UNIVERSITY OF NAIROBI

SUBDIVISION OF AGRICULTURAL LAND AND ITS IMPLICATIONS ON PRODUCTIVITY: A CASE OF KAJIADO COUNTY, KENYA.

BY

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NOVEMBER, 2018

DECLARATION

I, Museleku Erastus Kiita, hereby declare that this thesis is my original work and has not been presented for a degree or any other award in any other University.

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Lastly but certainly not the least, I thank God for the gift of life, health, resources and knowledge. His grace and favour is sufficient and new every day. Glory to Him!

God bless you all!

DEDICATION

I dedicate this work to;

Kenyan agricultural landowners who are operating their land in an Efficient, Optimal and Sustainable manner to feed the nation and beyond.

My wife Sharon and daughter Caren.

ABSTRACT

Efficient, optimal and sustainable agricultural production, including extensive pastoralism systems, usually requires large contiguous land to enable economies of scale and synergy. These requirements may be absent when the private agricultural land is subdivided into small sizes and fragmented into idle lands or non-agricultural land uses. This claim is further confirmed by the law of diminishing marginal returns which shows that intensification of land use has a limit. Despite this knowledge, subdivision of private agricultural land into small parcels, even in drylands, is happening in Kenya. Therefore, subdivision and fragmentation of agricultural land may lead to increased agricultural production costs and negative change in agricultural productivity resulting to a tragedy of spatial anticommons.

According to Heller's (1998) anticommons theory, when too many profit maximising individuals are endowed with exclusion rights in a scarce resource, they are likely to waste the resource by underutilizing it as they tend to block each other from access and use leading to a tragedy of spatial anticommons. Anticommons properties are, however, not necessarily tragic, thus there is need to understand the phenomenon of subdivision of private agricultural land into small units and their implications on productivity.

It is in this context that this study sought to create knowledge on the phenomenon of subdivisions of private agricultural land into small sizes by establishing the trends, drivers and implications of agricultural land subdivisions on agricultural productivity in the dry agricultural lands of Kajiado County. It is assumed that this knowledge will help land administrators and managers to put in place informed interventions to control untimely, unproductive and unsustainable agricultural land subdivisions.

The study focused on the issue of private agricultural land subdivision in the rural Kitengela Division, Kajiado County, Kenya. The methodology used involved a cross-sectional survey design whereby a total of 357 agricultural parcels and landowners were targeted. Self-administered questionnaires/schedules were thus administered to the target respondents. Other respondents in the study included land officials, real estate agents and

property developers in the study area. The overall survey response rate of the study was about 62%, which was adequate for analysis and generalization purposes. Statistical Package for Social Sciences (SPSS) was mainly used to perform data analysis which involved; cross tabulations, descriptive statistics, correlation and multiple regression analysis.

By use of mean scores and critical z-test, the study determined significant drivers influencing subdivision of agricultural land in the study area to be; agricultural land inheritance practices ($\overline{X}$ = 3.8, z = 42.32), individualization of titles ($\overline{X}$ = 3.7, z = 32.06), price/value of agricultural land ($\overline{X}$ = 3.2, z = 30.89), demand for urban housing ($\overline{X}$ = 3.2, z = 26.54) and future expectations on the value of agricultural land ($\overline{X}$ = 3.2, z = 25.89), among others.

The results of correlation analysis of agricultural productivity of sheep/goats, cattle and maize against the agricultural land size using Pearson correlation (2-tailed) at 95% confidence level resulted to correlation coefficients of; r = - .216, p = 0.002; r = - .195, p = 0.005 and r = -.028, p = 0.002, respectively. The weak inverse association was further confirmed by the multiple regression coefficients whereby the relationship between sheep/goat and cattle productivity was determined to be B = - .003, p = 0.000 and B = - .001, p = .009, respectively. The B coefficients associated with maize productivity, and taking only crop land size (usually a portion of the total land size) into account, was found to be 1.247, p = .000. When the total agricultural land size was considered in the MRA model, however, the B coefficient was found to be - .001, p = .679, signifying an insignificant negative and weak correlation between the two variables.

This inverse weak relationship between agricultural land size and agricultural productivity confirms that anticommons properties are not necessarily tragic. The study, therefore, recommends that agricultural landowners be encouraged to practice modern and intensive agriculture such as zero grazing, use of more variable inputs, high value crops, mixed cropping and irrigation. Besides, the County governments should prescribe the allowable minimum agricultural land sizes in their areas of jurisdiction.

TABLE OF CONTENTS

TITLE...i
DECLARATION.. ii
ACKNOWLEDGEMENTS... iii
DEDICATION.. iv
ABSTRACT... v
TABLE OF CONTENTS... vii
LIST OF TABLES.. xii
LIST OF FIGURES AND BOXES.. xiv
LIST OF ABBREVIATIONS.. xv
CHAPTER ONE.. 1
INTRODUCTION.. 1
1.1 Background of the Study.. 1
1.2 Problem Statement.. 6
1.3 Research Questions... 11
1.4 Objectives of the Study.. 11
1.5 Study Hypotheses.. 11
1.6 Significance of the Study.. 12
1.7 Scope and Limitation of the Study... 13
1.8 Structure of the Study... 14
1.9 Operational Definition of Key Terms.. 15
1.10 Chapter Summary.. 17
CHAPTER TWO.. 20
AGRICULTURAL LAND SUBDIVISIONS: THEORIES AND TRENDS................... 20
2.1 Introduction.. 20
2.1.1 The Concept of Agricultural Land Subdivision (ALS)................................... 20
2.1.2 Agricultural land subdivision and urbanization trends................................ 23
2.2 Theoretical Underpinnings.. 26
2.2.1 Urbanization theories and agricultural land subdivisions............................ 27
2.2.2 Smart growth theory.. 27
2.2.3 New urbanism theory... 28
2.2.4 New ruralism theory... 29

2.2.5 Neo-liberalism theory 30
2.2.6 The spatial anticommons 32
2.2.6.1 Spatial anticommons in agricultural lands 36
2.3 Drivers of Agricultural Land Subdivisions 42
2.3.1 Natural environmental factors 43
2.3.2 Economic and technological factors 44
2.3.3 Demographic factors 44
2.3.4 Institutional factors 45
2.3.5 Cultural and social factors 45
2.3.6 Political and legal factors 46
2.4 Chapter summary 47
CHAPTER THREE 50
AGRICULTURAL LAND SUBDIVISIONS: IMPLICATIONS ON PRODUCTIVITY 50
3.1 Introduction 50
3.2 Economic Implications of Agricultural Land Subdivisions 52
3.2.1 Implications on agricultural productivity 52
3.2.2 Determinants of agricultural productivity 55
3.2.3 Determinants of minimum agricultural land sizes 56
3.2.4 Other economic implications 56
3.3 Social Implications of ALS on the Rural Communities 58
3.4 Policy Interventions to Manage Agricultural Land Subdivisions 59
3.4.1 Large plot zoning 60
3.4.2 Adequate public facilities requirement 61
3.4.3 Development moratoria 63
3.4.4 Land banking 64
3.4.5 Property taxation 65
3.4.6 Land subdivision regulations 66
3.4.7 Agricultural land zoning 67
3.4.8 Purchase and/or transfer of development rights (PDRs/TDRs) 68
3.4.9 Ballots prior to the approval of large scale agricultural land development projects... 69
3.4.10 Agricultural land consolidation 69
3.5 Chapter Summary 71

CHAPTER FOUR 73

TOWARDS A THEORETICAL AND CONCEPTUAL MODEL 73

4.1 Introduction 73
4.2 Summary of Theories of Agricultural Land Subdivision 74
4.3 Summary of Drivers of Agricultural Land Subdivision 75
4.3.1 Natural/environmental/physical drivers 75
4.3.2 Economic and technological drivers 76
4.3.3 Demographic drivers 79
4.3.4 Land institutional drivers 79
4.3.5 Sociocultural drivers 79
4.3.6 Political and legal drivers 80
4.4 Summary of Implications of Agricultural Land Subdivision on Productivity 81
4.5 Summary of Policy Interventions to Manage ALS 81
4.6 Conceptual Model 82
4.7 Chapter Summary 85

CHAPTER FIVE 86

RESEARCH METHODOLOGY 86

5.1 Introduction 86
5.1.1 Background to the study area: Kitengela division, Kajiado County 86
5.2 Research Design 89
5.2.1 Target population, sample size and sampling techniques 91
5.2.2 Data types, collection tools and sources 97
5.2.3 Study variables 100
5.3 Data Analysis and Presentation 103
5.3.1 Trends and drivers of agricultural land subdivisions 104
5.3.2 Implications of agricultural land subdivision on productivity 107
5.4 Validity and Reliability 109
5.5 Chapter Summary 111

CHAPTER SIX 113

TRENDS OF AGRICULTURAL LAND SUBDIVISIONS IN KAJIADO COUNTY 113

6.1 Introduction.. 113
6.1.1 Land administration and management practices in Kenya............................ 113
6.2 Survey Response Rate 117
6.3 Socioeconomic Characteristics of Agricultural Landowners...................................... 118
6.3.1 Age of agricultural landowners 118
6.3.2 Level of education of agricultural landowners 119
6.3.3 Income of agricultural landowners.. 120
6.3.4 Number of adult family members 121
6.4 Trends of Agricultural Land Subdivisions in Kajiado County.................................... 122
6.5 Drivers of Agricultural Land Subdivisions in Kajiado County 133
6.6 Discussion of the Main Drivers of Agricultural Land Subdivision.............................. 143
6.7 First Hypothesis Testing 151
6.8 Chapter Summary.. 152
CHAPTER SEVEN.. 154
IMPLICATIONS OF AGRICULTURAL LAND SUBDIVISION ON PRODUCTIVITY IN KAJIADO COUNTY... 154
7.1 Introduction.. 154
7.2 Implications of Agricultural Land Subdivisions on Productivity in Kajiado County... 154
7.2.1 Cross tabulation analysis 155
7.2.2 Correlation analysis (CA) 166
7.2.3 Multiple regression analysis (MRA).. 171
7.3 Discussion on Implications of Agricultural Land Subdivision on Productivity........... 188
7.4 Second Hypothesis Testing.. 192
7.5 Chapter Summary.. 194
CHAPTER EIGHT 196
SUMMARY OF MAIN FINDINGS, CONCLUSIONS AND RECOMMENDATIONS........ 196
8.1 Introduction.. 196
8.2 Summary of Main Findings.. 197
8.2.1 Trends and drivers of agricultural land subdivision.. 197
8.2.2 Implications of agricultural land subdivision on productivity.......................... 198
8.3 Conclusions.. 200

