urban population growth in the world, at an average annual rate of 3.5% for the period 2005-2010 (ESCAP, 2011). Despite decline in population growth rates since the mid-1980s, Africa remains the world’s fastest growing region at an estimated rate of 2.4% per annum. Although future growth rates are expected to be lower, the region will attain an estimated population of 1.4 billion by the year 2030 (UNDP, 2002). It is worth noting that even in Africa, differences exist among the sub-regions. As presented in Table 2.1, the urban growth rates are high for every region in Africa but much more in East Africa.

Urban population in Africa is expected to grow at 3% per annum over the next two decades. These rates will however be six times the projected rate for industrialized countries. The scale and dynamic of growth behind the process of urbanization in developing countries are without any historical precedent. Hence, cities in developing countries are now accommodating more people than cities in industrialized nations during their greatest period of expansion.
Table 2.1: Percentage of African Population Residing in Urban Areas by Region

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>33.9</td>
<td>37.3</td>
<td>40.7</td>
<td>44.0</td>
<td>47.4</td>
<td>50.7</td>
<td>53.9</td>
<td>57.1</td>
</tr>
<tr>
<td>Eastern</td>
<td>21.8</td>
<td>25.4</td>
<td>29.0</td>
<td>32.5</td>
<td>36.0</td>
<td>39.6</td>
<td>43.2</td>
<td>46.8</td>
</tr>
<tr>
<td>Middle</td>
<td>37.8</td>
<td>41.6</td>
<td>45.6</td>
<td>49.5</td>
<td>53.5</td>
<td>57.0</td>
<td>60.4</td>
<td>63.6</td>
</tr>
<tr>
<td>Northern</td>
<td>44.6</td>
<td>47.9</td>
<td>51.2</td>
<td>54.5</td>
<td>57.7</td>
<td>60.7</td>
<td>63.6</td>
<td>66.3</td>
</tr>
<tr>
<td>Southern</td>
<td>54.9</td>
<td>58.2</td>
<td>61.3</td>
<td>64.2</td>
<td>66.8</td>
<td>69.3</td>
<td>71.6</td>
<td>73.8</td>
</tr>
<tr>
<td>Western</td>
<td>32.5</td>
<td>36.1</td>
<td>39.8</td>
<td>43.6</td>
<td>47.3</td>
<td>51.0</td>
<td>54.6</td>
<td>58.0</td>
</tr>
</tbody>
</table>


2.2.1 Urbanization, urban sprawl and expansion trends in Kenya

Kenya’s Concept Paper on National Spatial Plan (2010) notes that Kenya’s population is quickly urbanizing, estimated that about 50% of the total population would live in urban areas by the year 2050. Urban areas are already showing strain resulting from high population growths that are not commensurate with infrastructure, service provision, and employment creation. Nearly all Kenyan towns are characterized by serious urban sprawl, poverty, informality, and environmental deterioration, among other negative attributes. In the last 30-40 years, Nairobi has experienced tremendous growth with an average population annual growth rate of 4.7-4.8% (KNBS, 2009). This population growth rate is high in comparison to Kenya average national growth of 3.4% per annum. The Nairobi city population increased from about 0.8 million in 1989 to 2.1 million in 1999 and to 3.5 million in 2009 as seen in Table 2.2.
Table 2.2: Nairobi versus Kenya Population size trends

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nairobi</td>
<td>2.3</td>
<td>2.4</td>
<td>2.5</td>
<td>2.6</td>
<td>2.7</td>
<td>2.8</td>
<td>2.9</td>
<td>3.0</td>
<td>3.1</td>
<td>3.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Kenya</td>
<td>30.4</td>
<td>31.3</td>
<td>32.2</td>
<td>33.2</td>
<td>34.2</td>
<td>35.1</td>
<td>36.1</td>
<td>37.2</td>
<td>38.8</td>
<td>39.4</td>
<td>40.4</td>
</tr>
</tbody>
</table>

Source: Data provided by KNBS, (2009)

In the last 100 years, the city boundary has extended to cover a greater region to include rich agricultural and livestock areas in Kiambu, Kajiado, and Machakos district as seen in Figure 2.1. According to Ministry of Nairobi Metropolitan Development established in 2008, Nairobi Metropolitan Region was proposed to expand and cover over 32,000 km² to include purely agricultural areas of Kiambu, Thika, and Kajiado. However, the fertile agricultural land in Kiambu County has largely been designated for residential development while the arid and semi-arid Machakos and Kajiado Counties have been designated for agriculture and livestock (GOK, 2008).

Figure 2.1: Proposed boundary for Nairobi Metropolitan Region

Source: UNEP, (2008)
2.3 Urbanization and urban sprawl

Urbanisation is a form of metropolitan growth that is a response to often less understood implications of technological, economic, social, and political forces and to the physical geography of an area (Sudhira, 2008). Further, he observed that the significant economic and livelihood opportunities provided in the urban areas, results to an expansion for accommodating the immigrants resulting to greater urbanisation. Urbanisation, in this context then viewed not as a threat to the environment and development but the unplanned urbanisation and dynamic urban growth, or the sprawl that affects the land-use of any region that becomes a matter of concern through its affectation in the loss of prime agricultural lands. It is thus imperative to study and bring out the intricacies and implications associated with the problem of unplanned urban growth ensuing into sprawl.

Asamoah, (2010) notes that the unplanned expansion of cities and encroachment by people for various purposes also has contributed to land use changes more so, towards the urban fringes. Towns and cities are expanding in certain pockets with a change in the land-use along the highways and in the immediate vicinity of the cities due to ad hoc approaches in regional planning, governance, and decision-making. This dispersed development outside compact urban and rural centres that is along highways and in rural countryside referred to as sprawl. Sprawl generally refers to some type of development with impacts such as losses of agricultural lands, open spaces, and ecologically sensitive habitats in and around the urban areas (Mishra, et al., 2011). These regions lack basic amenities due to the unplanned growth and lack of prior information and forecasts of such growth during policy, planning, and decision-making. According to UNCED (1992), lack
of prior planning, coordinated decision-making, and visualisation of the outgrowths, the regions remain lacking of basic amenities like water, electricity, sanitation, and result in inefficient and drastic changes in land-use, affecting the ecosystem and thus threatening the sustainable development of the region.

2.4 Urbanization and peri-urban agriculture in Kenya

Peri-urban agriculture has a significant role in food and nutrition security in most low-income nations (Lee-Smith, 2010). Rapid urbanization threatens agriculture, which is the main source of livelihood of peri-urban dwellers, resulting to problems of land scarcity for agricultural purposes. Thus, the allocation of agricultural land for residential development has resulted in a reduction in the quantity (size) and quality of land. Farmers are therefore, often left with little or no land to cultivate and this renders them vulnerable. The peri-urban interface of most urban areas, which show characteristics of both rural and a few urban life is, in most cases the agricultural hub of the urbanites and supply’s most of their food requirements.

Agriculture sector in Kenya is the fundamental part of the economy contributing 25% of the total Gross Domestic Product (GDP), and another 27% indirectly. The sector employs over 40% of the total population and over 70% of the rural people and provides livelihood (employment, income, and food security needs) for more than 80% of the Kenyan population (Food and Agriculture Policy Decision Analysis, 2012). Kiambu County is one of the high potential agricultural areas in Kenya with nearly 70% of the population engaged in agriculture. However, rapid urbanization experienced in the area has attracted many people from the neighbouring towns and from the rural areas resulting to the clearing of
agricultural land to pave way for urban developments (Musa and Odera, 2014). As Naab (2012) notes, urbanization has therefore led to the inaccessibility of land, land fragmentation, loss of land fertility among many others. This does not create a favourable environment for the development of agriculture.

2.5 Effects of urban sprawl on agricultural activities

According to Cooney (2008), when sprawl takes place at the periphery of a certain locality it has direct or indirect impact on other parts of the same locality within its border or on a neighbouring community. The consequences of rapid urbanization on peri-urban areas include changing labour and market conditions, loss of farmlands, changes in social, cultural and lifestyles. Planning and development control becomes a problem where existing institutions are not adequately structured to handle consequences of urbanization and which cut across different administrative boundaries leading to land issues not being addressed or, at worst, leading to conflicting land use planning decision (Thuo, 2013).

The rapid urban expansion in developing countries is usually associated with unplanned development in the periphery that requires high cost of infrastructure. It is also evident that even in planned activity the development of infrastructure usually does not correspond to the large tract of land that develops in a low-density pattern. Thus, urban expansion consequently results social, environmental and economic problems to the society (Abdissa, 2005).

Due to their spatial proximity to urban areas, agricultural lands are the first ones affected adversely from the urban sprawl. In Europe, the cities have primarily
expanded to the former agricultural lands in the recent years. For example, throughout the Mediterranean region, 3% of farmland was lost to urbanization in the 1990s, and 60% of this land was prime farmland (EEA, 2006). Turkey has also been subject to land transformations into urban–industrial land uses, especially with the loss of fertile agricultural lands to urbanization (Doygun et al., 2008).

Urbanization threatens food supply drawing from the fact that, as cities grows, they affect agriculture land because they expands into surrounding areas of agriculture and this greatly affects food production. An immediate consequence of rapid urbanisation is the crowding out of agriculture land, and the reduction of agricultural capacity (Kim et al., 2003). Cohen and Garrett (2009) observed that there is a shift in employment within the food system, with fewer people working in agriculture and more working in transport, wholesaling, retailing, food processing and vending due to the need to meet the higher demand for processed agricultural products. The increase of urban encroachment onto farmland has “forced farmers to bring lower quality land under cultivation to meet the growing demand for agricultural products” (Statistics Canada, 2005b). Steady, long-term production is generally unsustainable on lower-quality land (ibid). Once farmland is bought, farmers cannot just simply move their farms farther away from urban areas and continue their livelihood (Cooney, 2008).

Urban centres often expand over their nations’ most productive agricultural land since most urban centres grew there precisely because of highly fertile soils (Satterthwaite et al., 2010). An instantaneous consequence to this is the threatened food supply drawing from the fact that, as urbanization grows, it
affects agriculture land because it expands into surrounding areas of agriculture and this greatly affects food production with an impact on food security. According to Food and Agriculture Organization of the United Nations (FAO), food security is defined as a solution that “exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preference for an active and healthy life (FAO, 1996). Food security encompasses the four dimensions, availability, stability, safety, and access.

Urban sprawl generally affects these four dimensions of food security in the sense that as population continue to grow and urbanize, the demand for food rises; rural and peri-urban area are required to cater for the rising food demand. Matuschkle, (2009) observes that sprawling cities may hinder the ability to meet new demand patterns due to the expansion of cities on prime agricultural land being converted into residential, commercial and industrial uses leading to the crowding out of peri-urban agriculture, which often plays a significant role in supplying perishable foodstuffs to cities (FAO, 2008). This threatens food availability of every developing city. As the cities and towns continue to expand more and more food will be required for the urban areas, putting additional pressure on rural infrastructures, transport, technologies, and food distribution, which are already insufficient further jeopardizing the stability of food supply (FAO, 2008).

2.6 Factors influencing land use changes in peri-urban areas

Many researchers and scholars (EPA, 1999; Allen and Barrel, 1985; Lambin et al., 2006; Chrysoulakis et al., 2004; Baulies and Szejwach, 1998) have explained
proximate and underlying causes of land use change to understand the land use decision-making process. Proximate causes of land use change involve a direct and immediate physical action on land cover at local level such as individual farms, households, or communities (Lambin et al., 2006; Ojima et al., 1994). The underlying causes of land use change are the fundamental forces that alter one or more proximate causes and operate at regional or even global level (Lambin et al., 2006). Some of the identified most commonly used fundamental forces are technological, economic growth, political, institutional, demographic and cultural (Geist et al., 2006).

According to Kiita (2013), the five factors likely to cause land use change include under resource scarcity, natural population growth and division of land parcels may be a cause of slow land use change, while decrease in land availability due to encroachment by other land uses may be a cause of fast change. Changing opportunities created by markets, especially improvement in accessibility through road construction (such as Thika Super Highway) may be another common cause of land use change. Outside policy intervention, especially poor governance and corruption and rapid change in policy may be another cause of land use change (Mundia and Aniya, 2005). Perhaps the most notable cause of land use change in Kenya may be changes in social organization, in resource access and in attitudes occasioned by changes in institutions governing access to resources by different land managers; growth of urban aspirations; growth of individualism and materialism and lack of public education and poor information flow on the environment. However, it is important to carry out research to determine exact causes of land use conversions in a particular area before making generalizations
and assumptions. In Nairobi, the main drivers influencing land use change in the rural-urban fringe include housing and land market failure, population increase, weak and conflicting institutional regulations, social-cultural and economic drivers (Thuo, 2013).

2.7 Overview of land use planning response to urbanization

Asamoah, (2010) notes, urban planning plays an important part in increasing the capacity of cities to cope with population growth. Poor planning leads to inefficiencies and institutional rigidities that hasten diminishing returns and causes inoperative capacities. Good planning however allows a city to take in more than what the average would permit (Mutiara, 2008). In an attempt to ensure better management of urbanisation, governments adopt macro and micro-economic policies that designed to mitigate the magnitude of urbanisation to manageable levels. In Kumasi, for instance, land use planning, managing, and controlling its growth and development has been a daunting task. The mechanism for controlling its development is rather weak, ineffective, inappropriate, and limited in scope; measures to enforce planning legislation are very unpopular and rarely implemented. As Adarkwa and Post, (2001) observed that development control in Ghana tends to be reactive instead of proactive. In addition, there is little coordination between various development stakeholders. Hence, most planning done is on a piecemeal basis and the overall effect is that development appears haphazard, uncoordinated, and uneconomical.