8.4 Policy Recommendations 202
8.5 Areas of Further Study 205
REFERENCES 206
APPENDICES 226
Appendix 1: Questionnaire to agricultural landowners 226
Appendix 2: Estimated/proposed Minimum and Maximum Land Holding Acreages per Household in Kenya 233
Appendix 3: Relative Percentage of Agro-Climatic Zones Coverage per County in Kenya 236
Appendix 4: The Agro-Climatic Zones Map of Kenya 238
Appendix 5: Kenya's Agro-Climatic Zones and Maize Productivity 239
Appendix 6: Amount of Rainfall Received in the Study Area 240
Appendix 7: Map of Kenya showing location of Kajiado County 241
Appendix 8: Google Image of the Study Area - 2006 242
Appendix 9: Google Image of the Study Area - 2015 243

LIST OF TABLES

Table 2.1 Minimum agricultural land holding ceilings in selected countries…...................22

Table 5.1 Summary of study sampling techniques and sample sizes……………………….....96

Table 5.2 Summary of study methodology……………………………………......................99

Table 5.3 Summary of study dependent and independent variables………………………101

Table 5.4 Critical z-values at various confidence levels………………………......................106

Table 6.1 Survey response rate……………………………...117

Table 6.2 Trends of agricultural land subdivision in Kajiado County………………………122

Table 6.3 Land holding acreages per landowner in the study area…………………………124

Table 6.4 Land under crop production in the study area…………………………………127

Table 6.5 Summary of land holding acreages in the study area in 2016…………………128

Table 6.6 Trends of agricultural land sizes per landowner in the study area……………129

Table 6.7 No. of subdivision consents issued in Kajiado East Sub-county……................130

Table 6.8 Applications V. Consents for subdivisions in Kitengela division………………...131

Table 6.9 Significant drivers of agricultural land subdivisions in Kajiado County………134

6.10 Hypothesis testing using critical and calculated z-values…………………………...139

Table 7.1 Agricultural land sizes V. agricultural productivity in 2016……………………155

Table 7.2 Livestock production and productivity trends in Kajiado East Sub- County….157

Table 7.3 Maize production & productivity trends in Kajiado East Sub-county…………159

Table 7.4 Change in sheep/goat productivity after agricultural land subdivision………161

Table 7.5 Change in cattle productivity after agricultural land subdivision………………163

Table 7.6 Change in maize productivity after agricultural land subdivision…..................165

Table 7.7 Summary of descriptive statistics on dependent and independent variables…167

Table 7.8 Summary of correlation analysis…………………………...............................169

Table 7.9 Multicollinearity diagnosis using correlation coefficients………………………172

Table 7.10 Multicollinearity diagnosis using collinearity tolerance and VIF……………….173

Table 7.11 Sheep/goat productivity MRA results (model summary)……………………….176

Table 7.12 Sheep/goat productivity: Analysis of variance (ANOVA)……………………...176

Table 7.13 Sheep/goat productivity MRA results (model coefficients)……………………...176

Table 7.14 Cattle productivity MRA results (model summary)……………………………179

Table 7.15 Cattle productivity: Analysis of variance (ANOVA)……………………………179

Table 7.16 Cattle productivity MRA results (model coefficients)……………………………179

Table 7.17 Maize productivity MRA results (model summary)……………………………181

Table 7.18 Maize productivity: Analysis of variance (ANOVA)……………………...................181

Table 7.19 Maize productivity MRA results (model coefficients)……………….....................181

Table 7.20 Agricultural land size MRA results (model summary)…................................184

Table 7.21 Agricultural land size: Analysis of variance (ANOVA)…..................................185

Table 7.22 Agricultural land size MRA results (model coefficients)…...............................185

Table 7.23 Summary of local land use practices in the study area……………..................190

LIST OF FIGURES AND BOXES

Figure 2.1 The full spectrum of property rights……………………………………......................35

Box 2.1 Typical drivers of agricultural land subdivision…………………………..................49

Figure 4.1 Conceptual framework………………………………………………………………...83

Figure 5.2 Location of Kitengela division in Kajiado County……..89

Box 5.1 Sample size for agricultural landowners and land parcels……………...................94

Figure 6.1 Trends of land subdivision in the study area…………………………...................123

Figure 6.2 Land holding acreages per landowner in the study area…………….................125

Figure 6.3 Land under crop production in the study area……………………………………...127

Figure 6.4 No. of consents issued in Kajiado East Sub-County………………...................131

Figure 6.5 Applications V. consents for subdivision in Kitengela division…………………132

Figure 7.1 Agricultural land sizes V. agricultural productivity………………………………156

Figure 7.2 Livestock production and productivity trends in Kajiado east Sub-County….158

Figure 7.3 Maize production and productivity trends in Kajiado east Sub- County…..…160

Figure 7.4 Change in goat/sheep productivity after agricultural land subdivision………162

Figure 7.5 Change in cattle productivity after agricultural land subdivision……………...164

Figure 7.6 Change in maize productivity after agricultural land subdivision……..............166

LIST OF ABBREVIATIONS

ACZ – Agro-Climatic Zone

ALS - Agricultural Land Subdivision

ALT – Agricultural Land Transformation

APFOs – Adequate Public Facilities Ordinances

ASALs – Arid and Semi-Arid Lands

ASDS – Agricultural Sector Development Strategy

CA – Correlation Analysis

CPRE – Campaign to Protect Rural England

DNLUP – Draft National Land Use Policy

EARB – Estate Agents Registration Board

FAO – Food and Agriculture Organization of the United Nations

GDP – Gross Domestic Product

GoK – Government of Kenya

HA – Hectare

HA = Alternative Hypothesis

Ho = Null Hypothesis

Ke – Kenya

KNBS – Kenya National Bureau of Statistics

MMLH - Minimum and Maximum Land Holding Bill

MRA – Multiple Regression Analysis

NCA – National Construction Authority

NIMBY – Not In My Back Yard

NSP – National Spatial Plan

PP - Physical Planning

PDRs/TDRs – Purchase and/or Transfer of Development Rights

RLT – Rural Land Transformation

SDGs – Sustainable Development Goals

SPSS – Statistical Package for Social Sciences

UK – United Kingdom

UNDP – United Nations Development Programme

USA – United States of America

VIF – Variance Inflation Factor

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Efficient, optimal and sustainable agricultural production, including extensive pastoralism systems, requires large contiguous land to enable economies of scale and synergy (Robson, 2012). These requirements may be absent when the agricultural land is privately owned in small sizes and fragmented by idle lands or non-agricultural land uses. Therefore, subdivision and fragmentation of agricultural land may lead to increased agricultural production costs and negative change in agricultural productivity resulting to a tragedy of spatial anticommons (GoK, 2009; 2017; Heller, 1998; Henry *et al.*, 2012; Lee, 1999; Robson, 2012; Syagga & Kimuyu, 2016).

In Kajiado County, for instance, Syagga & Kimuyu (2016) established that the minimum agricultural land size should be approximately 6.39Ha. This minimum agricultural land size is required for maize (Kenya's staple crop) production to support an average sized household in the County. Thus, subdivisions of agricultural land in Kajiado County below the above benchmark may transform the agricultural land into unproductive asset. Besides, such agricultural land subdivisions may occur in remote areas without basic services to support alternative land uses such as residential user. Essentially, such agricultural land subdivisions may be untimely and may not benefit either the agricultural landowner or the community at large. In addition, the subdivisions of agricultural land into small units, sometimes below economic sizes may eventually occasion conversions of agricultural land into non-agricultural uses thus reducing agricultural land base (Museleku, 2013).

There may be no consensus on what should be the minimum/economic size of agricultural land but it is globally acknowledged that small agricultural land sizes may have negative impact on agricultural productivity. Besides, intensification of agricultural production (use of more variable inputs such as fertilizer on fixed size of land) has a limit due to the law of diminishing marginal returns. Therefore, various countries in the world, Kenya included, have attempted to regulate on minimum agricultural land sizes (see table 2.1). Generally, however, minimum floor ceiling on agricultural land size has been pegged at 1ha (approximately 2.5 acres) or more depending on various factors like whether the agricultural land is irrigated or arable, type of crop planted, scale of operation, among other factors.

Worldwide, about 3.4 billion people (46 per cent) of the world's population live in rural areas. This number is expected to decline to 3.2 billion (34 per cent) by 2050. Africa and Asia, however, are mainly rural with 60 and 52 per cent of their inhabitants living in the countryside, respectively. The two continents account for 90 per cent of the world's rural population with India and China having the biggest rural populaces at over 850 million and over 630 million, respectively. Similarly, the number of people living in rural areas in Africa and Asia is projected to drop to 44 and 36 per cent by 2050, respectively (United Nations [UN], 2014).

The above trends imply that the world is urbanizing, including the less developed nations like Kenya. There is need, however, to put in place policy measures to improve lives of both urban and rural populations (UN, 2014). Thus, agricultural land is a key resource to land based economies to support rural economies and guarantee a smooth transition to inevitable urbanization. Besides, rural areas are important for food and material provision to the urban dwellers hence agricultural land will always be an important factor in any country's economic development. Urbanization, nevertheless, occurs through a process which involves agricultural land subdivisions and subsequent land use conversions hence the need for nations, especially whose majority populations live in rural areas, to manage untimely, unproductive and unsustainable transformation of agricultural land.

Globally, agriculture remains the single largest employer and provides livelihoods for more than 40 per cent of the globe's population. Besides, agriculture is the world's largest source of income and jobs for rural communities. Agricultural land, therefore, remains a key resource for the rural communities as well as urban dwellers. Thus, the size of agricultural land is as important as the distribution and access to this resource.

Over 80 per cent of Kenya's population reside in rural areas and obtain their livelihoods from agricultural land. The agricultural sector in Kenya directly contributes about 26 per cent to the Gross Domestic Product (GDP) annually and accounts for approximately 65 per cent of the national total exports. It creates over 70 per cent of informal employment opportunities in the rural areas thus making it a backbone of Kenya's economy. Agricultural land in Kenya plays a key role in poverty reduction in the lives of vulnerable groups such as the pastoralists and subsistence farmers who derive their livelihoods mainly from agricultural activities (GoK, 2009; 2017).

Kenya's landmass is approximately 582,646 square kilometres of which about 98 per cent is land and 2 per cent is water surface. Only about 20 per cent of Kenya's land is arable while the bulk of the land (over 80 per cent) is arid or semi-arid (ASALs). Besides, about 75 per cent of the Kenya's populace reside in the arable lands, thus contributing to high population densities in those lands (GoK, 2009). Essentially, the medium to high potential agricultural land in Kenya is already subdivided into small units which may be uneconomical.

A study carried out by Syagga & Kimuyu (2016) (see appendix 2) established that some areas with medium to high potential agricultural land in Kenya can only accommodate 0.4ha as the minimum agricultural land size. This minimum ceiling is already below the global benchmark and the proposed Kenyan minimum size of 1ha (GoK, 2015b). Besides, Kenya is currently formulating a policy to reverse agricultural land subdivisions especially in the high potential lands through land consolidation efforts. The above facts suggest that Kenya's future potential in terms of agricultural expansion and urban development lies in the ASALs and there is every need to appreciate that potential presently. This may be more important to Kenya since she is food insecure and her economy is mainly land based.

Globally, drylands cover about 40 per cent of the world's surface and sustain approximately 2 billion persons of whom 90% live in developing countries, commonly found in Asia and Africa. Consequently, drylands support both agricultural and urban populations whereby approximately 1 billion people directly derive their day-to-day existence from rain-fed or irrigated farming or pastoralism or agro-pastoralism (UN, 2011). Cities like Cairo, New Delhi and Mexico City are built on drylands. Most of the dry lands in the world are used for livestock production in form of pastoralism. The number of pastoralists in the world is estimated at around 200 million, out of which about 180 million (90%) are found in Africa (37%), Asia (45%) and South America (18%), with China and Pakistan having the highest number of pastoralists at 19.5 million and 15.7 million, respectively (Thornton *et al.,* as cited in Behnke and Freudenberger, 2013; UN, 2011).

The ASALs in Kenya have been mainly used for extensive livestock systems, predominantly pastoralism. More than 50 per cent of livestock in Kenya is sourced from ASALs (Njonjo Commission, as cited in GoK, 2017). Besides, the ASALs in Kenya support approximately 30 per cent of the republic's population, 50 per cent of the livestock sector and 70 per cent of the wildlife that act as tourism attractions (GoK, 2017). Consequently, livestock production is a key component of agriculture locally and globally.

Agricultural land in Kenya, including ASALs, however, is being subdivided into small sizes (sometimes below 1ha) despite the enormous importance it has on economic development. At the national level, the average farm size is approximately 2.5ha, with 98 per cent of agricultural land sizes being about 1.2ha (The Centre for Land, Economy and Rights of Women, 2006; Syagga & Kimuyu, 2016). The small agricultural land sizes are mostly found in the medium to high potential agricultural lands. This phenomenon has raised concerns among land administrators and managers, policy makers and general public that such transformations may impact negatively on the productivity of the agricultural land (GoK, 2009; Kelleher, *et al.*, 1998). The impact of such transformations may be more pronounced in vulnerable groups such as the pastoralists who directly rely profoundly on agricultural land as their core source of livelihoods.

The governor of Trans-Nzoia County, one of Kenya's grain baskets, aptly commented on the problem of agricultural land subdivisions into small sizes in Kenya as follows;

"People are creating slums in the rural areas by way of subdividing agricultural land into uneconomic sizes and sometimes subsequently converting agricultural land into other uses…The European countries have moved out of the farms but agricultural land in Kenya is very critical for employment and poverty alleviation. Our economy is tied to the land. Measures that are agreeable to the people should be established to curb this problem".

Therefore, agricultural land subdivision into small sizes (sometimes into less than 1ha) is a key rural land development challenge in Kenya and world over (GoK 2009; 2017; 2010a; 2016b; Lee, 1999; Mabea, 2014; Syagga & Kimuyu, 2016). The current debates and efforts by both the Kenyan national and county governments are further testimonies to this fact. At the national level, the government is enacting a law to recommend the minimum and maximum land ceilings in Kenya and is also formulating a National Land Use Policy to streamline land use matters in the country (GoK, 2017; 2015b). At the County government level, Counties have adopted various measures to control agricultural land development including extra-legal instruments such as development moratoria to ban agricultural land subdivisions and conversions.

Since the main concern of agricultural land subdivisions into small sizes is on their impact on productivity, there is need to determine whether this is the case in Kenya. Essentially, the policy makers and scholars are concerned that subdivisions of agricultural land into small sizes may be transforming the land into an underproductive asset leading to a tragedy of spatial anticommons. Besides, the success of the local land administrators and managers in controlling uneconomical agricultural land subdivisions (dictating the time and amount/level of agricultural land development) may lie with understanding the trends and drivers of this phenomenon. This is because landowners/property developers are key decision makers in land development (McDonagh, 1997).

Previous studies have shown in other countries that there is no universal correlation between agricultural land size and agricultural productivity, hence the need to study the applicable relationship in a particular locality (Lee, 1999; Henry et al., 2012; Randall et al., 2005; Syagga & Kimuyu, 2016).

1.2 Problem Statement

Traditionally, agricultural land in Kenya was owned and used communally and individuals did not have power to subdivide and sell off portions of the land. This tenure arrangement has however mostly changed since privatization of agricultural land through secure private land tenure has been noted to spur economic development. This is due to the fact that the agricultural landowners are able to access credit using their titles as security hence investing more in their land (UN, 2011; Mensah, 2015; Vien, 2006). Once the communal agricultural land is privatised, individual farmers/landowners acquire the right to subdivide and dispose the land. In other words, private land rights are likely to promote property market by making agricultural land tradable in the market.

An interesting phenomenon in development of private agricultural land in Kenya is subdivision of land into small parcels, even in drylands. Private ownership of land grants owners with power to exclude others from access and use thus restricting one to his/her land parcel. Besides, the resultant small parcels could be enclosed by fencing them off thus physically hampering livestock movement in search of resources and/or restricting the scale of agricultural production. Moreover, the small agricultural land parcels could be located in remote areas without basic services to support alternative land uses (Njeru, 2017).

According to Heller's (1998) anticommons theory, when too many profit maximising individuals are endowed with exclusion rights in a scarce resource they are likely to waste the resource by underutilizing it as they tend to block each other from access and use leading to a tragedy of spatial anticommons. Anticommons properties are, however, not necessarily tragic thus there is need to understand the phenomenon of subdivision of private agricultural land into small units and their implications on the agricultural productivity.

Subdivision of agricultural land into small sizes is not a unique land development challenge to Kenya rather it is a global concern. Regions and countries including North America, Europe, Canada and the UK (Henry, 2012; Kelleher *et al.*, 1998), India and

China (Mearns, 1999), New Zealand (Lee, 1999), among others, are facing this challenge. In Africa, this phenomenon is common place. Countries such as South Africa (Adams *et al.*, 1999), Rwanda (Syagga & Kimuyu, 2016), Nigeria (Famoriyo, 1978), among others, are grappling with challenges of agricultural land subdivision.

The global concern about subdivisions of agricultural land into small sizes, however, has been mainly on the medium to high potential or 'good' agricultural land. It is the opinion of this thesis that Kenya's concern regarding subdivisions of agricultural land into small sizes cannot be limited to the arable or 'good' agricultural land since most of her land is ASALs.

In Kenya, the National Land Policy (2009), the Constitution (2010), the Land Act (2012) and the National Land Use Policy (2017) have all identified subdivisions of agricultural land into small sizes as an area that requires research and attention of the scholars and land management authorities (GoK, 2009; 2010a; 2012b; 2017). Considering the number and sizes of households, land area for each agro-ecological zone (ACZ) in Kenya, land productivity and per capita maize consumption, the average minimum agricultural land size in Kajiado County, for instance, should be approximately 6.39ha (Syagga & Kimuyu, (2016).

The proposed floor land sizes in dry agricultural lands in Kenya may shift upwards if extensive livestock pastoralism is the main agricultural land use activity, as it is the case in Kajiado County and many other drylands in Kenya (see appendix 2). Despite this fact, agricultural land subdivisions in Kenya are sometimes being done below 0.05ha subplots and in areas without basic infrastructure to support alternative land use, contrary to the provisions of the Kenyan Constitution (2010), draft National Land Use Policy (2016) and the National Land Policy (2009), which require land to be used in an efficient, optimal, productive and sustainable manner.

From a global perspective, subdivision of agricultural land into small sizes may thus impact negatively on attainment of the Sustainable Development Goals (SDGs), especially on goals number 1 and 2: to end poverty and hunger respectively. Similarly, transformation of agricultural land through subdivisions into uneconomic sizes may hinder achievement of Vision 2030, Kenya's development blueprint. The economic and social pillars of the Vision 2030 are partly hinged on productive and sustainable use of land.

Although market forces could be responsible for influencing the trends and drivers of agricultural land subdivision, studies have shown that market approaches to land development control do not take into account the interests of the community and thus they cannot be relied on as the only option to regulate the property market (Pallagst, 2007). There is need, therefore, to understand the trends, drivers and implications of agricultural land subdivision on productivity in a particular locality to inform policy interventions.