Land use planning and management tools have, over the years, played crucial role in avoiding and mitigating the adverse impact of rapid, unplanned urbanisation (Masakazu, 2003). As a primary tool, physical plans established are
to address mid and long-term problems. Physical planning, as a complement to social and economic planning, has an important role to play in helping achieve the aims of social, economic and other forms of planning (Asamoah, 2010). The result manifested is in a meaningful and functional organisation of facilities in space. This includes the proper use of land, development of new land, and provision of water, energy, and infrastructure that favour decentralised economic development. Such planning approach is effective in establishing orderly and consistent use of land.

In addition, zoning regulations promote efficiency and allow for easier regulation of urban development. Zoning techniques, applied to implement master plans and guide urban development to spatially appropriate areas, include designation of sensitive land resources and areas, establishment of buffer zones, management of hazard-prone lands and protection of cultural resources. Others include conservation of open spaces and urban green, management of prime agricultural land and discouraging of excessive urban sprawl.

2.8.1 Land use planning in Kenya

The proper planning, design and management of land use demands a careful balancing of many goals, and the search for desirable land uses, coupled with effective and sustainable management practices, made more complex by the interactions between the environment, the economy and society (Masakazu, 2003). Therefore, land use planning is a process that is concerned with the preparation and actualization of spatial frameworks for orderly management of human activities. At the policy level, principles or rules to guide decisions formulated are to achieve rational land uses hence land use planning is essential
to the efficient and sustainable utilization and management of land and land
based resources.

In Kenya, however, there are minimal efforts made to ensure that such plans are
effectively prepared and implemented. This is largely due to the glaring
functional disconnect between the plan preparatory authorities and agencies, lack
of appropriate technical and institutional capacity of local authorities, inadequate
human resource establishment in the ministry responsible for physical planning,
lack of an effective coordinating framework for preparation and implementation
of the planning proposals and regulations (Kiita, 2013). These problems manifest
themselves in terms of unmitigated urban sprawl, land use conflicts, environmental degradation, among others. In addition, development control
(usually referred to as the Police Power) which is the power of the State to
regulate property rights in land, has not been extensively used to control or
otherwise regulate the use of land and to enforce sustainable land use practices
throughout the country. Furthermore, the Police Power exercised by various
Government agencies whose activities are uncoordinated with the result that the
attendant regulatory framework is largely ineffective (GOK, 2010). In addition,
Kenya does not have updated land use plans and development control guidelines,
a situation that has led to urban sprawl and maleficent conversions of agricultural
land (GOK, 2008; GOK 2010).

It is evident that land use conversions and management in the urban fringes has
been of great concern in the world over. In Kenya, for instance, the authorities
responsible for land use management and other stakeholders are experiencing a
dilemma as to what would be the most economically viable, technologically
feasible, and sustainable land use(s) in the fertile urban rural fringes. Indeed, Nairobi Metro 2030 Strategy confirms this by stating as follows, “the extent of Nairobi Metro Region (NMR) includes purely agricultural areas which are intended for agricultural and agricultural-supporting services. Designation as agricultural land will reinforce objectives of protecting the agricultural land base of the region. The strategy will address the dilemma on whether to allow indiscriminate land subdivisions and change of user or to promote agricultural activities by restricting urban growth and also address issues of food security” (Nairobi Metro Strategy 2030). According to Musa and Odera, (2014), understanding the changes is very critical for planners and resource managers as this will help control and restrict urban growth from eating into agricultural land, which is vital but scarce.

The uneven and unplanned expansion of metropolitan or urban region into countryside is also exerting pressure to the already inadequate provision of social services that are a result of the rapid urbanisation in the urban fringes, which include, poor solid waste and disposal management systems, inadequate sanitation and sewerage systems, inadequate water supply.

2.9 Application of remote sensing and GIS in urban planning

Remote sensing provides spatially consistent datasets that cover large areas with both high spatial detail and high temporal frequency. The importance of remote sensing was emphasized as a “unique view” of the spatial and temporal dynamics of the processes in urban growth and land use change (Herold et al., 2003). Satellite remote sensing techniques have been widely used in detecting and monitoring land cover change at various scales with useful results (Stefanov et
al., 2001; Wilson et al., 2003). Recently, remote sensing has been used in combination with Geographical Information Systems (GIS) and Global Positioning Systems to assess land cover change more effectively than by remote sensing data only (Muller and Zeller, 2002; Weng, 2002). It has already proved useful in mapping urban areas, and as data source for the analysis and modelling of urban growth and land use/land cover change (Grey et al., 2003; Herold et al., 2003).

The automated process is not only faster but also monitored effectively at any eventuality (Al Haddad, 2011). With multi-temporal analyses, Remote Sensing gives a unique perspective of how cities evolve. The key element for mapping rural to urban land use change is the ability to discriminate between rural uses (farming) and urban use (residential, commercial, and recreational). Remote Sensing method employed is to classify types of land use over large areas in a practical, economical, and repetitive fashion, over large areas.

The integration of remote sensing (and Geographic Information Systems (GIS) has been widely applied and recognized as a powerful and effective tool in detecting urban land use and land cover change (Ashbindu et al., 2001). Satellite remote sensing collects multispectral, multi-resolution and multi-temporal data and turns them into information valuable for understanding and monitoring urban land processes and for building urban land cover datasets. GIS technology provides a flexible environment for entering, analysing, and displaying digital data from various sources necessary for urban feature identification, change detection, and database development. Hence as handy tool, RS and GIS techniques was widely used in this study.
2.10 Conceptual framework

Urbanization has greatly contributed to the modification of urban areas in Kenya. The major contributor to urbanization is natural population increase intertwined with rural-urban migration in search for better opportunities in the urban areas. As a result, a host of problems occur in these areas resulting to movement of population to the urban fringes leading to the sprawling of urban land uses in the urban fringes which are majorly agricultural areas. The encroachment of urban land uses in urban fringes results to crowding out of agricultural lands impacting directly or indirectly on the inhabitants and the immigrants in these areas. The impacts on land uses include loss of farmlands, loss of labor in the agricultural sector and creation of jobs in other sectors mainly non-agricultural sectors among others. Consequently, a decline in agricultural productivity resulting to food insecurity related problems as vividly illustrated in Figure 2.2.

Figure 2.2: Conceptual framework

[Diagram of the Conceptual framework showing the relationships between Driving forces (D), Pressure (P), State(s), Impact (I), and Responses (R).]

This study has adopted the Drivers Pressures State Impact and Responses (DPSIR) Conceptual model developed by the European Environment Agency (1999), (Figure 2.2). The urbanization process is propelled by population growth either by natural growth, migration leading to the sprawling to the urban fringes. The sprawling effect exerts pressure on agricultural land coupled with other factors resulting to loss of prime agricultural lands. The loss of prime agricultural land further leads to a decline in agriculture productivity, increased land values and house rent and pressure on existing infrastructure as more people settle, in the area among other effects. All these are as a result of the urban influence on agricultural lands in the peri urban areas. It is also important to note that the effects of urbanization can be reduced if not totally controlled through the efforts of the government both at the national and local level. The government through its numerous regulations which if well implemented with effectively empowered institutions can control the tempo of rapid population growth, resulting in effective land use planning and management.

2.11 Theories of urban growth and urban land use

2.11.1 Bid-Rent theory

In order to have a good understanding of the way urban areas are likely to grow, it is important to have an understanding of the bid-rent theory. The bid rent theory is a geographical economic theory that refers to how the price and demand for real estate changes as the distance from the Central Business District (CBD) increases. It states that different land users will compete with one another for land close to the city center. The rents are higher near the city center and low in the periphery. This is based upon the idea that retail
establishments wish to maximize their profitability, so they are much more willing to pay more money for land close to the CBD and less for land further away from this area.

It can be seen that commerce (Figure 2.3) is willing to pay the greatest rent to be located in the CBD. The CBD is very valuable for them because it is traditionally the most accessible location for a large population. This large population is essential for department stores, which require a considerable turnover. As a result, they are willing and able to pay a very high land rent value. They maximise the potential of their site by building many stories. As you move from the CBD, commerce is unwilling to pay as much for a site. In fact, what they are willing to pay declines rapidly. Industry is, however, willing to pay to be on the
outskirts of the CBD. There is more land available for their factories, but they still have many of the benefits of the CBD, such as a market place and good communications. As you move further out, so the land is less attractive to industry and the householder is able to purchase land. The further you go from the CBD, the cheaper the land. This is why inner city areas are very densely populated (terraces, flats and high rises), whilst the suburbs and rural areas are sparsely populated (semi and detached houses with gardens). However, in modern times this is rarely the case, as many people prefer to trade off the accessibility of being close to the CBD, and move to the edges of the settlement, where it is possible to buy more land for the same amount of money (as Bid Rent states). Likewise, lower income housing trades off greater living space for greater accessibility to employment. For this reason, low income housing in many cities, for example, is often found in the inner city such as in slums, and high income housing is at the edges of the settlement.

Similarly, in Kenya many high income households are preferring housing in the urban fringes thus raising demand for residential land. Consequently, agricultural land in the urban fringes is experiencing pressure for change of user. Every household wants to maximize utility while reducing costs such as transport costs. The households also prefer houses with large land parcels which are available in the rural-urban fringes. Therefore, we can aptly conclude that urban fringes are preferred for residential development since they are located close to the city center and transport costs are affordable, especially with the current infrastructure improvement.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title of Study</th>
<th>Key Findings</th>
<th>Gaps Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiita (2013)</td>
<td>causes and effects of agricultural land use conversions in the urban fringes; a case study of Nairobi-Kiambu interface</td>
<td>Established the various legal and institutional frameworks, causes and effects on a household level</td>
<td>The mitigation measures by the authorities not outlined. Mapping of land use changes not determined</td>
</tr>
<tr>
<td>Thuo, (2010).</td>
<td>Community and social response to land use transformations in the Nairobi Rural-urban fringe</td>
<td>Focused on adoption strategies being adopted by the farming community towards the land use transformations. Actions however have created enabling conditions for further land conversions</td>
<td>Response of management to the adoption strategies by the community and the magnitude of land use transformations.</td>
</tr>
<tr>
<td>Asamoah, (2010)</td>
<td>urbanization and changing patterns of urban land use in Ghana: policy and planning implications for residential land use in Kumasi</td>
<td>Increases in economic activities, many dwelling units are converted into commercial units in order to accommodate the increase demand for commercial land use.</td>
<td>The study however does not focus on the peri-urban zone of Kumasi and how urbanization is affecting the peri-urban areas.</td>
</tr>
<tr>
<td>Naab (2012)</td>
<td>Urbanization and its Impact on Agricultural Lands in Developing Cities: A Case Study of Tamale Metropolis</td>
<td>rapid urbanisation is as a result of location, increasing commercialisation and the influx of migrants, resulted in the conversion of agricultural lands to non-agricultural uses, mainly residential and commercial</td>
<td>Extent of urbanization not mapped. The response of</td>
</tr>
<tr>
<td>Musa and Odera (2014)</td>
<td>land use land cover change and its effects on food security (case study of Kiambu county – Kenya )</td>
<td>Spatial distribution of land use/cover changes determined. Focused on effects on food security</td>
<td>Planning and management responses not determined.</td>
</tr>
</tbody>
</table>
CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the methods of data collection and analysis and materials used during the study. Remote sensing and GIS analysis was used to establish changes that have occurred in the area. Key informants’ interviews gave the historical perspectives of the land-use and land cover.

3.2 Description of the Study Area

3.2.1 Location and size

The study area has an area of 2,037 Ha and covers two sub-counties namely, Karuri and Kiambu sub-counties in Kiambu County (Figure 3.1). Geographic coordinates of the area are latitudes 1° 10′60” South of the Equator and Longitude 36′45′0” East. It borders Githunguri Sub County to the north, Juja Sub County to the east, Kabete Sub County to the South West, Limuru to the North West and Nairobi County to the South (GOK, 2013).

3.2.2 Climate

The study area experiences bi-modal type of rainfall. The long rains fall between Mid-March to May followed by a cold season usually with drizzles and frost during June to August and the short rains from Mid-October to November. The annual rainfall varies with altitude, with higher areas receiving as high as 2,000 mm and lower areas receiving as low as 600 mm. The average rainfall received by the county is 1,200 mm.
The mean temperature in the study is $26^\circ C$ with temperatures ranging from $7^\circ C$ to $34^\circ C$. The lowest temperatures are experienced in July and August, whereas in January to March temperatures rise. The county’s average relative humidity ranges from 54 percent in the dry months and 300 percent in the wet months of March up to August.

### 3.2.3 Geology and soils

The Northern area is covered by high-level upland soils, which are from volcanic rocks, being very fertile. Their fertility is conducive for livestock keeping and growth of various cash and food crops such as tea, coffee, horticultural products, pyrethrum, vegetables, maize, beans, peas, and potatoes. It also experiences bimodal type of rainfall with the long rains between Mid-March to May followed by a cold season usually with drizzles and frost during June to August and the short rains from Mid-October to November (GOK, 2013).