Different scholars have studied different aspects of the phenomenon of agricultural land subdivisions in different localities. Henry *et al.* (2012) and Lee (1999) studied drivers and impacts of agricultural land subdivisions in parts of rural New Zealand on the farmers. They found out that the farmers had been affected negatively by the phenomenon. The impacts of agricultural land subdivisions were in terms of environmental, economic and societal and depended largely on the different viewpoints of the stakeholders involved. Some of the impacts the farmers termed as negative, for example, were viewed by other stakeholders such as property developers as positive. They noted, however, that some positive impacts cannot be expressed in monetary terms such as a serene living environment with beautiful scenic views.

Similarly, researches have been carried out in Europe, UK, North America, among other places, on the phenomenon of agricultural land subdivisions (Henry *et al.*, 2012). The focus of these studies, however, has been on the 'good' or arable agricultural land and not on ASALs. Indeed, some respondents in these studies have supported subdivisions of agricultural drylands. Besides, these studies have appreciated the fact that drivers and impacts of agricultural land subdivisions are not universal thus there is need to understand applicable drivers and impacts in a particular locality due to different political, legal, economic and socio-cultural factors.

Locally, there are no known researches focusing on subdivisions of private agricultural land into small units. Besides, most of the research on subdivision of agricultural land in Kenya is skewed towards the arable agricultural land, as has been the case internationally. Heller (2008), who further developed and popularized the theory of anticommons after Michelmann (1982), observed that whereas there have been many theoretical comments and articles supporting his theory, there have been no empirical studies to test the theory. This thesis is partly filling that gap by determining the implications of subdivisions of private agricultural land on productivity.

Some of the available relevant local researches on this phenomenon include a study by Mwangi (2007) who investigated the drivers underlying Maasai's (pastoralists') support for privatization/individualization of their collective group ranches through subdivisions, contrary to the theoretical anticipation. Her study found out that the main drivers of this phenomenon were to tap the benefits associated with individual land tenure, mainly to enhance security of tenure for their land. These findings are reasonable given the historical land injustices occasioned by the colonial masters in Maasailand. This study, however, is on subdivisions of private agricultural land (after individualization/privatization of communal land tenure). Besides, Mwangi (2007) did not determine impacts of subdivision of communal land on agricultural productivity.

Jayne & Muyanga (2012) studied the influence of rising population density in central Kenya's agricultural land on small-scale farmer response and income distribution. Their research established that as rural population density increases, farm productivity rises up to about 625 square kilometres. After that edge, farm productivity and incomes decline sharply with increasing rural population density. Their study, however, did not establish the drivers of agricultural land subdivisions. Moreover, their study focused on the arable agricultural land.

Randall *et al.* (2005) looked at the impact of subdivisions of group ranches into smaller parcels in Kajiado District on quantity of wild animals, from ecological point of view. Their study found out that the phenomenon was inevitable and the quantity of wild animals and livestock was declining due to subdivision of group ranches land. Indeed, most of the group ranches land in Kenya are now subdivided and owned by private individuals. Kidemi (2007) carried out a research on the implications of land use change (conversions) on pastoralism in Olgulului Group Ranch in Loitoktok District, from a planning point of view. Her findings paralleled Randall's *et al.* (2005). These two studies, nevertheless, focused on communal land and not private agricultural land nor did they establish drivers of this phenomenon.

Ayonga (2008) examined the issue of land use conflicts and in-optimality in the peri-urban areas from a planning perspective. He concluded that until the subdivisions, conversions and sale/purchase of agricultural land are regulated land use conflicts in the peri-urban areas will continue to abound. Museleku (2013) evaluated the causes of agricultural land use conversions in the Nairobi-Kiambu urban fringe. The study focused on the causes of arable land conversions in the peri urban area and established that one of the key causes of agricultural land use conversions was subdivisions of agricultural land into small sizes hence the need to understand the drivers of private agricultural land subdivisions in Kenya and its implications on productivity.

Therefore, the existing local and international studies have largely focused on the arable agricultural land. Nevertheless, they all point to the fact that agricultural land subdivisions into small units are driven by different forces and their impacts on agricultural productivity are not uniform hence the need to understand specific drivers and impacts on agricultural productivity in a particular locality. Besides, there are no known studies on the impact of private agricultural land subdivisions on productivity in Kenya. Further, trends and drivers of such phenomenon have not been established

In view of the above, the study seeks to create knowledge on the phenomenon of subdivisions of private agricultural land into small sizes by establishing the trends, drivers and implications of agricultural land subdivisions on agricultural productivity in Kenya. It is assumed that this knowledge will help land administrators and managers to put in place informed policy interventions to control untimely, unproductive and unsustainable agricultural land subdivisions. The study, however, does not seek to determine optimal/economic agricultural land sizes since such a research would require a multidisciplinary approach.

The choice of the study area, Kajiado County, was purposive due to its location near the Nairobi City Centre, the largest urban area in Kenya which is likely to influence subdivision of agricultural land in the County. Urban population growth rate has been assumed to be the most significant driver of agricultural land subdivision in most rural lands situated near urban areas in Kenya. In addition, the study area was chosen because Kajiado County is largely (99%) arid and semi-arid (see appendix 3), which is the focus of this study.

1.3 Research Questions

i. What are the trends and drivers of agricultural land subdivisions in Kajiado County over the last 10 years?

ii. What are the implications of agricultural land subdivision on agricultural productivity in the study area?

iii. What policy interventions are necessary to manage agricultural land subdivisions in Kenya?

1.4 Objectives of the Study

The purpose of this study is to create knowledge on the phenomenon of subdivisions of private agricultural land into small sizes by determining the trends, drivers and implication of this phenomenon on productivity. It is assumed that findings of this study may inform future efforts in managing development of agricultural land. In particular, the study met the following specific objectives:

i. To examine the trends and drivers of agricultural land subdivisions in Kajiado County over the last 10 years
ii. To determine the implications of the agricultural land subdivisions on agricultural productivity in the study area
iii. To develop models to guide policy on subdivision of agricultural land in Kenya.

1.5 Study Hypotheses

Null Hypothesis (H_O) 1: Population growth rate is not the most significant driver of agricultural land subdivisions in Kajiado County.

Null Hypothesis (H_O) 2: There is no positive relationship between agricultural land sizes and agricultural productivity in Kajiado County.

Alternative Hypothesis (H_A) 1: Population growth rate is the most significant driver of agricultural land subdivisions in Kajiado County.

Alternative Hypothesis (H_A) 2: There is a positive relationship between agricultural land sizes and agricultural productivity in Kajiado County.

1.6 Significance of the Study

Generally, the discipline of land economics is devoted to the study of rural and urban land matters, natural resources, public utilities and housing. The broad aim of this study is to create knowledge on land administration and management as well as on economics of land use. The findings of this research will be of importance to the land economists and researchers who want to know more on the economics of agricultural land use and land administration/management policy guidelines. This is because the study will determine the trends, drivers and implication of agricultural land subdivisions on productivity. Particularly, land administrators/managers, real estate valuers, estate agents and property managers will directly gain from the findings of this study. Such knowledge would help them to offer informed professional advice to their clients.

Land administration and management policy makers such as the government, both at the national and county levels, appreciates the need to control land development to achieve balanced land development in urban, peri-urban and rural areas. A balanced land development may go a long way in achievement of Kenya's Vision 2030 which is premised on the economic, social and political pillars. This fact is demonstrated by various efforts put in place to address the issue of agricultural land subdivisions in the country. The current interventions, however, seem to produce little success as agricultural land continues to be subdivided into small sizes. Therefore, the land managers and policy makers seem to be grappling with this phenomenon hence the findings of this research may be important to the efforts to manage development of agricultural land.

The choice of the study area (Kitengela Division in Kajiado County) was purposive. The study area is mainly arid and semi-arid and the main agricultural activities are livestock pastoralism and crop production (Nkedianye, 2009). This is important since the study is investigating the trends, drivers and implications of agricultural land subdivisions on productivity (livestock and crop production).

Kajiado County is 99 per cent arid and semi-arid land, with only 1 per cent of the land being semi-humid (GoK, 2015b). See the average Agro Climatic Zone (ACZ) coverage for each County in Kenya in appendix 3. Therefore, the site represents most of the other agricultural drylands in Kenya, which fall under the same Agro Climatic Zones (ACZ). Besides, the phenomenon of agricultural land subdivisions into small plots has been noted to proliferate in the area whereby sometimes subdivisions are done below 1ha subplots and in areas where there are no basic services to support alternative land uses such as residential user (Ayonga, 2008; Koissaba, 2015; Mabea, 2014). Thus Kitengela division in Kajiado County was purposively selected as a case study to represent similar parts in Kenya.

1.7 Scope and Limitation of the Study

Generally, the scope of this study is limited to its objectives. The focus of this study is on the phenomenon of private agricultural land subdivisions into small sizes by establishing the trends, drivers and impact of the phenomenon on agricultural productivity in Kajiado County. The study is appropriate in rural areas since it is the rural residents and communities who are likely to be more affected by the phenomenon of ALS. This study would be unnecessary in urban areas because urban land subdivisions and conversions are truism. In addition, various land uses in urban areas are usually planned and many studies have been carried out on urban land issues.

This study was carried out within Kitengela Division (192.1 square kilometres) in Kajiado County. The physical scope, however, excludes the Kitengela Township/urban area comprising of 39 villages and is limited to the agricultural landowners/rural households, having 39 villages. The Division, excluding the urban area of Kitengela, represents the physical scope of the study, where the phenomenon of ALS has been noted to flourish. The study area represents similar areas in Kenya.

The impacts of ALS are usually environmental, economic and societal. The implications examined in this study, however, are mainly economic (agricultural productivity) since that has been the main global and local concern regarding subdivision of agricultural land into small sizes and also due to the limitation of the discipline of land economics. Thus, the study takes a land economics perspective. The study however does not seek to determine optimal/economic agricultural land sizes since such a research would require a multidisciplinary approach.

1.8 Structure of the Study

The thesis report is organized into eight chapters as follows.