### 3.2.4 Population size and distribution

According to the Kenya Population and Housing Census, (2009), Kiambaa and Municipality sub counties have a population of 158,918 and 94,883 respectively. Further, the population is expected to reach 317,715 people by the end of 2017. This is influenced by the county’s high population growth rate, which is at 2.81 per cent and the influx of people working in the city who prefer to stay in Kiambu and its environs where there is less congestion and well developed infrastructure (Kiambu District Planning Unit, 2011). Table 3.1 gives population distribution and projection by urban centres, which constitutes the study area from the baseline year 2009 to 2017.
Table 3.1: Population Projections by Urban Centers

<table>
<thead>
<tr>
<th>Town</th>
<th>2009</th>
<th>2012</th>
<th>2015</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karuri</td>
<td>107,716</td>
<td>117,190</td>
<td>127,498</td>
<td>134,868</td>
</tr>
<tr>
<td>Kiambu</td>
<td>84,155</td>
<td>91,557</td>
<td>99,610</td>
<td>105,368</td>
</tr>
</tbody>
</table>

Source: Kiambu District Planning Unit, (2011)
Figure 3.1: Map of the Study area

Source: Basemap provided by Survey of Kenya, Sheet No 148/2, (1997)
3.2.5 Socio-economic activities

The main economic activity in the study area is agriculture in tea, coffee, dairy, poultry and horticulture farming. It is the leading sub sector in terms of employment, food security, income earnings, and overall contribution to the socio-economic well-being of the people. Majority of the people in the county depend on the sub sector for their livelihood, with 304,449 directly or indirectly employed in the sector. and contributes 17.4 per cent of the county ’s population income.

3.2.6 Land use and land cover

Northern area is characterized by cropland with agriculture being the predominant land use though the trend is rapidly changing towards real estate developments. Coffee and tea are the main cash crops in the county. The main food crops grown in the county are maize, beans, pineapples and Irish potatoes (D.A.O, 2008). Besides the cultivated lands, the main land-cover types are forests both indigenous and plantation forest, scattered trees, shrubs and bushes. The area under settlements is expanding very rapidly on cultivated lands due to population increase.

3.3 Research design

The study employed a descriptive survey research design to make intensive investigation of the extent of urban expansion and its implications on land use in the Northern area. Hence, to maintain triangulation in its findings, the design manifested the basic features of both the qualitative and quantitative research.
3.3.1 Sampling methods and techniques

Mixed sampling methodological approach of the purposive and convenience sampling used was to select relevant stakeholders for the study. Purposive expert sampling technique was precisely used in the selection of institutional respondents (planning department, lands office, as they harbour particular expertise in regards to land use planning and management. By use of Google earth maps and reconnaissance visit to the study area under the guidance of the town planner, six large-scale residential estates were identified for the study: Fourways Junction (approximately 100 homes), Five star Meadow (approximately 100 homes), Migaa estate, (approximately 250 homes), Edenville (approximately 700 homes), Thindigua (approximately 100 homes), and Runda Mumwe (approximately 200 homes). The selected residential had were above 10 acres in size as well as the low density developments.

Convenience sampling was used purposely to choose land owners/local residents within the five chosen estates in order to avoid cost and time implications Key-informants comprising of landowners from the selected estates, real estate developers, town planner, agricultural officers, and land officer(s) were selected according to their knowledge and involvement in land use planning and management.

3.3.2 Site reconnaissance

A preliminary reconnaissance was conducted in Kiambu County to capture the existing situation of the area, to aid in selection of study sample areas and the general idea of the physical characteristics of the area. Visual observations were made along selected routes for the identification of surface features and land-use
types. The units of observation included new and upcoming residential developments, current state of agricultural land parcels in the area. Global Positioning Systems (GPS) points were taken in the study area for each land use/land cover. The process involved overlaying street network data on the 2014 supervised image and usage of Google maps to identify the mapping routes. This process was carried out in two phases: Phase 1 was carried out in Kiambu Sub County and Phase 2 in Karuri Sub County. The GPS point recorded were overlaid and compared to the 2014 supervised classified image to determine the accuracy of classified satellite images and recoded where necessary. The GPS used in this study was Garmin Map 60 with accuracy of four (4) meters.

3.4 Data collection and techniques

3.4.1 Source and types of data

Data collection methods in this study included both primary and secondary sources. Different methods of data collection for primary sources included satellite image interpretation and analysis through image classification and change detection techniques, key informant interviews (refer to Appendix 2, 3 and 4) and transect walk along selected routes within the study area so as to supplement the information obtained from satellite images. Landsat satellite images for 1986, 2002, and 2014 provided by United States Geological Survey and were to produce land-use/land-cover maps of the study area. Source and acquisition date of this data is given in Table 3.2.

Ancillary data in this research included aerial photographs from Google Earth, topographic maps, and GPS points, which were used in class separation and accuracy assessment. Topographic sheets from sheet number, 134/4, 135/3,
148/1, 148/2, 148/4 and 149/1, at a scale of 1:50,000 compiled from ground-verified aerial photographs and population data were used to supplement the RS data and the production of study area extent.

Secondary data was gathered through review of works related to the area of study/topic. These included journals, articles, and published and unpublished thesis.

Table 3.2 Characteristics of satellite images

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Spatial Resolution</th>
<th>Spheroid and Datum</th>
<th>UTM Zone</th>
<th>Band Combinations</th>
<th>Acquisition Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 5</td>
<td>30m</td>
<td>WGS 84</td>
<td>37 North</td>
<td>4,5,1</td>
<td>Jan 1st 1986</td>
</tr>
<tr>
<td>TM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landsat 7</td>
<td>30m</td>
<td>WGS 84</td>
<td>37 North</td>
<td>4,5,1</td>
<td>Feb 10th 2002</td>
</tr>
<tr>
<td>ETM+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landsat 8</td>
<td>30m</td>
<td>WGS 84</td>
<td>37 North</td>
<td>5,6,2</td>
<td>Feb 3rd 2014</td>
</tr>
<tr>
<td>OLI-TIRS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


3.4.2 Image processing software

ERDAS IMAGINE 2013, ArcGIS10.1 and QGIS 1.8.0 were the principal Digital Image Processing software used in this study, to classify and reclassify the satellite images, produce various thematic layers, and finally, generate the land use/cover map.
3.5 Land use/cover classification

3.5.1 Image pre-processing

Image enhancement involved creating false colour composite through layer stacking using 4, 5, and 1 for TM, ETM+ images and 5, 6 and 2 for Landsat 8 OLI image acquired from USGS run under Erdas Imagine 2013 Spectral toolbox.

Band 4 (0.76 - 0.90μm): operates in the best spectral region to distinguish vegetation varieties and conditions. Because water is a strong absorber of near IR, this band has delineated water bodies (lakes and sinkholes), distinguished between dry and moist soils (barren land and croplands). In this band croplands and grasslands have showed higher reflectance (brighter tone) than the forest. This band has also separated croplands from bare croplands. Since standing crops (vegetation) has higher reflectance in the near IR region, they have appeared as brighter tone and due to presence of moisture content in the bare croplands, they have appeared as darker tone. In the band 4 barren lands, urban areas and highways have not been highlighted and they appeared as dark tone. Band 4 is useful for crop identification and emphasizes soil-crop and land-water contrast.

Band 5 (1.55 - 1.75μm): is sensitive to the turgidity or amount of water in plants. Band 5 has separated forest lands, croplands, water body distinctly. Forests have appeared as comparatively darker tone than the croplands (light gray). Band 5 has separated water body (dark tone) from barren lands, croplands, and grass lands (lighter tone). Since urban area and croplands have responded almost in same spectral reflectance band 5 could not be able to separate these areas. Band 1 (0.45 - 0.52μm): provides increased penetration of water bodies and also capable of
differentiating soil and rock surfaces from vegetation and for detecting cultural features, (USGS, 2013).

The band combination 4, 5 and 2 used for the remote sensing analysis was selected it provides the user with a great amount of information and colour contrast. In addition, healthy vegetation in this band combination appears in shades of reds, browns, oranges, and yellows. Soils may be in greens and browns, urban features are white, cyan, and grey, bright blue areas represent recently clear-cut areas and reddish areas show new vegetation growth, probably sparse grassland. As noted earlier in the raw images specifications, all the images acquired were in UTM zone 37N while the study area lies below the equator under UTM zone 37S datum new Arc 1960 hence the images were re-projected to the same UTM zone 37S as the study area. This ensured that all the data i.e. satellite images, feature classes and shape-files were in the same coordinate system. Resampling the satellite images to the same spatial resolution involves resampling the images from a high-resolution image to low resolution image in this case; all the images were in the same spatial resolution hence no resampling was required.

3.5.2 Image classification

Supervised classification used in this study was to cluster pixels in data sets into classes corresponding to user defined training classes. This classification type required selecting training areas for use as the basis for classification. Of the most common supervised classification techniques, maximum Likelihood Classifier (MLC) for parametric rule was applied. Having, prior knowledge of the area,
knowledge of reflectance properties of ground material considered for a better and effective classification of the images.

The land use/land cover classes applied in this paper adopted were from AFRICOVER land use/land cover classification scheme widely applied in East African Countries (FAO, 2002). For the sake of simplicity, the researcher modified the descriptions of some of the land use/land cover classes considering the land use/land cover of the study area. Therefore, five major land use/land cover nomenclatures: built-up, agricultural lands, forest areas, and bare fields used to produce the final land use/land cover map of the study area as presented in Table 3.3.

Table 3.3: Land use land cover classification scheme

<table>
<thead>
<tr>
<th>No.</th>
<th>Land use/land cover</th>
<th>Descriptions based on the AFRICOVER land cover classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Urban/Built-up Areas</td>
<td>Continuous and discontinuous urban fabric, Residential, industrial and commercial units, road and railway networks and other associated lands.</td>
</tr>
<tr>
<td>2</td>
<td>Agricultural Lands</td>
<td>Irrigated and rain fed arable lands, crop land with permanent crops, farming and fallow fields</td>
</tr>
<tr>
<td>3</td>
<td>Forest</td>
<td>Natural and manmade forests, natural grasslands, sparsely planted trees.</td>
</tr>
<tr>
<td>4</td>
<td>Bare Fields/others</td>
<td>All vacant spaces, sands, rocky areas, cleared lands</td>
</tr>
<tr>
<td>5</td>
<td>Water bodies</td>
<td>Rivers, dams</td>
</tr>
</tbody>
</table>

Source: Modified from AFRICOVER classification scheme, (FAO, 2002)

3.5.3 Training data acquisition

Individual training data sets created with the help of ground truth data and topographic maps compiled from ground-verified aerial photographs interpretation for the individual images and used as a guide for defining feature classes in satellite images. The training areas created was through delineating polygons along pixels that represent a particular spectral class. The polygon
method simply allows drawing a polygon that defines the location of the pixels that represent the particular spectral class (Chiwa, 2012). The sets were then stored in the signature editor and used to classify the images.

3.5.4 Accuracy assessment

Accuracy assessment is a process used to validate the accuracy of image classification by comparing the classified image with a reference data (Caetano et al., 2005). The accuracy of classified images applied the use of ground truth points randomly selected and distributed over the study area. The confusion matrices for all the images generated in Erdas Imagine 2013 was by using Accuracy Assessment tool to select a set of randomly selected pixels whose true values were well known. ERDAS IMAGINE uses a square window to select the reference pixels. Among the three different types of distribution parameters namely random (no rules will be used), stratified (the number of points will be stratified based on the extent and area of each thematic class), and equalized random (each class will have an equal number of random points regardless of its extent). Overall accuracy uses only the main diagonal elements of the error matrix, and as such it is a relatively simple and intuitive measure of agreement (Maingi et al. 2002).

Producer’s accuracy is the total number of correct pixels in a category divided by the total number of pixels of that category as derived from the reference data (column total). This statistics indicates the probability of a reference pixel being correctly classified and is a measure of omission error. Producer’ accuracy gives how well a certain area can be classified (Jensen, 2007). User’s accuracy is when the total number of correct pixels in a category divided by the total number of
pixels that were actually classified in that category (row total), the result is a measure of commission error. The user’s accuracy or reliability is the probability that a pixel classified on the map actually represent that category on the ground (Jensen, 2003). Overall accuracy = (number of pixels correctly classified)/ (total number of pixels). Kappa coefficient computed was to explain the proportional improvement of the classification over a random assignment of classes. The study assessed accuracy of the classification results with 100 equalized randomly sampled reference points for each classified image. The error matrix for each classification was created and then overall accuracy and Kappa coefficient were calculated and evaluated in (Table 3.2 and 3.3).

Table 3.4: Producer’s and User's accuracy for individual land-use/land-cover classes

<table>
<thead>
<tr>
<th>Class Name</th>
<th>1986 (%) Accuracy</th>
<th>2002 (%) Accuracy</th>
<th>2014 (%) Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Producer's</td>
<td>User's</td>
<td>Producer's</td>
</tr>
<tr>
<td>Built-up</td>
<td>95.00</td>
<td>95.00</td>
<td>100.0</td>
</tr>
<tr>
<td>Agricultural</td>
<td>78.26</td>
<td>90.00</td>
<td>63.33</td>
</tr>
<tr>
<td>Forest</td>
<td>93.75</td>
<td>75.00</td>
<td>93.0</td>
</tr>
<tr>
<td>Water body</td>
<td>100.00</td>
<td>100.00</td>
<td>100.0</td>
</tr>
<tr>
<td>Bare land</td>
<td>85.71</td>
<td>90.00</td>
<td>90.4</td>
</tr>
</tbody>
</table>

Table 3.5: Overall accuracy and Kappa ($K^2$) statistics for the classifications

<table>
<thead>
<tr>
<th></th>
<th>1986</th>
<th>2002</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall classification accuracy (%)</td>
<td>90</td>
<td>86.00</td>
<td>80</td>
</tr>
<tr>
<td>Overall Kappa (K) statistics</td>
<td>0.8750</td>
<td>0.8250</td>
<td>0.7500</td>
</tr>
</tbody>
</table>

Source: Fieldwork, (2014)
3.5.5 Change detection analysis

A post-classification comparison technique was applied in change detection analysis via the use of overlay operations of classified images to detect the changes that would have occurred in each cover type over the study period. It is a comparative analysis of independently produced classifications of different dates via a simple mathematical combination pixel by pixel (Sallaba, 2009). The outcome was a matrix of change classes that shows the change from one to class in a cross-tabulation. The thematic change analysis was carried out using Erdas Imagine 2013. Using the formula below, percentage change in land use/cover was computed.

\[
\text{Percentage change} = \frac{\text{Observed change}}{\text{Sum of Area}} \times 100
\]

3.6 Data analysis

Qualitative data for objective two and three was analysed through narrative and content analysis. The statistics obtained from the coding frequency were exported to Microsoft excel for further analysis which included production of pie charts, tables and graphs. Data presented was in form of tables, graphs, photographs, and thematic maps.

3.7 Ethical considerations

The researcher followed ethical guidelines, as specified by the Office of Research Ethics, Kenyatta University. This included undergoing an Ethics Review process before engaging interview participants to ensure that procedures were fair and unbiased to all involved. Great care was taken to ensure that these participants were completely anonymous in the research. When designing this study, this
researcher struggled with whether or not to keep the interview participants anonymous. It was eventually decided that the interviews should remain anonymous so that the reader cannot find out who was interviewed. The benefits of assuring the participants of anonymity were that they would be more willing to consent to an interview and that they would be more likely to reveal more and higher quality information, including personal opinions and insights that they would not otherwise want to be quoted as saying. However, making the participants anonymous means that this study cannot reveal who said what statements or who had what opinions, and this is sometimes awkward.
4.1 Introduction

This chapter presents and discusses the results from the classified Landsat images and field survey conducted at northern area of Nairobi. Results of land-use and land cover changes, effect of urban land-use change on agricultural land use as well as measures taken to mitigate negative externalities resulting from land use/cover changes.

4.2 Land use and land cover change between 1986 and 2014

From the ground truth data and classified Landsat images of 1986, 2002 and 2014; the study area has undergone various land-use and land cover changes. The general statistics for land use land cover distribution for 28 years’ period covered as derived from the thematic maps are presented in the Table 4.1 below;

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>1986</th>
<th>2002</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (Ha)</td>
<td>Area (%)</td>
<td>Area (Ha)</td>
</tr>
<tr>
<td>Forest</td>
<td>4749.0</td>
<td>23.5</td>
<td>1210.3</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>13061.8</td>
<td>65</td>
<td>12993.3</td>
</tr>
<tr>
<td>Built-up land</td>
<td>280.6</td>
<td>1.4</td>
<td>3140.8</td>
</tr>
<tr>
<td>Water body</td>
<td>135.6</td>
<td>0.7</td>
<td>134.1</td>
</tr>
<tr>
<td>Bare land</td>
<td>2010.0</td>
<td>9.9</td>
<td>2758.5</td>
</tr>
<tr>
<td>Categories Total</td>
<td>20237</td>
<td>100</td>
<td>20237</td>
</tr>
</tbody>
</table>

Source: Fieldwork, (2014)
The spatial distribution of land cover change within the area from 1986 is shown in Figure 4.1. Agricultural land comprising of irrigated and rain fed arable lands, cropland with permanent crops, farming and fallow fields occupied the largest area at 13,061.8 hectares attributed land that was still under large holdings of tea and coffee plantations (Maina, 1994). In addition, the land was still under large-scale farming with majority holding. At independence, large farm production was the mainstay of the country's economy and these had to remain intact in order to safeguard the economy (Githumo, 1981). Mundia and Aniya (2005), study on dynamics of land use/cover changes of Nairobi city indicated that, agricultural areas increased in area coverage from 49 km$^2$ in 1976 to 57.83 km$^2$ in 1988; the increase was closely related to the increase in population that led to a high demand for food leading to intensification of peri-urban agriculture and expansion of agricultural land.

Built up land comprising of residential, industrial and commercial units occupied 280.6 hectares attributed to less developments and increased agricultural activities (Mundia and Aniya, 2005). Further, according to National Development Plan, (2002), the period between 1985-1995 experienced slow economic development which explains the low rate of urban expansion in 1986 in the study area. Bare land comprised of all vacant spaces, sands, rocky areas, cleared lands occupied 2010 hectares attributed to the clearing of agricultural land in preparation planting season (D.A.0, 2008). Water body at 135.6 hectares comprising rivers, dams occupied the least area.
Figure 4.1: Land-use/land-cover map of the study area in 1986

In 2002, the agricultural land in the study area covered a total of 12,993.3 hectares in table 4.3 which was a decrease from the 13,061.8 hectares recorded in 1986, while the area under built-up land occupied 3,140.8 hectares an increase from 280.1 hectares in 1986 and an increase in bare land 2758.5 hectares from 2010 hectares in 1986. The increase of urban population raises the demand for urban land, that is, more housing developments as seen in table 3.1. Aguilar
(2008) observes that rapid urban population increase means an increasing demand for urban land, particularly for housing, but also for other various urban uses.

In many countries, the increasing demand is most likely to affect or is affecting rural-urban fringe areas. Ifeoluwa et al., (2011), observed that Akure city in Nigeria had haphazardly expanded outwards depleting cultivated land and vegetation in the fringe. This was particularly towards the north western part of the city where area covered by built-up/settlement land had increased from 10.1% in 1986 to 32.51% in 2002 closely related to continuous construction of both residential and commercial buildings to serve the community. The increase in area coverage of built-up land attributed to the clearing of agricultural land for the planting season and explained by the clearance of agricultural land to pave way for urban developments, particularly, housing, and infrastructure (Nairobi Metro Strategy, 2008)

The area covered by Forest occupied 1210.3 hectares decreased from the 4,749 hectares in 1986, as a result of the increased deforestation mainly for charcoal burning, farming and encroachment of people for farming, building of residential and commercial purposes. Kiambu County Development profile (2013) further states that the massive felling of trees is brought about by population pressure and the high demand for fuel by production (tea, coffee, milk-processing plants) industries. Area under bare land increased to 2758.5 hectares from 2010 hectares in 1986, attributed to the clearing of agricultural land in preparation for planting and the land cleared to pave way for urban developments. Figure 4.2 shows the spatial distribution of land uses in the Northern area in 2002. As derived statistics
indicated, (Figure 4.2) it is evident that in the built-up land had increased compared to 1986 spreading to the south of the study area.

**Figure 4.2: Land-use/land-cover map of the study area in 2002**

Source: Fieldwork, (2014)

In 2014, the area under agricultural land had decreased to cover 7,130.6 hectares while built-up land had increased to an area of 8,717.6 hectares, representing 43.1% of the land area in the study area. The increase in built-up land area
coverage is attributed to the further increase of population that continues to raise the demand for residential development and other amenities. Table 3.1 shows that the population in the study is on the increase with the projection of up to 127,498 by 2015 (Kiambu District Planning Unit, 2011). The area under Forest increased to cover 2,660 hectares as compared to 1210.3 hectares recorded in 2002.

The increase in forest coverage is attributed to the massive sensitization of conserving trees by the forestry department. Farmers in the study area being mobilised to plant trees to achieve a 10% forestage of the total land with tree being fruit trees, fodder trees or any other plantation. (Kiambu County Development Profile, 2013). Further, the promotion of agro-forestry and the green economy as an income generating activity has seen farmers planting more trees for commercial purposes hence explaining the increase in Forest coverage in 2014. In addition, the enforcement of Environmental Coordination and Management Act (2002) and Forest Act (2005) to discourage cutting down of trees is also a key player in the increase of Forest in the area. The spatial distribution of the land cover and use in 2014 as shown in Figure 4.3.

The area covered by water decreased to cover 90 hectares compared to 134.1 hectares in 2002 while the area under bare land occupied a total of 1638 hectares compared to 2758.5 hectares in 2002. This attributed to the reasoning that the bare land transformed into other land features. A study conducted by Tahir et al., (2013), in Mekelle city Ethiopia, showed that bare lands which were spread over in 14 km, transformed into other land features and reduced to only 1 km showing a changes of 336%.
Figure 4.3: Land-use/land-cover classified map of the study area in 2014

Source: Fieldwork, (2014)

Figure 4.4 shows the area in hectares of land-use/cover changes between 1986 and 2014. It is evident that the area covered by agricultural land is on the decline. The period between 1986 and 2002 shows a minimal decline in area coverage of agricultural land where it occupied 13,061.8 hectares and 12,993.3 hectares,
respectively, a decline of 68.5 hectares. This contrasts sharply with the production between 2002 and 2014 in agricultural land further declined, to occupy an area of 7,130.7 hectares in 2014, a decline of 5862.6 hectares. Using the population data provided by the KNBS (2009), we observe that there was a rapid increase of population in the study area between years 1999 and 2009 of 187,055 and 253,801 per km². This has largely contributed to increase the demand for land required for urban development, mainly construction of residential houses.

**Figure 4.4: Land use/cover distribution between 1986 and 2014**

![Figure 4.4: Land use/cover distribution between 1986 and 2014](image)

Source: Fieldwork, (2014)

The results indicate in Figure 4.5, between 1986 and 2002 (16 years’ period), the areas covered by agricultural land and Forest decreased by 0.34% and 17.4% respectively, while the built-up land and bare land rose by 14.1% and 3.7% respectively. This is attributed to the increase of population that has increased demand for houses in the area. Farmers in this area commonly clear agricultural
fields or subdivide their farms to construct houses to cater for the increasing demand for residential houses (Musa and Odera, 2014).

**Figure 4.5: Graph of change in area of land-use/land cover classes**

![Graph of change in area of land-use/land cover classes](image)

Source: Fieldwork, (2014)

The results also indicated that between 2000 and 2014 (14 years’ period) the area covered by agricultural land continued to decrease by 28.9% while the built-up land continued to increase by 27.5%. Interestingly, the area covered by Forest increased by 7.2%. The area covered by bare land and water decreased by 5.5% and 0.21% respectively. For the period covered by the study (1986-2014) the area showed great land-use changes, 29.3% of agricultural land was converted to other uses, the built up area increased by 41.6% while forest land decreased by 10.3%. During this period, the area covered by bare land and water also decreased by 1.8% and 0.22%. This indicated that the demand for land in the area has increased, resulting into conversion of bare land, forest and agricultural mainly for settlement uses and for non-extensive agricultural purposes.
4.3 Location of change in built-up land

In terms of location of change, the emphasis was on built-up land. Figure 4.6 shows the change of built-up land between 1986 and 2002. The observation here is that there seems to exist a growth away from the urban centres in 2002 and is spreading to agricultural areas with no specific pattern. There exists more growth towards the south west part of the study area.

**Figure 4.6: Overlay of built-up land to show location of change 1986/2002**

Source: Fieldwork, (2014)
Between 2002 and 2014 as shown in Figure 4.7, drastic gains were made in the spatial expansion of the built-up. The growth being more concentrated towards the south and south eastern part of the study area in 2014 while spreading fast to the northern parts. In addition, the built-up land has increased in the area around the urban centres, that is, Karuri and Kiambu town centres.

**Figure 4.7: Overlay of built-up land to show location of change 2002/2014**

Source: Fieldwork, (2014)
4.4 Change detection analysis

Multi-date post-classification comparison change detection performed was to investigate land cover change in the study area from 1986 to 2014. The post-classification change detection engrossed on a supervised classification using five classes: forest, agricultural lands, built-up land, water, and bare land. The resulting 1986, 2002 and 2014 classifications were used as inputs to quantify the ‘from-to’ change yielding an area change matrix (Tables 4.2, 4.3 and 4.4) and were classified into change and no change map. Land covers that had no change separated were from the land covers, which had change by comparing the three thematic layers. The same types of land cover for the three years identified were observed not to have changed, while different types of land cover changed. This analysis produced five change classes: change in agriculture land, change in built up, change in water, change in forest, and change in bare land.

The diagonal values shaded in yellow from cross tabulation matrix (Tables 4.2, 4.3) and spatial distribution of the cross tabulation matrix (Figure 4.8) show land-use/land-covers that were unchanged in the given years. This thematic change detection was calculated by subtracting the area of each land cover classification of 1986 from 2000. Of the 4749 hectares, that were Forest in 1986, 676.114 hectares did not change while there was a 3538.7 decrease in hectares representing 74.5% of 1986 a period of 16 years.

For the Agriculture land, results show the extent to which was converted, where 1533.55 hectares out of 13061.7 hectares of agriculture land were converted to built-up land while 1614.97 hectares of the same agricultural
land were converted to bare land. 786.769 hectares of a total of 2010 hectares of bare land have changed to agriculture while 459.408 hectares have changed to built-up. 12.9067 hectares of a total 135.5651 of water have changed to built-up land while 29.7848 and 9.2062 hectares have changed to forest and agriculture respectively. This indicates that a significant area of water bodies has been converted for agriculture uses by draining farming and overgrazing, as well for urban development purposes such construction of residential, commercial and infrastructure development.