Chapter ONE on *Introduction*, introduces the work by giving background of the phenomenon of ALS and outlines the research issues, purpose or the main objective, specific objectives and hypotheses. In addition, the chapter explains the significance of research, scope and definition of concepts. It also gives an outline of the organization of the thesis report.

Chapter TWO on *Agricultural Land Subdivisions: Theories and Trends* discusses in detail the relevant theories underpinning the study. The concept and trends of ALS are also discussed under this chapter. Drivers of agricultural land subdivisions as identified by other scholars elsewhere are also discussed.

Chapter THREE presents *Agricultural Land Subdivisions: Implications on Productivity and Policy Interventions*. Typical socioeconomic impacts were identified through literature review. The emphasis on the socioeconomic impacts, however, was on agricultural productivity. In addition, relevant policy interventions meant to manage agricultural land subdivisions are highlighted in this chapter.

Chapter FOUR, *Towards a Theoretical and Conceptual Model*, is a summary of chapters two and three. This chapter acts as a link up to the previous chapters and the subsequent chapters by presenting a conceptual framework, indicating interrelationship of the main study concepts and variables, to give the desired outcome.

Chapter FIVE on the *Research Methodology* discusses the study area and research methods used in the study including survey design, data collection tools and data analysis approaches adopted.

Chapter SIX on *Trends of Agricultural Land Subdivision in Kajiado County* analyses and presents data using the methods indicated in the preceding chapter to determine the trends and significant drivers of the agricultural land subdivision in the study area. The data analysis and presentation under this chapter is in line with objective number 1 of the study.

Chapter SEVEN on *Implications of Agricultural Land Subdivision on Productivity in Kajiado County* analyses and presents data using the methods indicated in chapter five to determine implications of the agricultural land subdivision on the productivity. The data analysis and presentation under this chapter is in line with objective number 2 of the study.

Chapter EIGHT on *Summary of Main Findings, Conclusions and Recommendations* reports on the study's main findings, conclusions and suggests appropriate policy interventions for managing ALS. Further areas of study are suggested in this chapter.

1.9 Operational Definition of Key Terms

Agricultural Land: Agricultural land generally refers to land that is located outside cities and towns and people live in relatively isolated and sparsely populated areas. In this study, agricultural land is therefore areas containing farms, pasturelands and scattered houses (Agatsiva, 2006; Kenya National Bureau of Statistics [KNBS], 2010; Moseley, 2003). The study's focus is on dryland or arid and semi-arid (ASAL) agricultural land. Thus, rural land and agricultural land are sometimes used interchangeably since the main rural land use is agriculture (crop farming and livestock production).

Urban Land: Urban land is land situated in an area with high density of man-made buildings or built environment compared to the areas nearby and has a minimum population of or more than 2,000 persons. Urban areas in Kenya therefore include urban councils, town councils, municipalities and cities (KNBS, 2010). Accordingly, Kitengela Township is excluded from this study even though it falls within the study area.

Dryland/Arid and Semi-Arid Lands (ASALs): These are drylands in regions with climates characterised by high temperatures (average annual temperature of 18^0C) and low rainfall below potential evapotranspiration. The focus of this study is on hot arid and semi-arid lands **(Agro-Climatic Zone V).** Various Agro Climatic Zones (ACZ) and maize productivity (Kenya's staple food) per ACZ for Kenya are shown in appendices 3, 4 & 5.

Agricultural Land Subdivision (ALS): In this study, ALS means division and creation of new exclusive private land rights in agricultural land. Such a land administration process may lead to agricultural land subdivisions into uneconomic sizes hence may transform agricultural land into an under/unproductive asset (Heller, 1998; Lee, 1999; Robson, 2012).

Private Agricultural Land: This refers to agricultural land that is owned by exclusive private individuals, usually created through a process of subdivision of communal/collective agricultural land (Njeru, 2017).

Agricultural Land Transformation (ALT): In this study, ALT denotes an economic transformation, rather than physical transformation, of agricultural land from a productive asset to an under/unproductive asset due to agricultural land subdivisions into small sizes thus signifying a presence of a tragedy of the spatial anticommons. According to Heller (1998), agricultural land is likely to be economically transformed if subdivided into small subplots which are owned by many rational profit-maximizing individuals, each acting separately to collectively waste a scarce resource (agricultural land).

Agricultural productivity: Agricultural productivity in this study is measured as a ratio of outputs to input (agricultural land). The agricultural output in this study is maize grain (Kenya's staple crop), measured by weight in kilogrammes. Besides, since agricultural drylands/ASALs in Kenya are principally used for livestock production, agricultural output is also measured by the carrying capacity/number of the livestock (cattle and goats/sheep) per unit land area. Carrying capacity denotes the area of natural pasture land that can support one animal throughout the year without exhausting the pasture (Syagga, 1994).

The key agricultural input in this study is agricultural land. Consequently, agricultural productivity will be measured by yield (kg/Ha) and carrying capacity (number of livestock/Ha).

Spatial Anticommons: This theory was first developed by Michelmann (1982) and later advanced and popularised by Heller (1998) to explain a scenario whereby too many rational profit-maximizing individuals, each acting separately, collectively waste a scarce resource by creating too many small subplots that are not efficient in production leading to underutilization of the land resource. One of this study's central objective is examining whether subdivisions of agricultural land into small sizes in the study area has resulted to a negative change in agricultural productivity (tragedy of spatial anticommons).

1.10 Chapter Summary

Chapter one has introduced the phenomenon of agricultural land subdivisions into small sizes. Negative economic transformation may occur (change of agricultural land into an under/unproductive asset) when private agricultural land is subdivided into small sizes and/or when the resultant subplots are situated in areas without basic infrastructure to support alternative land uses. This is a global agricultural land development challenge but is more important to the land based economies such as Kenya.

The chapter has also presented the study's problem statement by identifying a research gap that justifies the study. Research gap exists due to the fact that there is no known local or international research that has investigated the phenomenon of subdivisions of private agricultural land into small sizes in Kenya, especially in the dry agricultural lands. In addition, it has been shown that there is no universal law/relationship that relates land size and agricultural productivity. In other words, as Heller (1998) argued, anticommons property are not necessarily tragic, hence the need to establish the correct position in a particular locality. The findings of the previous studies have established either a positive or inverse correlation between land size and agricultural productivity. The hypotheses, significance, scope and definition of key terms used in the study have been highlighted. The proposed structure of the thesis report has been outlined as well.

There may be no consensus on what should be the optimal/minimum/economical size of agricultural land but it is globally acknowledged that small agricultural land sizes may have negative impact on agricultural productivity. This is evidenced by attempts by various governments in the world, Kenya included, to regulate on minimum agricultural land sizes. Generally, however, minimum floor ceiling on agricultural land has been pegged at 1ha (approximately 2.5 acres) or more depending on various factors like whether the agricultural land is irrigated or arable, type of crop planted, scale of operation, among other considerations.

Although market forces could be responsible for influencing the trends of agricultural land subdivision, studies have shown that market approaches to land development control do not take into account the interests of the community and thus they cannot be relied on as the only option to regulate land development. There is need, therefore, to understand the underlying drivers of agricultural land subdivision in a particular locality to inform policy interventions.

The next chapter discusses relevant theories explaining the phenomenon of agricultural land subdivisions. These theories have been adopted to support the study and study's findings are evaluated against them. The drivers of the agricultural land subdivisions are also identified and discussed in the next chapter, through review of relevant literature.

CHAPTER TWO

AGRICULTURAL LAND SUBDIVISIONS: THEORIES AND TRENDS

2.1 Introduction

Chapter one has introduced the study by presenting background to the study, problem statement, purpose and objectives of the study, study hypotheses and operational definitions of key terms. The previous chapter has generally helped in delineating and focusing the study for further investigation. This section explores in depth the concept of ALS by examining existing literature on theories explaining the phenomenon of agricultural land subdivisions into small sizes and drivers of this occurrence.

Discussion of the theories explaining agricultural land subdivisions helps in directing and focusing the study by anchoring it on a broad perspective while discussion of the drivers is important in identifying typical drivers/variables of agricultural land subdivisions that have been observed elsewhere. These drivers were then presented to the survey respondents to select the ones that are applicable in the study area and rank them according to their level of significance. This was necessary to determine significant drivers of ALS in the study area.

The purpose of the following discussion is to mainly establish whether there are universal concepts/theories that explain the phenomenon of agricultural land subdivisions into small sizes. First, the section commences with a discussion on the concept of agricultural land subdivision to enable the reader understand it better.

2.1.1 The Concept of Agricultural Land Subdivision (ALS)

Agricultural land subdivision means partition of agricultural land into two or more smaller subplots, mainly for sale or gift purposes (GoK, 1996). The new private subplots are usually issued with separate certificates of titles which enable the new owners to exclude others from access and use. Economic transformation of agricultural land may occur when the resultant subplots are too small to support optimal agricultural production or occur in a remote agricultural area where there are no basic infrastructural services to support alternative use of the agricultural land, thus making the agricultural land an underproductive asset or dead capital.

Thus, agricultural land subdivision is a land administration process that generates new land parcels with separate certificates of titles. The new titles can then be held by different owners (Lee, 1999). Consequently, the many new private landowners with small agricultural land sizes may end up not utilising their agricultural land and may block/exclude other people (community) who are willing to use the land.

The general concern about subdivisions of agricultural land into small sizes is their likely negative impact on agricultural productivity which directly impacts on the livelihoods of rural communities (Robson, 2012). The negative influence of subdivision of agricultural land on productivity would be more pronounced where farmers are not using technology (intensive land use practices) to improve productivity. The requirement of intensive land use practices, however, is likely to fail in the long run. Intensive agricultural land use practices have a limit due to the law of diminishing marginal returns. The law of diminishing marginal returns states that output (such as agricultural production/productivity) will increase when variable inputs (like fertilizers) are added to a fixed input (such as land) up to a point then the output will increase at a reducing rate/decline. Therefore, the government of Kenya, land managers, policy makers and the world over are concerned about subdivisions of agricultural land into small sizes (GoK, 2009; 2010a; 2015b; Syagga & Kimuyu, 2016).