Table 4.2: From-to area change matrix (ha) from 1986 to 2002

<table>
<thead>
<tr>
<th>1986 Classes</th>
<th>2002 Forest</th>
<th>Built up</th>
<th>Agriculture</th>
<th>Water</th>
<th>Bare land</th>
<th>Total(Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>676.114</td>
<td>963.763</td>
<td>2715.47</td>
<td>12.2749</td>
<td>381.426</td>
<td>4749.0479</td>
</tr>
<tr>
<td>Built up</td>
<td>20.8493</td>
<td>171.127</td>
<td>65.346</td>
<td>6.40824</td>
<td>16.878</td>
<td>280.60854</td>
</tr>
<tr>
<td>Agriculture</td>
<td>471.141</td>
<td>1533.55</td>
<td>9416.5</td>
<td>25.633</td>
<td>1614.97</td>
<td>13061.794</td>
</tr>
<tr>
<td>Water</td>
<td>29.7848</td>
<td>12.9067</td>
<td>9.2062</td>
<td>83.3974</td>
<td>0.270</td>
<td>135.5651</td>
</tr>
<tr>
<td>Bare land</td>
<td>12.4555</td>
<td>459.408</td>
<td>786.769</td>
<td>6.40824</td>
<td>744.98</td>
<td>2010.02074</td>
</tr>
<tr>
<td>Total</td>
<td>1210.3446</td>
<td>3140.755</td>
<td>12993.2912</td>
<td>134.12178</td>
<td>2758.524</td>
<td>20237.0366</td>
</tr>
<tr>
<td>Total Change</td>
<td>-3538.703</td>
<td>2860.15</td>
<td>-68.5028</td>
<td>-19.4433</td>
<td>748.5033</td>
<td></td>
</tr>
</tbody>
</table>

Source: Fieldwork, (2014)
The diagonal values (shaded in yellow) from cross tabulation matrix (Table 4.6) and Figure 4.9 show land-use/land-cover that were unchanged in the given years. Out of 12993.2 hectares of land under agriculture in 2002, 5768.23 hectares remained unchanged while 4523.77 were converted to built-up with an increase
of 5576.79 hectares, representing 42.9% of 2002. 813.395 hectares were converted to bare land, assumingly to pave way for built-up area resulting to a decrease of 1119.132 hectares, representing 8.6% change. 1329.3 hectares out of 2758 hectares covered by bare land converted to built-up while 704.184 hectares converted to agriculture. This clearly indicates that there is a high demand for built-up land to cater for the increasing in population in the study area. Area under Forest, 372.942 hectares converted to built-up out of the total 1210.3445 hectares while 263.911 hectares converted to agriculture. It is interesting to note that 1887.5 hectares, out of 12,993.3 hectares occupied by agriculture in 2002 converted to forest, attributed to afforestation activities in the study area. 31.4 hectares converted to built-up and 10.8 hectares to agriculture, from the 134.1 hectares under water.

Table 4.3: From-to area change matrix (ha) from 2002 to 2014

<table>
<thead>
<tr>
<th>Classes</th>
<th>2002</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forest</td>
<td>Built up</td>
</tr>
<tr>
<td>Forest</td>
<td>554.899</td>
<td>372.942</td>
</tr>
<tr>
<td>Built up</td>
<td>153.888</td>
<td>2460.13</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1887.54</td>
<td>4523.77</td>
</tr>
<tr>
<td>Water</td>
<td>0.361028</td>
<td>31.4094</td>
</tr>
<tr>
<td>Bare land</td>
<td>63.3603</td>
<td>1329.3</td>
</tr>
<tr>
<td>Total</td>
<td>2660.0483</td>
<td>8717.5514</td>
</tr>
</tbody>
</table>

Source: Fieldwork, (2014)
Figure 4.9: Change and no change map between 2002 and 2014

For the entire period covered by the study area, it is clear that the area covered by agriculture is slowly being edged out by other land uses, mainly by built-up land. Out 13061.8 hectares of land under agriculture in 1986, 5234.81 hectares were converted to built-up with an increase of 3968.503 hectares, representing 30%
increase. 985.696 hectares converted to bare land, assumingly to pave way for built-up area resulting to a decrease of 371 hectares (Table 4.4.). 318 hectares, representing 2.8% change hence 1032.27 hectares out of 2010 hectares covered by bare land were converted to built-up while 471.231 hectares were converted to agriculture, 2205.34 hectares of a total of 4749 of forest have changed to built-up land as shown in Figure 4.10. Table 4.3 show that 383.592 hectares out 3140.7576 hectares of the built up area in 2002 converted into agriculture land, hectares of which it is not possible in reality. This may be because some areas had been cleared awaiting cultivation. Hence, the classification of these areas as built up since built up and bare soils have almost the same spectral signatures.

Table 4.4: From-to area change matrix between 1986 and 2014

<table>
<thead>
<tr>
<th>Classes</th>
<th>Forest</th>
<th>Built up</th>
<th>Agriculture</th>
<th>Water</th>
<th>Bare land</th>
<th>Total(Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>995.173</td>
<td>2205.34</td>
<td>1333.82</td>
<td>2.52719</td>
<td>212.194</td>
<td>4749.05419</td>
</tr>
<tr>
<td>Built up</td>
<td>19.0442</td>
<td>205.695</td>
<td>32.2217</td>
<td>4.6031</td>
<td>19.0442</td>
<td>280.6082</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1548.63</td>
<td>5234.81</td>
<td>5284.63</td>
<td>8.03286</td>
<td>985.696</td>
<td>13061.7988</td>
</tr>
<tr>
<td>Water</td>
<td>7.67184</td>
<td>39.4423</td>
<td>8.84518</td>
<td>73.5594</td>
<td>6.04721</td>
<td>135.5659</td>
</tr>
<tr>
<td>Bare land</td>
<td>89.5348</td>
<td>1032.27</td>
<td>471.231</td>
<td>1.2636</td>
<td>415.723</td>
<td>2010.0224</td>
</tr>
<tr>
<td>Total</td>
<td>2660.05</td>
<td>8717.55</td>
<td>7130.7479</td>
<td>89.9862</td>
<td>1638.704</td>
<td>20237.0494</td>
</tr>
<tr>
<td>Total Change</td>
<td>-2089.00</td>
<td>3968.50</td>
<td>-5931.0509</td>
<td>-45.579</td>
<td>-371.318</td>
<td></td>
</tr>
</tbody>
</table>

Source: Fieldwork, (2014)
Figure 4.10: Change and no change map between 1986 and 2014

Source: Fieldwork, (2014)

The change detection result indicates that agricultural land is being edged out slowly by other land uses, especially by built-up land. The implication of these rapid changes of land use is a decline in area under agricultural land. As Musa and Odera (2014), observe agricultural land within Kiambu County where the
study area lies, is experiencing high population increase and a rise in demand for land hence an increase in the amount of agricultural land converted for urban developments. Urban encroachment converts urban land at the rural-urban fringe to uses such as residential development (Asamoah, 2010). The movement of people to urban periphery results to marginal clearing of the already limited agricultural land for building homes and other infrastructure constructions such as roads, parking lots among others. As agricultural land conversion continues, food security in the area is at a threat as production is on the decline (GOK, 2012).

The primary focus of this study was to understand the level of change in built-up area in the designated study area period. The major land-use/land-cover that contributed to the increase of built-up area is presented in Table 4.8. Based on the land-use/land-cover change statistics between 1986 and 2002, 1533.55 hectares of agricultural land, 963.763 hectares of Forest, 12.90 hectares of water land and 459.4 hectares bare lands converted to built-up area. Between 2002 -2014, 4523.77 of agricultural land, 372.94 hectares of Forest, and 31.4 hectares of water and 1329.3 hectares of bare land were converted to built-up area. The overall change for the period of the study (Table 4.5), indicates that agricultural land is the most affected by the the land use/cover changes with 61.5% of its total area being converted to built up area within a period of 28 years.
Table 4.5: Land-use/Land-cover class conversion to Built-up area in hectares

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (Ha)</td>
<td>%</td>
<td>Area (Ha)</td>
<td>%</td>
<td>Area(Ha)</td>
<td>%</td>
</tr>
<tr>
<td>Agricultural to Built-up</td>
<td>1533.55</td>
<td>51.6</td>
<td>4523.77</td>
<td>72.3</td>
<td>5234.81</td>
<td>61.5</td>
</tr>
<tr>
<td>Forest to Built-up</td>
<td>963.76</td>
<td>32.5</td>
<td>372.94</td>
<td>6.0</td>
<td>2205.34</td>
<td>26.0</td>
</tr>
<tr>
<td>Water body to Built-up</td>
<td>12.90</td>
<td>0.4</td>
<td>31.40</td>
<td>0.5</td>
<td>39.44</td>
<td>0.5</td>
</tr>
<tr>
<td>Bare Land to Built-up</td>
<td>459.40</td>
<td>15.5</td>
<td>1329.3</td>
<td>21.2</td>
<td>1032.27</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2969.61</strong></td>
<td><strong>100</strong></td>
<td><strong>6257.41</strong></td>
<td><strong>100.0</strong></td>
<td><strong>8511.86</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Fieldwork, (2014)

4.5 Factors contributing to declining agricultural land

An interview with district agriculture officer ascertained that there has been a decrease in average farm sizes with the current the average farm size under small-scale farming being 0.36 Ha and 69.5 Ha under large scale farming with residential land developments fast consuming agricultural lands respectively. Over 1,000 acres of agricultural land are being lost to urban developments every year. According to the survey, most landowners have lost their land to residential use. The study depicted that, 72.7 % of farmers currently have farms below 5 acres against 16.67% of farmers who owned land within the same category ten years ago. It is again clear that 58.33% of the respondents owned land above 10 acres ten years ago against 9.1 % of farmers who owned land within same category now (Figure 4.11).
Acreage under crops in the study area is on the decline with cash crops being the most affected due to the rapid land use conversions in the area (Figure 4.12). It is observed that the area covered by cash crops between 1986 and 2000 decreased from 13,450 hectares to 7,019 hectares. This could be attributed to the harsh weather conditions (dry and hot) experienced in the year 2000, while between 2000 and 2009 (9 years’ period) decreased from 7,019 hectares to approximately 5920 hectares. The decrease is attributed to the increase in population that has continuously led to the demand for land for residential, commercial and infrastructure developments and the low producer prices due to lack of value addition and high costs of inputs (DAO, 2009).
As discussed earlier, data from classified Landsat images indicates that over the last two decades, land use in Kiambu County has been changing from predominantly agricultural uses to non-agricultural uses, such as provision of residential and recreational space, transportation facilities, and industrial production, mainly dictated by the urbanisation phenomenon. Data from the interview conducted on the field suggests that this attributed to a number of factors, which are discussed in the section that immediately follows.

### 4.5.1 Population growth

It is evident that the declining agricultural land in Kiambu County is as result of an increase in urban population growth from both natural and migration to the study area. Natural population growth in Kiambu County combined with the influx of immigrants in the area has consequences on land use changes such as agricultural to urban land use. Table 4.6 shows the population changes in the study area for the past 20 years.
Table 4.6: Population trend 1989-2009

<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1999</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karuri</td>
<td>80,440</td>
<td>116,127</td>
<td>158,918</td>
</tr>
<tr>
<td>Kiambu</td>
<td>55,926</td>
<td>71,928</td>
<td>94,883</td>
</tr>
</tbody>
</table>


4.5.2 Demand for real estate

Another factor that is contributing to declining agricultural land is the high demand for real estate development. As the population increases, the demand for housing rises as seen in Figure 4.13, a case in point Edenville estate, consists of two phases with phase one which of 345 housing units, phase two 454 total of 799 housing units with a third phase on the way that will consist of apartments, commercial and recreation services. Fourways junction has 971 housing units, Five Star Meadow has a total of 116 housing units Tatu city that is set to be a home to 70,000 people among other several large and small-scale housing projects occurring in the area. According to Nairobi Metro 2030 Strategy (2008), the provision of shelter in Kenya remains a huge challenge; with annual housing supply at 35,000 housing units against the 150,000 housing units annually demand. All these projects geared towards reducing the demand for housing experienced in the country.

According to a report by World Bank (2011), growing prosperity has also increased the demand for larger and better quality housing. The Ministry of Housing estimates that current levels of construction are around 50,000 units annually. This implies an annual housing deficit of some 156,000 units currently.
4.5.3 Low producer prices

The research revealed that low economic returns received by farmers were a contributor to the declining agricultural land in northern area of Nairobi. Farmers have responded by either diversifying their farming or selling their land as way of protecting themselves from the not viable enterprise. The occurrence made apparent from an interview with a key informant:

“I have been a coffee farmer and used to get huge profits before the prices went low. This got me in huge personal and input loans from the financial institutions so it was hectic to service the loans hence when some people approached me with an offer to sell my land I could not resist as their offer was irresistible. With the money I was able to offset my loans and start other businesses. I sold one acre of land at 25million. I have never made so much money at once from the coffee profits. I sold 20 acres. That’s a lot of money to say no to. Right now I own apartments and also other business which are more profitable than the coffee farming. I make a lot of money. And I do not regret my decision to sell my land. I now see that others have finally woken up”.

Figure 4.13: The construction of residential areas

a) Edenville estate  
b) Five Star Meadow

Source; Google Earth, (2014)
Thuo (2013) observes that reduced income from agriculture has also been occasioned by the implementation of SAPs that led to the high cost of inputs against the reducing earnings. An evaluation report by BEACON in 2008 on small scale coffee farmers’ project, revealed low payments to the farmers a major problem that contributes to the declining agricultural land as farmers either completely uprooted their coffee trees, others abandoned the farms and others converted their coffee farms to other non-agricultural uses.

4.5.4 Proximity to major urban centers

The study area borders Nairobi city with the distance being approximately 8km from Nairobi hence makes it possible for people to live in the study area and work in Nairobi City by commuting on daily basis. Kiita (2013) noted that real estate developers are developing housing in the urban fringes to meet demand for housing for such people putting pressure on agricultural land in the urban fringes where large land parcels are available at lower cost compared to land in and around the Nairobi City Centre. An informant explained that:

“I commute daily from home to work in Nairobi and take approximately use less than 30 minutes. I relocated to this area because it is so close to my workplace, good housing. Generally, it is a very convenient area to be in.”

The Nairobi Metro 2030 Strategy, (2008) acknowledges that the urban sprawl has rapidly annihilated the rural land uses by encroaching the rich agricultural hinterland Kiambu, Thika and Kajiado areas, and that the large coffee, tea and livestock estates are under serious threat from urbanisation. Further, the proposed extent of Nairobi Metropolitan Region would cover purely agricultural areas in
(see NMR boundary attached Appendix 1). This is a testimony to the fact that urban centres (for instance, Nairobi City) are expanding over time. According to Doos (2002), the cities experiencing the most rapid change in urban population are mostly located in developing countries and it is estimated that 1 to 2 million hectares of prime cropland are being taken out of production every year to meet the land demand for housing, industry, infrastructure and recreation.

### 4.5.5 Access to improved infrastructure

According to Carey (2001), improved infrastructure especially road network provides substantial benefits to highway users, in terms of reduction in travel time, increased access to outlying locations and reduction in vehicle operating costs. This is due to the fact that there has been improved road network, especially over the last five years. For instance, roads like Thika Superhighway, the Eastern, and Northern Bypasses, which passes through study area, have led to growth of real estate sector by opening up areas that were not easily accessible in the past. During the field survey, residential houses observed were coming up along the major roads in the study area like Kiambu road as seen in Figure 4.14 below.
4.5.6 High costs of inputs

High cost of agricultural inputs was alluded to as a major determinant to declining agricultural land. According to Kiambu County Development Profile (2013), the high cost of inputs is a major contributor to the low agricultural productivity. Further, Over 70% of the county’s population depends on agriculture as their source of livelihoods. However, the cost of farm inputs has been on an upward trend making them unaffordable for the majority of the farmers (KFS, 2012). Discussion with a key informant revealed that majority of farmers lack the financial capability to purchase these inputs so they turn to financial institutions for loans and due to the fluctuations of market prices, the farmers result to incising sections of their land for sale to pay for loans.
4.5.7 Lack of organized marketing structures

According to an evaluation, report by Makau, (2008) on small-scale coffee farmers’ project in Kiambu county, poor marketing facilities was a major constraint that farmers faced. The report cited that the over exploitation by intermediaries did affect the marketing of coffee as the farmers either did not have the full knowledge of the real price value of coffee they sold. An informant commenting on marketing structures indicated that:

“The opening of coffee markets has led to an upsurge of middlemen who are either conning farmers or over charging them to sell their coffee. These intermediaries do not reveal the real price of coffee that they sell. This is made worse by the fact that the farmers themselves have no knowledge coffee prices locally and internationally…… the cooperative societies are suffering from mismanagement and corruption and the farmers are the hardest hit by the results as there is nothing to show for their coffee.”

The inability of small scale farmers to form strong co-operative societies has led to middlemen exploiting their situation and offering low prices for their produce as stated by Kiambu District Profile (2013). Alila and Atieno (2006) also observed that poor marketing facilities and institutions are some of the constraints that affect agricultural production. Further, they identified the major marketing constraints comprising of high transportation costs due to dilapidated roads, improper handling, poor storage facilities and wastage and these results in fluctuations in both productions and incomes. These challenges have led to either farmers neglecting their coffee as shown in plate 4.4 others intercropping and
some opting to fully uproot their coffee and convert their farms to other land usages.

Plate 4.1: A neglected coffee farm

Source, Fieldwork, (2014)

4.5.8 Lack of public participation

Another factor revealed by the research to be contributing to declining agricultural land use is inadequate public participation in land use planning process. The research revealed that very few change of user notices displayed were on site properties mostly large-scale properties. A research conducted by Kiita (2013) in Nairobi-Kiambu interface revealed that the notices of agricultural land use conversions were usually displayed on sites/parcels that are about to change user and advertised on daily newspaper classifieds, for fourteen days.
They were meant to inform the immediate/neighbouring landowners of the proposed change of user to forward their objections and claims to the county clerk, if any, before permission for change of user is given. This is not adequate public participation since public participation implies that the public's contribution will influence the land use decisions by ensuring that the media used is accessible and understood by many people in a form and language that is widely understood by the target group. For instance, putting the advert on a newspaper classifieds and on site, limits a lot of interested parties since not all people have access to a newspaper and can read.

Physical Planning Act, chapter 286, laws of Kenya require only notices of change of user to advertise on the land parcel that is changing user and in two daily newspapers, for fourteen days. The Act does not provide for public participation explicitly. However, according to UNEP (2002), effective public awareness and participation in land use decision making is a must so as to ensure sustainable land use management. Public participation is regarded as a way of empowerment and as vital part of democratic governance. Mitchell (2005) further stresses that public engagement in decisions made about natural resources and land regardless of ownership is a vital process. Effective public participation allows long-term residents to know and respect the land and have a valuable say in future (Halseth and Booth, 2011).

4.6 **Implications of changing land uses in Kiambu County**

Changes in agricultural land into urban land uses have identifiable positive effects. One identified benefit was the creation of jobs in the various sectors including banking, construction, transportation, grocery shops. Another benefit
was the provision of housing for renting and commercial buildings. Provision of market to financial institutions was also identified as a benefit to the banking sector and the real estate industry as the changing the social interaction and lifestyles. The conversion of agricultural land into urban land uses also has exhibited negative effects of urban land uses on agricultural land as identified from fieldwork include declining agricultural land as the farming land is converted as discussed below;

4.6.1 Declining agricultural production

The declining agricultural land has really affected production in the area leading to reduction in agricultural production. Field data indicates that the declining agricultural land is affecting crop production in a midst of the other contributing factors to reduced crop productions. Figure 4.15 shows crop production between 1986 and 2009 for the period representing the period covered by the study. The results indicated that the total annual production of coffee in 1986 was 20,003 tonnes compared to 12,881 tonnes produced in 2000 (14-year period) while in 2009 coffee production recorded 2,246 tonnes compared to 20,003 tonnes achieved in 1986. Maize production in 1986 achieved 66,130.75 tonnes compared to 1,822.86 tonnes produced in 2009 while in 2000, the total production achieved was 11,443.5 tonnes indicating a huge decline in production by 64,307.89 between 1986 and 2009, representing 80.9% decline as shown in figure 4.17. Cabbage production increased in the 2000 to 52,383 tonnes compared to 23,250 tonnes achieved in 1986 then decreased (GOK, 2014)

In 1986, the total beans production achieved was 7,902 tonnes decreased to 3,465 tonnes in 2000 and major decline recorded in 2009 where the total production
achieved was 927 tonnes. Over a period of 23 years, the total production of beans has decreased by 6,975 tonnes. Tomatoes production in 2000 was 5,320 tonnes compared to 23,381 tonnes achieved in 1986, while in 2009, the total production achieved was 1,575 tonnes. Irish potatoes production achieved 86,388.3 tonnes compared to 4,300 tonnes produced in 2009 while in 2000, the total production achieved was 73,350 tonnes indicating a huge decline in production by 82,088.3 tonnes between 1986 and 2009 representing 50.4% decline as indicated in figure 4.14.

**Figure 4.15: Crop Production from between 1986 and 2009**

![Crop Production Categories](image)

Source: Statistics obtained from Kiambu District Agricultural Office, (2014)

Figures 4.15 shows percentage change in crop production between 1986 and 2009. The results indicated that, between 1986 and 2000 (14 years period), coffee, maize, beans, Irish potatoes, tomatoes and bananas production decreased by 20.27%, 68.8%, 36.09%, 8.08%, 59.65% and 23.4% respectively while
cabbages rose by 37% respectively. The major decrease during between 1986 and 2000 was maize which representing 68.8% decrease.

According to the Annual Agriculture Report of 2000, the total production of maize was 11,443.5 tonnes compared to 66,130.7 tonnes produced in 1986. The reports highlights low soil fertility as farmers were unable to replenish lost soil nutrients due to the low economic returns realized from maize, prevalence of pests and diseases coupled by the drought and the clearing of land to build houses as the main causes of the decrease in maize production.

The results also indicated that between 2000 and 2009 in figure 4.16, coffee, maize, beans, Irish potatoes, and tomatoes production continued to decrease by 30.27%, 12.1%, 20.6%, 42.09%, and 12.36 respectively, cabbage also registered a 63.5% drop in production while banana registered the lowest decrease in production by 4.9%. Over the period of time (1986 to 2009), Coffee production decreased by 50.5%, maize decreased by 80.9% beans by 56.7%, Irish potatoes decreased by 50.4%, tomatoes registered a 72% decrease and cabbages decreased by 26.3 % while bananas registered a decrease in production by 26.3%.
Figure 4.16: Percentage change of crop production over the period of time

Source: Kiambu District Agricultural office, (2014)

Figure 4.17 below shows the relationship between area coverage of crops and production. It’s evident that declining area of agricultural land has an effect on production among other factors that like harsh weather conditions, invasion by pests and diseases, low soil fertility and usage of low quality seeds to mention a few (D.A.O, 2009). As illustrated in figure 4.18 below, the area coverage of coffee on 1986 was 13,450 ha with recorded production being 20,003 tonnes, in 2000, the area of land under coffee reduced to 7,019 ha and the production decline to 12,881.25 tonnes while in 2009, the area recorded under coffee was 5920 and the production declining further to 2246 tonnes. Area under maize crop in 1986 was 26,452 ha with production that year being 14,750 tonnes that declined to 11,443.5 tonnes under the area of 14,750ha in 2000. In the 2009, the area under maize had declined to 3,538ha with 1,822.86 tonnes.
Between 1986 and 2009, the area under maize decreased to 22,914 ha. In 2009, the area under cabbage was 265 ha with production achieved being 2,650 tonnes which would be seen as a high production in regards to total area. In 1986, the area under cabbage was 1,550 ha with the production being achieved being 23,250 tonnes. In 2000, the area under cabbage increased from 1,550 ha in 1986 to 2,757 ha and the production increased from 23,250 tonnes in 1986 to 52,383 tonnes. This was the only year that an increase was recorded during the study period. In 1986, the area under Irish potatoes was 9,093 ha with production being 86,388.3 tonnes. In 2000, the area increased to 9,780 ha but the production decreased to 73,350 tonnes and further recorded a decline in 2009, to 2150 ha with 4,300 tonnes in production as illustrated below.

Figure 4.17: Relationship between area coverage of crop and crop production

![Graph showing area coverage and production of various crops](image)

Source: Fieldwork, (2014)

According to the Agricultural Sector Development Strategy (ASDS) 2010-2020 as cited by Kiita (2013), reduction in agricultural land has many inherent and
associated further negative effects which include food shortage; reduced agricultural exports hence reduced foreign exchange; lost job opportunities in agricultural sector, among others. Gachimbi *et al* (2003) carried out a study on the agricultural production and its constraints in Kiambu District and found out that one of the constraints to maize and beans production is diminishing agricultural land and is also affecting coffee and tea production in the area.

According to Doygun, (2009), An immediate consequence of rapid urbanisation is the crowding out of agriculture land, which often plays a significant role in supplying perishable foodstuffs to cities whereby agricultural capacity is reduced due to urban sprawl on high quality agricultural land (Doygun, 2009). Urban spread out is impugned for disorganized use of land resources and energy and large-scale intrusion onto the agricultural lands (*Katare et al.*, 2012). Threatening food supply drawing from the fact that, as it grows, it affects agriculture land because it expands into surrounding areas of agriculture and this greatly affects food production.

Diminishing fertile agricultural land in Kenya has far-reaching negative effects, especially because Kenya depends on rain-fed agriculture. From the literature reviewed, it is also evident that quantity and quality of cultivatable land has declined over the years and agricultural productivity has dwindled as well. Kenya, specifically, continues to experience devastating persistent and unpredictable droughts and famines.
4.6.2 Loss and creation of employment

Field data indicates that loss of employment in agricultural sector is the second highest negative effect of the land use changes in the northern area. Over 70% of the county’s population depends on agriculture as their source of livelihoods (County Spatial Plan 2013-2017) and the declining agricultural opportunities due to consequences of land conversions and population increase, most families formerly relying on farm for food and income are turning to looking for non-farm jobs within their locality or elsewhere (Thuo, 2010). This poses serious livelihood problems as majority of the population depends on agriculture as a means of sustenance. Some of these respondents who noted that the lives of people have changed for their worse especially those who used to work in coffee related activities that have been replaced by change of land use to residential land uses which has proved to be more economical viable than coffee farming.

On the other hand, creation of jobs was identified as a positive effect that came out strongly during the study. The increasing urban land uses and population in the area moving into the area is bringing some opportunities into the old rural population. The study noted that the people moving to the area are creating business opportunities for the indigenous residents and other groups such as former farm labourers in that they present needs that must be met daily. These needs include services, food, and other home-related requirements. Along the major roads and even access roads, there are roadside kiosks and grocery shops selling foodstuffs and bodaboda services offering transportation services as depicted in Plate 4.2.
A study conducted by Thuo, (2010) in Town council of Karuri, established that the increasing urban developments in the area have led to the adoption of multiple sources of income that is meant to complement the dwindling earnings from the farming mainly rental houses within the farms. An informant supports these observations by indicating that: “majority of people are both working outside this area maybe in the city or as casual workers or selling in their kiosks....these are people who claim to be farmers and most of their income is from the rental houses on their lands.”. It was noted that the availability of non-farm jobs within and outside study area for the aboriginal residents is creating a serious labour shortage especially agriculture sector and the same time creating new job opportunities that end up reabsorbing the farm labourers.

Plate 4.2: Creation of Jobs

a) Flower vases on sale along Kiambu road
b) Bodaboda business that offers transportation service to Edenville estate
Source: Fieldwork, (2014)

4.6.3 Increasing land values and housing costs
Increasing land values in the area was identified as one the effects of changing land use from agriculture to residential/commercial developments. The land value of Five Star Meadow estate, which is approximately 20 acres in size, was valued to be approximately Kenya shillings 5.6 million in 2005; in 2009, the price of land per acre rose to 15 million and with one acre of land in this area selling at approximately 30 million. This indicates that the price of land in the area has increased by 33% over the last five years, (AMS Properties Ltd, 2016).