Countries in the world have thus tried to regulate subdivisions of agricultural land (including drylands) into small sizes/below economic sizes by prescribing minimum land holding sizes. The table below shows minimum land holding sizes in selected countries in the world.

Table 2.1: Minimum agricultural land holding ceilings in selected countries

ASIAN COUNTRIES	
India	3.6 ha varying with the conditions and between states
Indonesia	5.0 ha irrigated land, 6.0 ha upland, varying according to population density
Nepal	2.7 ha for owner-cultivated holdings and from 0.5 ha for tenanted land
Japan	3.0 ha
Korea	3.0 ha
Taiwan	3.0 ha
The Philippines	1.2 ha
LATIN AMERICAN COUNTRIES	
Brazil	Less than 2.0 ha
Mexico	1.6 ha per cow on poor quality pasture land
AFRICAN COUNTRIES	
Egypt	1.0 ha
Rwanda	1.0 ha
South Africa	In the process of enacting a policy to prescribe land size holding ceilings
Kenya	1.0 ha, as per the Minimum and Maximum Land Holding Acreage Bill, 2015. Kenya, however, is in the process of enacting a law to prescribe land size holding ceilings

Source: Syagga & Kimuyu, 2016, with adaptations

From the above statistics, it is clear that subdivisions below 1ha are likely to be uneconomical for traditional/extensive agricultural production systems, from a global perspective. Prescriptions on the minimum land holding acreages have been based on various factors including crop types, soil type, weather patterns, whether the land is irrigated and government's discretions. In India, for instance, some crops are exempted from land ceiling such as vegetables, coffee, tea, cocoa and rubber. Mechanized farms are also excluded from land ceilings.

In dry agricultural lands, especially where livestock keeping is the main activity, however, the key consideration on fixing the minimum land holding size has been based on the land's carrying capacity. According to Syagga (1994), carrying capacity denotes the capacity of the natural pasture to support an animal throughout the year without straining the pasture. It is evident that minimum economic agricultural land sizes increase with decreasing quality/fertility of land, as is the case in Mexico. Worldwide, minimum land sizes have mainly been prescribed by way of legal provisions.

2.1.2 Agricultural land subdivision and urbanization trends

The phenomenon of agricultural land subdivision (ALS) into small sizes may be fuelled by expansion of urban areas which might sprawl into the surrounding rural areas (Bruegmann, 2006). This has been a general assumption in many countries. Bruegmann notes that the population density gradient of all the industrialising cities in the world, like Nairobi, has inclined to a similar arrangement whereby the urban population density of the city centre would rise during urbanization period and would remain heavily concentrated in the urban centres and their environs. Then, with continued economic growth and the expanding networks of public transport, urban population, especially the middle class, would slowly migrate towards the suburbs and surrounding rural areas, gradually reducing the urban population in the city centres.

This point of economic development is usually attained when a city reaches a specific phase of commercial growth. In London, for example, this point was reached in the first half of the 19th century, in Paris toward the end of the 19th century and in New York at the turn of the 20th century (Bruegmann, 2006). As urban residents look for housing in the rural areas surrounding urban centres, they are likely to raise demand for agricultural land thus encouraging subdivision of agricultural land, sometimes below economic sizes. The influence of urbanization on agricultural land subdivisions, however, may be more pronounced in peri-urban areas than in remote rural areas, as residential location theory dictates (McDonagh, 1997). The general assumption that the key driver of agricultural land subdivisions is due to expansion of urban areas may thus not hold true.

Concerns of influence of urbanization on agricultural land subdivisions through urban sprawl in United Kingdom, for instance, appeared first in an article in *The Times* newspaper in 1955 signifying a negative state of London's outskirts. Efforts to control agricultural land subdivisions in England, however, were made as early as 1934. Indeed, the city of London, Kolakowski *et al.* (2000) note, had been sprawling out of its medieval confines within the City centre since the 18th century, when the city experienced its first great urban surge. Areas to the west of Westminster, for instance, were increasingly built up for the wealthy people who chose to live in the suburbs of the city. In the United States, agricultural land subdivisions were influenced by both social and technological developments in the 19^{th} and 20^{th} centuries, particularly by the evolution of transportation routes, ethnicity and income of the residents (Kolakowski *et al.* 2000). These accounts demonstrate that agricultural land subdivisions into small sizes can be driven by diverse factors, including urbanization trends as the urban areas expand into the surrounding rural areas.

Due to the potential influence of urbanization on agricultural land subdivisions, efforts to address untimely transformation of agricultural land dates back to 1934 in United Kingdom. In the early 20th century, opponents of urban sprawl in the United Kingdom began to join their voices and formed movements like the garden city movement and campaign groups such as the Campaign to Protect Rural England (CPRE). In 1934, a proposal by the Greater London Regional Planning Committee was formally made to establish greenbelts to protect open spaces and recreational areas. As a result, the Town and Country Planning Act of 1947 was enacted to specifically incorporate green belts into all further national urban developments in the United Kingdom (Government of United Kingdom, 1947). In the United States, the first urban growth boundary was established in 1958 to control agricultural land transformation in Fayette County, Kentucky (Kolakowski, *et al.* 2000).

Agricultural land subdivisions, therefore, reflects decisions of individuals and groups hence the need to understand the drivers and impact of this phenomenon (Pollock, 2008; Found, 1971). Gibbs *et al.* (2013) and Wibberly (1959) noted that without proper rural and urban land management strategies, the explosive effects of potential urban demand intensify widely into the suburbs and rural areas. A large amount of rural land is thus held undeveloped/vacant anticipating (speculating) new higher value uses. Consequently, if there are no adequate urban and rural growth management strategies the use to which the rural land is put is finally decided by market forces (Alonso, 1964; Pollock, 2008; Wibberly, 1959). Market based approach to growth management is based on the decision-maker. While market forces may be efficient, they support inequality in areas with high property prices (Metcalf, as cited in Pallagst, 2007). This is because these consumer choices are not coordinated with each other and the single decision-maker is not required to take the impacts on the community as a whole into account (Metcalf, as cited in Pallagst, 2007).

Therefore, the needs of future generations (sustainable development) cannot be fully catered for by a market-based approach since it leaves out other considerations such as social and environmental needs. Thus, for rural land managers and policy makers to put in place effective policy interventions to manage ALS, there is need to gain more understanding on the phenomenon of agricultural land subdivisions, that is, to understand the motivations and challenges of the decision makers (mainly the agricultural landowners).

Global urbanization and population trends indicate that some agricultural land subdivisions will certainly occur. In Africa and Asia, however, this transformation may not occur in the immediate future. Besides, agricultural land is not only important to the rural communities but to the urban population and industries as well. Agricultural land will thus forever remain a vital economic component in supporting both the urban and rural populations. We must admit, nonetheless, that uncontrolled and untimely agricultural land subdivisions into small sizes may create new problems to the rural and urban communities and leave the old problems unresolved. Unrestrained and piecemeal subdivision of agricultural land that results in uneconomical agricultural land sizes may impact negatively on the agricultural productivity (Brower, 1976; Pollock, 2008; Robson, 2012).

2.2 Theoretical Underpinnings

Nachmias & Nachmias (2000), postulates that scientific theories help us explain and predict a phenomenon of interest to the researchers and as a result assist us in making intelligent and practical decisions. They contend that theory should therefore not be compared with practice but rather it relates to practice. Thus, theories are abstractions demonstrating particular aspects of the empirical world and they are concerned with "how" and "why" of the empirical phenomenon and not with philosophy. A theoretical framework therefore comprises interrelated concepts which form the structure and determine what things to measure and expected statistical relationships (Khan, as cited in Rukwaro, 2016). Theories therefore provide broad explanations and predictions of empirical phenomena.

The discipline of land economics deals mainly with economics of land use, a complex and difficult concept to understand due to many the variables involved. A single theory may thus not be sufficient to explain various aspects of land use economics. Consequently, several theories have been developed to explain how and why people use or misuse land the way they do, thus explaining predominance of land use patterns in a particular locality and drivers of land subdivisions.

Some urban land use theories explaining the process of urbanization could be adapted to explain the drivers and process of ALS to some extent, due to the potential influence of urbanization on ALS. Urban land use theories and concepts have thus been advanced to explain how an urban area should expand to avoid negative impacts of urbanization on the surrounding agricultural land. Besides, there are theories that have been put forward to explain the phenomenon and impact of subdivision of agricultural land into small sizes.

2.2.1 Urbanization theories and agricultural land subdivisions

Most of the urbanization theories point to the influence of urbanization on agricultural land transformation. The earliest agricultural land use theory was developed by Johann Heinrich Von Thunen in 1826, which has been adapted and advanced by other scholars to explain the location of various land uses in relation to the urban areas/city centre and the process of urbanization. The ecological succession theory (1916), Ernest Burgess' concentric rings (1923), Homer Hoyt's sector/wedge theory (1930), Harris and Ullman's multiple nuclei theory (1945) and William Alonso's bid rent theory (1964), among others, postulate that urban areas will always expand into the surrounding rural/agricultural lands and transform agricultural land through subdivisions and land use conversions into urban land uses (McDonagh, 1997).

The influence of urbanization on agricultural land transformation, however, may be more evident if the new agricultural land units are developed with new urban housing. In many parts of Kenya, nevertheless, agricultural land subdivisions into small sizes are sometimes not accompanied by development of urban housing or alternative land uses but instead the agricultural land remains vacant or 'undeveloped'. This may suggest that expansion of urban areas may not be a key driver of agricultural land subdivisions in Kenya. Besides, most of the above urbanization theories ignore the role of land use planning or the role of the land managers and technology in influencing land use patterns. Technology, for instance, has made integration of various land uses in the same piece of land possible. The urbanization theories therefore provide a general explanation of the tendency of urban areas to expand into the surrounding rural/hinterlands, especially if land development decisions are mainly decided by market forces.