The land values are determined by its use, demand, and location. The size and scale of the real estate market makes it attractive and lucrative sector for many investors hence if the if land is being used for real estate development then the
land values increases depending on the use for land. Location of land also
determines the value of that land in the sense; land located where urbanization is
expected is more valuable than rural land. Such land rises in value, and either
purchased from the original owner by developers and speculators or held by the
original owner as speculation. According to Reader (2011) the effects of road
construction on property values is great. Road construction can have a large
effect on property values. Another study done by Carey (2001) found out the
following impacts of highways on property values: That these highways provide
substantial benefits to highway users, in terms of reduction in travel time,
increased access to outlying locations and reduction in vehicle operating costs.

Secondly, these access benefits accrue to property owners in the form of
aggregate increases in property values. With improved infrastructure like the
Thika Super Highway and the bypasses’, land adjacent to these infrastructures
tends to increase in value. The benefits include reduction in travel time, increased
access to outlying locations as for instance Where in 2010 to beginning of 2012
travel time to Kiambu, a town about 15 km outside of Nairobi was two or more
hours during the peak period. With the completion of the Thika Super Highway
travel time has been reduced to half an hour or 45 minutes at the most during
peak time and 15 minutes off peak hence (Kariuki, 2012). This explains the
increasing land values adjacent to major roads.

The increase in urbanization affects the demand for housing significantly. Nairobi
is one of the fastest growing cities in the world. Recent report by the Kenya
National Bureau of Statistics (2009), shows that demand for real estate in the
urban areas in the last ten years, exceeded supply by more than five times. This
demand is mostly being brought by locals and an ever-increasing expatriate community including diplomats, and staff of the various UN agencies and multinationals who are looking for permanent high-end homes within easy reach of public services, access to basic amenities, communications, utilities and financial services. This is leading to developers’ response to this by constructing more houses in the areas that their clients prefer which is in the urban fringe (Kariuki, 2012) and as Naab (2012), notes landowners and property owners respond to the increasing demand for peri-urban lands by also increasing the prices of land and that of habitable spaces.

Increasing land values have direct effects on housing costs. The higher the value of land the higher the price of housing will be after conversion. A case in point is Fourways Junction measuring approximately 100.64 acres, which was under this study; the land value of this agricultural land in 2007 was ranging between Kshs 8.5 to 10 million shillings per acre. The farm was converted into residential use and commercial developments and sub-divided into 33 sub-plots. The sub plots were further divided into 331 double storey residential houses built with a 147 sq. ft. 3-bedroom house is valued at 19.5 million shillings, 157sq ft. 4 bedroomed house valued at Kshs 20 million and 205 sq. ft., 4 bedroomed spacious valued at Kshs 29 million. Six hundred and forty residential apartments valued between Kshs. 8.5 million to Kshs. 12.5 million each. 130,000sq ft. of 32 office blocks valued at Kshs. 80 million, each shopping mall valued at Kshs. 1.75 billion, a 3-star hotel valued at Kshs. 100 million and club house valued at Kshs. 70 million. The rentals charged are quite high ranging between Kshs. 110,000 to 140,000 per month, for the double storey houses and Kshs. 50,000 to Kshs 60,000 for
apartments, as per the prices in 2014. In 2009, the land value of this agricultural land was about Kshs 15 million per acre, built with double storey residential houses valued at Kshs 14 million, each, residential apartments valued at Kshs. 7 million, each. Similarly, the rentals charged are quite high ranges between Kshs. 60,000 per month, for the double storey houses and Kshs. 30,000 per month, for the apartments. These rentals or housing prices are unaffordable to majority of Kenyans.

4.6.4 Uncontrolled developments

Uncontrolled development was identified as a negative effect of the encroachment of urban land uses on agricultural land, where the rural land is slowly losing its character to becoming part of the larger urban centre, Nairobi City. The rapid land use conversions as noted during the field survey have led to haphazard developments on farms (Plate 4.4) due the uncoordinated sale of land hence there is no uniformity in the pattern of developments that is leading to some areas to be covered with residential developments while the adjacent farms are still under agriculture. The process is aggravated further by the laxity of institutions responsible for controlling land uses or simply lack of proper zoning of land uses in the area. Thuo (2013) further noticed that the sprawling residential settlement is reducing land available for farming either directly through conversion or indirectly through negative consequences on agriculture such as pollution from domestic wastes. An uncontrolled development in the area is not without pressure put forth on existing infrastructure.
Plate 4.4: Houses built in coffee and maize farms

Source: Fieldwork, (2014)
4.6.5 Pressure on existing infrastructure

Due uncontrolled development, pressure on the existing infrastructure emerged as another negative effect. According to Thuo (2013), the dispersed residential developments or leapfrog land use development is costliest in respect to providing services and facilities. The road networks especially the rural roads, supply of water and electricity are becoming inadequate and experiencing more pressure due to increased demand from the new residential estates, which were not envisioned during initial installation. In an ideal situation, infrastructure and services should be provided before development takes place, however, in the study area provision of services and infrastructure is done in retrospect without improving capacity of the old infrastructure (Mundia and Aniya, 2005; Kiita, 2013). For instance, in the new high-rise residential flats in the coffee estates intermittent water supply and narrow access roads that are challenging to motorists is very frequent phenomenon. Others complained of persistent power outages and inadequate waste management systems. In one of the high-end estates, a notice regarding an impending water disconnection, a clear depiction of the pressure on existing infrastructure.

4.6.6 Changing social interaction

Changing social interactions and lifestyles identified as one of the positive effects of the urban land uses on agricultural land. According to the discussion with key informants, the people coming into the area are bringing with them new modes of interactions and lifestyles that are diffusing to the indigenous residents. The churches have become the new communal where members form groups irrespective of family or clan of the customary organisational attributes and
functions with most of these groups meeting on Sundays after the church service, either within the church compound or in members’ homes. Thuo, (2010) notes that these groups are more or less mirror the customary groups among clan members with the major difference being their origin. The current setup of the church groups mirrors most of the customary organisational attributes and functions. Apart from the church meeting, other groups like *chamas* and investments groups where people meet in members’ homes on rotational bases and public places. These groups are providing new spaces for people (both the newcomers and indigenous) to interact, although the level of representation (for newcomers and indigenous) varies from one group to the other depending on the level of interpenetration among the people (Thuo, 2010).

Several consequences emerge as the newcomers join the indigenous farmers and residents such as breakdown of communal, kinship and families. The intrusion by the newcomers not tied to local customs and norms, has weakened the cohesion among the members of the formerly rural communities. As result, people are losing the ways through which rallying people together for a particular communal cause had always been achieved. These groups are providing new spaces for people (both the newcomers and indigenous) to interact, although the level of representation (for newcomers and indigenous) varies from one group to the other depending on the level of interpenetration among the people. As these new spaces of interaction continue to play significant role in the area, the customary institutions are losing their ground. These customary institutions are necessary in safeguarding family and communal land and its resources and more so in such areas as in the Nairobi rural-urban fringe, where land is tied to some aspects of
family ownership. With continued disintegration of communal and customary values more and more people are losing values attached to the family land and are now regarding it as a commodity that can be put on sale. This can partly explain why there are widespread land conversions but also at the same time the existence of land still under farming. An indication of varied individual Values manifested by the presence of people who are still farming against the identified constraints or are still culturally attached to land as a resource to be bequeathed to the next of kin and not meant for sale whatsoever. The question is, however, whether farming activities will hold for long as residential land use dominates while bringing with it some consequences not so favourable for continued economically viable agricultural activities (Thuo, 2010).

4.6.7 Provision of houses

The results from key informants during the study indicated the encroachment of urban land uses on agricultural land more so in the urban fringes is leading to provision of houses (21.43%) for single-density housing. From the field, a case in point Edenville estate, consists of two phases with phase one which of 345 housing units, phase two 454 total of 799 housing units with a third phase on the way that will consist of apartments, commercial and recreation services. Fourways junction has 971 housing units, five-star meadow has a total of 116 housing units Tatu city that is set to be a home to 70,000 people among other several large and small-scale housing projects occurring in the area. All these projects are geared towards reducing the demand for housing experienced in the country. The demand for housing in Kenya is immense and driven by a growing
population and urbanization. Growing prosperity has also increased the demand for larger and better quality housing (World Bank, 2011).

4.7 Perception towards land use/cover change

The study revealed that 78% of the respondents do agree with the land use/cover change while 22% are against the land use/cover changes as illustrated in figure 4.18. A discussion with a key informant revealed that the changing land uses do promotes the real estate industry in the sense that new concepts introduced to develop beautiful houses for example, using concepts from South Africa, Italy, and Israel. Real estate is providing new opportunities for the native people in the area such as new job opportunities, transforming agriculture (Thuo, 2010). 78% of the respondents who agreed to the land use conversions were of the opinion that the living conditions have improved or changed for the positive over time as compared to a couple of years back. They indicated that they have benefited from the good road network and increase of economic activities that have provided more job opportunities for the residents.

Land use/cover changes in Northern area are slowly edging out farmlands to give way to urban developments. The increasing population requires food yet they are occupying the same land that is supposed to be providing the food that they require. The food demand is higher than the supply. According to the Kiambu Profile Report (2013), the county where the study area lies is 25.1% food poor. The declining agricultural land coupled with low soil fertility has led to low production as discussed earlier. The small land sizes are not producing sufficient food to feed area let alone the county at large hence the need to intensify training
of farmers on modern methods of farming to produce more sufficient food and cash crops on limited space.

Figure 4.18: Perception towards land use and cover change

Source: Fieldwork, (2014)

4.8 Measures taken to mitigate the effects of land-use and land cover changes

The fourth objective of this research was to study the response of management framework towards the rampant land use changes experienced in the study area aimed at regulating agricultural land use conversions. The objective concentrated mainly on the state of institution including the challenges experienced i.e. agricultural and county planning departments and policy frameworks and the measures put in place. The study observed that different initiatives are in place to control the negative outcome of land-use change in the study area. The measures were divided according to the two departments that were under scrutiny

Discussion with the key informant in the agricultural department revealed that farmers in the area were struggling with reduced agricultural land due to population pressure and rapid increasing residential developments. This was due
to the various challenges that farmers were facing hence prompting them to look for other reliable alternative to earn income. Further the study revealed that, the lapse in the existing regulatory framework due to the conflicting legal and institutional framework is a challenged in addressing the reduction of agricultural land. A key informant recounts,

“The Agriculture Act, for example, does not give the Agricultural Officers, at district level, power to regulate agricultural land use conversions and having so many laws that are not in harmony, hence no coordination among the relevant authorities in land use planning and management.”

Discussion with the key informant revealed that the following key strategies are in place to control the declining agricultural lands in the study area:

1. To improve the efficiency of farmers, measures such as education on adoption of new farming technologies, intensification of extension services and upgrading of the various farmers training centres, setting up county agricultural information centre were going to be set up in the area and the entire county as a whole.

2. Carrying out extensive training on production and management to the farmers and encouraging farmers to plant trees through farm visits and exhibitions in agricultural fairs as well as seminars

3. Provision of the insurance covers to farmers and zero rating of agricultural products to reduce the high cost of inputs, subsidies and grand and also outsourcing for government aid to co-operatives societies through issuance of affordable credits.
4. To address the challenge of lack of organised marketing structures for produce and lack of value addition, the agricultural department seeks to conduct market research regularly. Increase value addition through quality assurance on agricultural products. Train farmers on proper management of societies and branding of agricultural produce and products.

5. A soil and agro-ecological zone map has been developed as shown in figure 4.16 and conducting in-service training for agricultural staff and producers.

According to Kiambu county report (2014), major steps have been taken including training of 800 farmers on greenhouse construction and vegetable as well as rehabilitating and constructing dams for irrigation purposes.

The study area has been an extensive agricultural area although due to the increasing population, expansion of urban centres; the area has witnessed a rapid change of agricultural land use to concrete jungles. The key challenge is the unplanned manner in which these developments are occurring due to the poor physical planning of urban centres, lack of spatial plan, policy vacuum, and lack of zoning regulation. To address these challenges, the planning department came up with the following measures,

1. Development of an agro-ecological (figure 4.19) map and zoning regulations within the 12 sub counties that clearly outline the various land use zones as depicted in figure 4.20 and 4.21 that is set to boost vertical growth in property development while safeguarding agricultural land.
2. The proposed development of county spatial plan that is meant to provide long term spatial development framework to cover a period of ten years and also to enforce zoning regulations.

3. A short-term mitigation measure was the temporary ban on change of user pending zoning and marking of the agricultural and commercial land that was lifted when zoning was completed.

4. Ensuring that all the farmers who wish to change their farms from agriculture to residential must apply for change user. The town planners are achieving this through field inspections.

5. Formulation of a policy that will seek to regulate change of user in addition to ensuring that the public is involved in all matters regarding the change of user/development application and generally public participation in all planning processes.

Mitigation measures to land-use/cover change influences land use development and management. The existing mitigation measures are not only limited to this part of the study area but extend to the larger Kiambu County.
Figure 4.19: Kiambu County Agro-ecological zone.

Source: Kiambu County Planning Department, (2014)
Figure 4.20: Zoning map of Kiambaa Sub County

Source; Kiambu County Planning Department, (2014)
Figure 4.21: Zoning map of Kiambu Municipality Sub County

Source; Kiambu County Planning Department, (2014)
CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the findings and draws conclusions. It also makes recommendations from the results achieved and observations during the study. Details provided in subsections of this chapter.

5.2 Study objectives and methodology

This study aimed at assessing urban expansion and its implications on land-use and land cover changes in Northern area of Nairobi. The specific objectives were to:

1. Investigate the dynamics of rural land being lost to urban land uses in Kiambu County 1986, 2002 2014.

2. Assess effects of urban land use changes on agricultural land use in Kiambu County.

3. Investigate the urban planning and management response to land use changes in Kiambu County.

The study used both quantitative and qualitative research techniques. Descriptive statistics, GIS analysis methods, and change detection analysis were used. The integration of remote sensing, GIS and other tools for assessing urban expansion and its implications on land use/cover change provided useful information and understanding of the problems under study.
5.3 Summary of key findings

Conversion of land to feed and shelter the growing human enterprise has been one of the primary modes for human modification of the environment (Chiwa, 2012). It was evident that there has been a significant land-use and land cover change in the area where the agricultural land covered 65% in 1986, decreased to 64% in 2002, and further decreased to 13.1% in 2014. However, the area occupied by built up land increased from 1.4% in 1986 and 15.5% in 2002 to 43.1% in 2014. There was also a decrease in Forest from 23% in 1986 to 6.1% in 2010 later increased to 13.1% in 2014. The area occupied by water bodies was 0.7% in 1986, 0.7% in 2002 and showed a slight decrease to 0.4% in 2014. The changes are attributed to the growth of urban areas, increase in population through natural, and immigration, reduced income from agricultural in the area to satisfy the demands of increasing population. For the period covered by the study the thematic maps produced from the Landsat images across the area revealed that 61.5% of agricultural land was converted to built-up, while forest 26.0% has been converted to built-up. During this period, the 12% of bare land was converted to built-up land while 0.5% of water body also converted to built-up land.

The study also revealed that haphazard development, caused by urbanization and demographic factors, is one of the major factors contributing to land-use/cover changes in the area. Although the drivers/causes of land use/cover changes were not part of the issues being investigated in this study, they were highly mentioned during the fieldwork hence it was important to elaborate them. These drivers include expansion of urban centres, proximity of the study area to Nairobi, low agricultural returns, lack of public participation in the change of user processes,
population increase, subdivision of land, and weak and conflicting institutional framework. The effects brought about by the changing land uses/cover as revealed in the study were, declining agricultural land as farmers clear their land to tap the benefits that come with urban developments. Loss of jobs in the agricultural sector due to the reduced availability of non-paid family labour and creating jobs in the various services industry was a major effect of the changing land use/cover on agricultural land. Other effects include increasing land values and increasing housing costs, changing social-cultural interactions, uncontrolled development, and provision of houses and causing pressure on existing infrastructure.

This study found various mitigation measures put forward by the relevant institutions such as developing of agro-ecological zones, encouraging farmers to adopt new farming methods, zoning, planting of trees in response to land-use change in area. However, it was noted that there is conflicting and weak policies, institutional framework enforcement in the area that led to a mismatch between the information reaching the local population and macro level institution.

5.4 Conclusion

The study of urban expansion and its implications on land use/cover change is of much benefit to citizens as well as planners and policy makers as it provides an insight into the significant factors and effects determining land use change. This will to help identify problems in terms of increasing residential land use at the expense of farming land and provide the platform for better management of land resources in the peri-urban area. The better management of land resources is essential for sustainability and for improving the quality of life of people living in
the city and the peri urban areas who are mostly farmers (Naab, 2012). With major changes being agricultural land use giving way to residential land use in the peri urban area, access to agricultural land is drastically reduced causing food insecurity problems in the region.

The study revealed that there is major land-use and land cover changes in Northern area for the period covered by the study, are mainly associated with expansion of settlements due to population increase and proximity to Nairobi city. These changes have had negative effects and positive outcomes on agricultural land use. With increased high demand for land for construction of both commercial and residential developments also infrastructure such as road networks. The results also revealed that more land-use and land cover changes are likely to take place as more land is converted over time, forest to agricultural land, and agricultural land to built-up land, which threatens the existence of agricultural land and water sources in the future.

Usage of efficient tools such as satellite remote sensing and Geographic Information System (GIS) are currently being used to assess urban growth. The integration of remote sensing and GIS in urban planning provides a powerful tool for assessing, monitoring and making future projections on urban growth, effects on the various land uses/cover. With multi-temporal analyses, Remote Sensing gives a unique perspective of how cities evolve. The key element for mapping rural to urban land use change is the ability to discriminate between rural uses (framing, pasture forest) and urban use (residential, commercial, and recreational). Remote Sensing method is employed to classify types of land use
over large areas in a practical, economical, and repetitive fashion, over large areas.

As witnessed in the study area through satellite image analysis and interviews as well as observations, it is possible to conclude that urban sprawl has resulted to increased pressure on the natural land. In addition, urban sprawl has negatively impacted agricultural land resulting to conflict of interest in land uses between agricultural uses and built up urban uses.

In conclusion, urban expansion is inevitable in the course of urban growth. Current trends of land-use/cover change continue, if mechanisms are not put in place to control development. Hence the need to investigate and gain an in depth knowledge on the trend of land use/cover change as an assessment of urban expansion in the peri-urban area utilizing remote sensing and GIS techniques.

5.5 Recommendations
This section is devoted to making relevant recommendations based on the findings of the study that are pertinent to appropriate land use management to regulate agricultural land use conversions in the urban fringes

1. There is the need for stakeholder participation and institutionalize stakeholders’ participations in land use planning process and urban planning. It is only when the public and land owners are well informed about land management issues that a positive change of attitude, adherence to laws on land use among others can be achieved.

2. The county government and the national governments should come up with policies to outlaw arbitrary sale of land especially in areas where the
main form of land use is agriculture to enhance the effectiveness of zoning regulations. It is important that the management of land be made the first priority in the study area and the nation as a whole. The various land sector agencies and institutions responsible for land management should enforce the existing laws on land management. Zoning and planning regulations is a tool that is used to achieve development control is an effective mechanism that can be used in land management. Land should therefore be managed using zoning and planning regulations and development should be channelled bearing in mind the zoning and planning laws of the area. The authorities should ensure the compliance of such regulations by penalizing all those who flout them. Zoning will help ensure that fertile agricultural lands are protected for sustainable cultivation.

3. The farmers in the study area should be provided with modern methods of farming or supplementary economic activities to boost their income so as to prevent them from selling their farms to the property developers or sub-dividing to put up residential apartments.

4. Measure which increase the opportunities for good markets for agricultural produce are recommended. Small-scale industries should be set-up to boost value addition of the produce and also boost producer prices and also come up with ways that make agriculture as lucrative as real estate industry.

5. There’s the need to encourage the adoption of mixed land uses by property developers so as to prevent the wiping out of certain land uses.
6. The need for planners to integrate GIS in their planning to for the purposes of identifying patterns of development, monitoring spatial changes and creation maintenance of a land use database systems

7. Harmonization of the legal and institutional framework so as to ensure that all the institutions involved in planning and management of land use work as one for an effective management of land. In addition, there is need to strengthen relevant land institutions with powers and capacity to regulate land use conversions by either being equipped with adequate technical personnel and funds to handle land use conversions to generate effective institution that is responsive and proactive to the ever changing economic, political and social realities.

8. Land use plans to be updated regularly and the creation of new plans. Planners must also ensure that all stakeholders are on board before the detailing of the plan is done to ensure compatibility. Plans should therefore be prepared with intensive consultation especially with the original land owning communities

9. Costs benefit analysis of land use conversions to alternative uses for posterity and sustainability of agricultural sector against urban land uses.

5.6 Further research

This study acts as the starting point for other researchers on land-use/cover changes in Kiambu County fuelled by urban expansion. Detailed analysis of the effects of urban expansion on service delivery in the area, which may help understand the consequences and challenges of service provision in urban developments that occur in the urban fringes. Future studies should also focus on
the impact of land use changes on all aspects of the environment. Targeting environmental pollution and contamination of both surface and underground water sources as well as encroachment on riparian reserves. Furthermore, future studies can also incorporate the impacts of land-use change on agriculture productivity and the effects on food security.
REFERENCES


Baulies, X., and Szejwach, G., 1998. LUCC data requirements workshop survey of needs, gaps and priorities on data for land-use/land-cover change research organized by IGBP/IHDP-LUCC AND IGBP-DIS, Barcelona, Spain, 11-14 November 1997 LUCC report series no. 3.


Cooney, E. (2008). *What can be learned from the case of South Simcoe County Concerning the best ways to respond to the threats of agricultural land preservation posed by suburban development leapfroging the Toronto Greenbelt?* Undergraduate Thesis.


Musa, M. K., & Odera, P.A. (2014). Land use land cover change (lulu) and its effects on food security: Case study of Kiambu County, Kenya. 4th


UIUC (2006). *Framework and Methods: Analysis Course Lectures*, University of Illinois at Urbana-Champaign, Department of Urban and Regional Planning.


LIST OF APPENDICES

Appendix 1: Proposed Land uses in Nairobi Metropolitan Region

Appendix 2: Semi-structured interview guide for Landowners

This is a research interview guide to solicit for information on the topic ‘Assessment of Urban expansion and its implications on land use changes in Kiambu County’. The information provided herein is strictly for academic purpose and will be treated with the utmost confidentiality. You are therefore requested to answer the questions as accurately as possible. Thank you

1. To what use was your land 10 years ago?
   a) Agriculture  c) Residential
   b) Commercial  d) Others

2. What was the approximate size of the land 10 years ago?
   a) Below 50 acres  c) 60 acres to 70 acres
   b) 50 acres to 60 acres  d) Above 70 acres

3. Which categories of people have obtained land from you during the past 15 years?
   a) Farmers  c) Others
   b) Real estate firms(investors)

4. What is the approximately size of land that they acquire?

5. To what use are the lands currently being put into?
   a) Agriculture  c) Commercial
   b) Residential  d) Industry

6. What accounts for your decision to sell land?

7. Which is the most predominant use of land today?
   a) Agriculture  b) Commercial
   b) Residential  d) Others

8. Do you agree to these current uses of land?
Appendix 4: Semi-structured interview guide for Institutions Survey

This is a research interview guide to solicit for information on the topic ‘Assessment of Urban expansion and its implications on land use changes in Kiambu County’. The information provided herein is strictly for academic purpose and will be treated with the utmost confidentiality. You are therefore requested to answer the questions as accurately as possible. Thank you.

AGRICULTURE DEPARTMENT

1. What was the average size of a farm 10yrs ago?
   a) 10 acres and below
   b) 10 acres to 20 acres
   c) 20 acres to 30 acres
   d) Above 30 acres

2. What is the current average size of a farm in the area?
   a) Below 10 acres
   b) 10 acres to 20 acres
   c) 20 acres to 30 acres
   d) Above 30 acres

3. What accounts for the phenomenon in (1) and (2) above?

4. In what ways do (3) affect agriculture?

5. What crops are mainly grown in the area?

6. Do you think there have been changes in agricultural productivity of (5) for the last 10 years?

7. What is the agricultural productivity of the crops in (5) for the past 15 years?

8. What accounts for (6) above?

9. What are some of the land uses that compete with that of agriculture?

10. In what way do the above uses affect agriculture?

11. Is there a policy to protect agricultural lands?

12. Is the policy effective in protecting agricultural lands?

13. If no, what are the measures being out to protect the lands?

14. What is your perception towards the land use changes that you have observed?
Appendix 5: Semi-structured interview guide for Institutions Survey

This is a research interview guide to solicit for information on the topic ‘Assessment of Urban expansion and its implications on land use changes in Kiambu County.” The information provided herein is strictly for academic purpose and will be treated with the utmost confidentiality. You are therefore requested to answer the questions as accurately as possible. Thank you.

COUNTY PLANNING DEPARTMENT

2. Where do these people migrate from into the area?
3. Are there any reasons why they migrate into the area?
4. What are some of the possible causes for the growth of the area?
5. What are the main land uses that have been affected by the above phenomenon?
6. What were the principal uses of land 15 years ago?
   a) Agriculture     c) Commercial
   b) Residential     d) Industry
7. Have you noticed any changes occurring in major land uses?
   a) Yes  b) No
8. If yes, which land uses are actually changing to which ones?
9. What factors account for the changes in land use being observed?
10. Are these land use changes creating any problems in the area?
    a) Yes  b) No
11. What are some of the problems?
12. Has the entire area being zoned and planned?
13. What are some of the principal uses of land per the zoning?
14. How many change of user permits are you able to grant monthly and yearly?
15. What are measures being put in place to control the changes of land use?
Appendix 6: Semi-structured interview guide for Real Estate Developers
(This is a research interview guide to solicit for information on the topic Assessment of Urban expansion and its implications on land use changes in Kiambu County) The information provided herein is strictly for academic purpose and will be treated with the utmost confidentiality. You are therefore requested to answer the questions as accurately as possible. Thank you)

Name of the firm/ estate_________________________ Date ______________

1. What accounts for you to develop in this area as opposed to any other area?

2. Would you consider developing in another place rather than here?

3. What was the price of land before you acquired it?

4. What is the current price of an acre of land?

5. What accounts for the changes of land values?

6. Do the changes in land values affect housing costs?
   a) Yes  b) No

7. If yes, how do they affect housing costs?

8. How did you acquire this land?

9. What was the previous predominant use of this piece of land before acquiring it?
   a) Agriculture (coffee, tea, maize, others)
   b) Others(specify)

10. What are the effects of changing land uses from agriculture to residential?

11. Do you support the changing of land uses in this area?
   a) Yes  b) No