2.2.2 Smart growth theory

The term smart growth is normally used in North America while in Europe and particularly the United Kingdom use terms such as compact city or urban intensification to describe the same concept. The concept of smart growth, which arose in 1970s, means building urban and suburban communities with housing and transportation near working areas and other facilities such as shops and schools (Gibbs *et al.*, 2013; Krueger, 2010). It acknowledges that growth must occur and provides how growth will be directed, mainly to the existing settlements. Therefore, smart growth minimizes urban sprawl and subdivision of agricultural land by advocating for compact urban areas.

The principles of smart growth include preservation of farmlands, open space and natural scenic views and directing land development towards existing communities. Other principles entail encouragement of mixed land uses, creating a variety of housing choices and involvement of public in land development decision making process, among others (Krueger, 2010). The concept of smart growth could thus be applied in both urban and rural areas. Accordingly, if the principles of this concept are adopted in land development matters then the phenomenon of ALS may be minimized.

The principles of smart growth provide broad policy action plans for the land administrators to adopt, specific interventions, however, are needed, for example, to ensure agricultural lands/farmlands are protected. Policy interventions in this respect could include management of agricultural land subdivisions, the focus of this study. The re-development and intensification of land use, mixed land uses, legislation on minimum and maximum land holding acreages in Kenya, among other land administration efforts, could be cited as some of the local aspirations of smart growth in Kenya.

2.2.3 New urbanism theory

The concept of new urbanism or simply urbanism arose in the United States of America in 1980s. Just like the concept of smart growth, it advocates for compact urban areas and cities as a remedy for urban sprawl and agricultural land subdivisions. Similarly, the principles of new urbanism parallel those of the smart growth; mixed land uses, mixed housing opportunities (types, sizes and prices), increasing land use density, re-development of brownfields, green transportation, among other principles (Calthorpe, 1993; Gibbs *et al.* 2013).

Compatible land uses, affordable housing initiatives, intensification of land use and re-development of low density or old residential estates could be cited as some of the local land development practices supporting the concept of new urbanism. One of the key objectives of these initiatives is to keep urban populations within urban areas thus protecting agricultural land in the rural areas by limiting aspirations of urban areas within the urban growth boundaries.

2.2.4 New ruralism theory

A new and innovative framework for protecting agricultural land from untimely and unsustainable subdivisions was proposed in 2006 in U.S. This concept is under review to arrive at an agreeable definition and its applicability. Kraus (2006) defines new ruralism as a framework for creating a bridge between sustainable agriculture and new urbanism. Newman & Saginor (2016), however, proposed new ruralism to be defined as a framework that creates grouped settlements in the rural areas/agricultural lands surrounded by profitable farms producing food systems. In this arrangement, the rural/agricultural lands are usually under pressure from expansion of the urban areas. In addition, the agricultural land should be viable for it to be protected from subdivision and transformation into urban land.

The rationale for new ruralism, Kraus (2006) notes, is based on the fact that for urban areas to thrive and endure, they need a vital local agricultural system that encompasses individual farms, rural communities and stewardship of natural resources. The final principles of new ruralism should be formulated along these lines. However, as it stands, Kraus (2006) further opined, agricultural lands, especially those near urban areas, face enormous challenges of subdivision and subsequent land use transformation. Generally, the objective of this concept is to preserve and enhance agricultural land since it is indispensable to the economic, environmental and social welfare of nations.

Kenya is in the process of formulating a land consolidation policy to enable clustered settlements in the rural areas and free up agricultural land for joint agricultural production. According to Newman & Saginor (2016), it appears Kenya should also ensure agricultural land is viable for the land consolidation policy to succeed.

Smart growth, new urbanism and the new ruralism concepts/theories advocate for common things: containment of urban growth and protection of agricultural land. The Kenyan National Spatial Plan [NSP] (2016) has also called for urban containment, smart growth and protection of agricultural land (GoK, 2016b). These concepts and the national spatial plan, therefore, stipulate how land development, including agricultural land subdivisions, should be carried out thus managing untimely, inefficient and unproductive subdivision of agricultural land. Fundamentally, they promote optimal, productive, efficient and sustainable agricultural production and productivity.

2.2.5 Neo-liberalism theory

The term neoliberalism was first invented by Alexander Rustow in 1938 during the worldwide Great Depression of 1930s which was attributed to failure of economic liberalism. McCarthy & Prudham (2004), observed that this theory is a complex mix of ideologies, discussion and institutional practices facilitated by highly specific class association and structured at various geographical scales. It is the re-emergence of early modern principles of liberalism which advocated for the superiority of private property, free choice in consumption and a minimal regulation role for the state. Indeed, the state is viewed as interfering with formerly free choices of the members of society (McCarthy & Prudham, 2004).

John Locke founded the idea of liberalism by asserting for the enclosure of land and access to natural resources for individual's use (Grant, 1987). Its objective was to restructure social relations to nature by enclosing commons to facilitate development of increasingly capitalist, export oriented agricultural operations.

Similarly, Raco (2005) supported this idea and contended that all humans have equal value in the society and each individual has the power and moral choice within them to plan their lives according to own goals and gratification. Consequently, these scholars supported the principles of neo-liberalism which include open, competitive and unregulated markets; commodification of everything and resentment towards state regulation which is seen as an unwelcome interference while at the same time requiring the state to protect property right and commodification. Others include restructuring fiscal and administrative functions based on market forces; devolved regulation to local or county governments that promote non-binding rules and self-regulation and individuals are entrepreneurial, self-made and ideal.

Raco (2005), however, highlighted the need for liberalism to be checked by the state to mitigate the challenge of discrimination and inequality brought about by individual gratification and market forces. He observed that the parasitic nature of neo-liberalism does not take into account its impacts on the communities thus producing winners and losers in the process. In land development matters, neo-liberalism is manifested through land use patterns characterised by policy failures and inadequate regulation, signifying a general development control challenge.

The neo-liberalism theory is to some extent applicable in explaining the phenomenon of agricultural land subdivisions in Kenya. Many governments in the world have heeded to Hardin's (1968) call to cure the problems of commons property by creating exclusive private property rights which are thought to be superior to communal ownership of property. Creation of exclusive private property rights was meant to encourage economic development by fostering competitive property markets which are largely driven by market forces with little interference from the state. Private property rights were, therefore, created to support the entrepreneurial nature of liberalists.

Therefore, the predispositions of neo-liberalists may in part explain drivers of agricultural land subdivisions. Besides, the governments and land managers seem to be reluctant or uncertain of how to manage subdivisions of agricultural land, suggesting minimal (ineffective) state regulation of private property or permission of free choice in consumption and market triumphalism. The individual private agricultural landowners appear to dictate the subdivisions of agricultural land into small sizes mainly for their own gratification or profit motive, with little concern about their impacts on the rural communities. Besides, the agricultural land appears to have been commoditised since sale of land was not common in African traditional set up as land was owned and used communally and had great social value.

Land markets in Kenya, however, are not open and/or unregulated. There are policy interventions both at national and county/local levels. In essence, the subdivisions of agricultural land into small sizes occur under the supervision of mainly local/county land administrators and managers. In addition, the devolved land administration and management to the county governments do not promote non-binding rules and self-regulation, since the county governments are controlling land development through measures such as development moratorium, approval of new land developments, approval of agricultural land subdivisions and conversions, among others. Thus, the role of the national and county governments in influencing agricultural land development patterns should be appreciated.

2.2.6 The spatial anticommons

The theory of the anticommons was first introduced by Frank Michelmann (1982) and then developed and popularized by Michael A. Heller (1998) to explain a situation whereby a resource has too many exclusive users who prevent others from utilizing it thus resulting to underutilization of the resource, to the detriment of the social welfare of the community (Heller, 1998). Michelmann (1982) defines anticommons property as " *a type of property in which everyone always has rights respecting the objects in the regime and no one, consequently, is ever privileged to use any of them except and particularly authorized by others".*

Heller (1998) in his article on 'the tragedy of the anticommons: property in the transition from Marx to markets, defines anticommons as *"a property regime in which multiple owners hold effective rights of exclusion in a scarce resource".* Thus, when too many owners hold exclusive private rights in a scarce resource like land, the resource is likely to be underused – a tragedy of the anticommons.

The theory of the anticommons mirrors the theory of the commons property whereby in a commons property too many users with the right of access and use to a given resource, and no user has exclusion rights over the others, lead to overutilization of a resource hence resulting to a tragedy of the commons. In this scenario, a community is impacted negatively by actions of many rational profit-maximizing individuals. Overgrazed common fields are examples of tragedy of the commons (Hardin, 1968). Thus, whereas the tragedy of the commons leads to overutilization, the tragedy of the anticommons leads to underutilization or suboptimal utilization of scarce resources.

Usually anticommons properties are accidentally created by governments when creating new property rights under political and economic problems. They appear when the government creates too many exclusive property rights and decision makers who end up physically and legally blocking each other from using a scarce resource. Thus, the anticommons could be legal or spatial. Heller (1998) explained legal anticommons by using a case study of empty storefronts in Moscow, Russia which had too many owners (council, planning committees, architects etc.) who ended up legally blocking each other from use thus resulting to empty/underutilized storefronts – a tragedy of the legal anticommons.

In spatial anticommons, *"each anticommons owner receives a core bundle of rights, but in too little space for the most efficient use in given time and space"* (Heller, 1998). Basically, the spatial anticommons explain land subdivisions into small sizes since the resultant subplots may be too small to support economies of scale in agricultural production and/or occur in remote areas lacking basic infrastructural facilities and services to support alternative land uses. Consequently, the small pieces of agricultural land may remain vacant or 'undeveloped' and may not benefit the individual agricultural landowners or the rural community at large.

Anticommons property rights may occur either simultaneously or sequentially. In simultaneous anticommons, multiple land rights holders exercise their exclusion rights independently but at the same time. Parisi *et al.* (2003) gives an example of several exclusive rights owners of small pieces of land that are required to be developed together in order to realize a joint venture project, like in agricultural land consolidation efforts. In this case, each owner holds and utilizes exclusion rights at the same level of decision making.

In sequential anticommons, however, the owners excise their exclusion rights in consecutive stages hence are at different levels of decision making. Essentially, in sequential anticommons, the multiple exclusive rights holders exercise their rights in succession, denoting a pyramid-like arrangement. Sequential legal anticommons would arise in land if a fragmented freehold/fee simple title is held by several owners who in turn grant exclusive leasehold rights to others. Anticommons in agricultural land in Kenya is likely to occur simultaneously since most of the lands are held under private freehold interests.

Anticommons property regimes are not necessarily tragic. In anticommons regime, if there are no transaction costs, the owners can bargain with each other and find ways to overcome the problem of anticommons property. In reality, however, there are transaction costs of even finding other owners who are willing to cooperate in pulling scarce resource together to overcome anticommons, for instance, in the case of land consolidation efforts. Secondly, communities locked in a system of anticommons can create informal strategies to manage anticommons property efficiently. In agricultural lands, for example, close-knit rural communities may informally agree not to fence off their small pieces of agricultural land so that they can be accessed and used for grazing as a whole. Thirdly, intensive land use practices (use of more variable inputs such as fertilizer on a fixed piece of land) could be used to circumvent tragedy. There is a limit, however, to intensive agricultural land use systems as dictated by the law of diminishing marginal returns. Finally, some properties are better managed as anticommons and not as private property such as roads.

Even though the anticommons properties may not be tragic now, Heller (1998) postulates that they will eventually be due to positive transaction costs, rational behaviours of users and lack of perfect information. In anticommons, too many rational individuals, each acting separately, collectively wastes scarce resource by underusing it, to the detriment of the society at large (Heller, 1998; Parisi et al, 2003). Figure 2.1 below illustrates the full property rights spectrum and the associated tragedies.

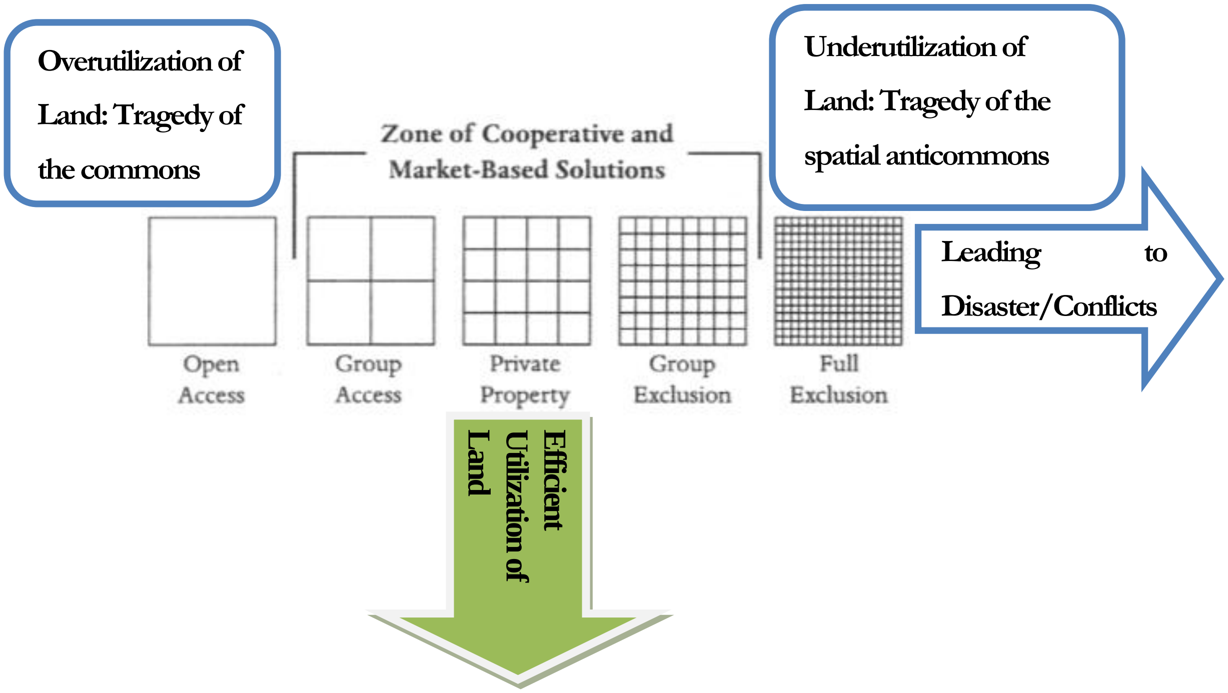

Fig. 2.1: The full spectrum of property rights

Source: Adapted from Heller, 1999.

Private property has been suggested as the appropriate remedy for commons property problem (Hardin, 1968). Private property rights in agricultural land grants the private owner with a right to further subdivide and transfer the agricultural land and may lead to full exclusion rights, resulting to underutilization of land - a tragedy of the spatial anticommons, as shown in fig. 2.1 above. It appears, therefore, private property rights in agricultural land are appropriate only if the land sizes can guarantee optimal and efficient agricultural production and productivity. Land administration, management and use practices are key in defining private agricultural land since without the right to exclude others physically and/or legally, private agricultural land could actually be a 'common property' in practice – only existing as private on paper. The same could apply in common agricultural land where some users could allocate themselves some land and exclude others.

Consequently, anticommons property regimes may bring more benefits to individual owners and fewer benefits to the community. An exclusive owner of a small sized agricultural plot benefits from excluding others by preserving the value of the plot for future sale (speculation) or for leasing it out in the future to earn rent, at the expense of the community at large. The costs of keeping the small agricultural plot undeveloped are less because the owner would only need to visit the site occasionally.

When the markets fail to correct problems of allocations in anticommons scenarios, economic losses are likely to occur in the form of underutilization or conflicts over the scarce resources. As Parisi *et al.* (2003) suggest, anticommons arise due to mismatch between the rights of use and exclusion.

2.2.6.1 Spatial anticommons in agricultural lands

The theory of anticommons explains a scenario whereby too many rational profit-maximizing exclusive users or individuals, each acting separately, collectively wastes a scarce resource by blocking each other from use leading to underutilization of resources (Heller, 1998; Michelmann, 1982). Spatial anticommons describe land subdivisions when *"each anticommons owner receives a core bundle of rights, but in too little space for the most efficient use in given time and space"* (Heller, 1998).

The theory of the spatial anticommons is tied to the property rights systems used to administer and manage land resources. In the context of land, property rights include right to determine the type of use, subdivide, exclude others and conditions under which these rights can be exercised. The tragedy of the spatial anticommons occurs when agricultural land subdivisions result to small subplots that cannot support agricultural economies of scale (Robson, 2012). This is because for agricultural land to produce certain level of output there is need to use a minimum agricultural land size. For maize production, Kenya's staple food, agricultural land in Kajiado County (agro-climatic zone V) should produce approximately 6.7 bags of 90kg per ha (FAO, 2006). Based on this productivity and the national per capita annual consumption of maize of 125kg, Syagga & Kimuyu (2016) established that the average minimum agricultural land required to support an average sized household in Kajiado County is 6.39ha.

Thus, if agricultural land in Kajiado County is subdivided below 6.39ha and the resultant subplots, using the same agricultural production systems and practices, produce less than 6.7 bags of 90kg per ha, that could signify a tragedy of the spatial anticommons. Essentially, an economic transformation of the agricultural land may occur if small agricultural land parcels cannot produce the expected productivity for a given agro-climatic zone.

Buchanan & Yoon (2000) postulates that agricultural land subdivisions may ignore agricultural production or the resultant agricultural subplots may be too small to support economic agricultural use hence resulting to tragedy of spatial anticommons. This often occurs, as Robson (2012) puts it; when individuals creating and exercising exclusive rights to agricultural land, through private agricultural land subdivisions, do not appreciate the productive use of the agricultural land resource. Alternatively, the individuals holding exclusive agricultural land rights may lack personal interest to invest or use the land thus failing to capture the potential benefits of the resource. This scenario does not benefit either the agricultural landowner or the rural community at large, resulting to a tragedy of spatial anticommons.

Previously, land in Kenya was mainly owned communally (mostly in group or community commons) and it could be managed and used by the entire community, to the benefit of individual and the community at large. This system of land ownership, however, was considered to be hindering economic growth due to problems of commons property. In an attempt to overcome this challenge, Kenya has continued to convert communal land rights to private land rights, as suggested by Hardin (1968). As a result, currently land rights in Kenya are mostly entrusted to individual private entities (GoK, 2010a).

The private property rights confer exclusive rights to hold, use, subdivide, sell and transfer property rights to the individual owner. Most of the agricultural lands held under communal land tenure regimes have been subdivided and allocated to individual owners in form of freehold/fee simple private titles. This, the government and policy makers assumed, would spur economic growth. While the private property rights may encourage economic growth, the system can also lead to subdivision and fragmentation of agricultural land resource into small uneconomic sizes, especially if the rights created are held by too many exclusive owners and in disjointed small quantities.

In Kenya, land is categorised into public, community and private (GoK, 2010a). Ownership of registered private land ensures exclusive possession and use of land, including agricultural land. This arrangement makes it easier for the agricultural landowner to trade in agricultural land. Whereas this regime encourages economic development, it may also lead to transformation of agricultural land through subdivisions into uneconomic sizes (Parisi, 2002). This may occur when each agricultural landowner subdivides their agricultural land without taking into account the complimentary benefits of the resultant agricultural land subplots.

In many parts of Kenya, agricultural land is being subdivided into small sizes which might be uneconomical (GoK, 2009; 2017). These subdivisions mainly occur on private land, most of which was created by subdivisions of communal agricultural land (Mabea, 2014; Nkedianye *et al.*, 2009). Changes in rural and urban populations are assumed to be the key drivers of these subdivisions. This is because social practices of land inheritance are likely to encourage subdivisions of agricultural land, sometimes into uneconomic sizes. Besides, expansions of urban areas into agricultural areas coupled with demand for affordable housing by the urban population are also expected to influence subdivisions of surrounding agricultural land. Most of the agricultural drylands in Kenya, however, have low population densities and some of the new agricultural land subplots remain largely vacant or 'undeveloped' hence putting to question these assumptions.

Subdivisions of agricultural land in Kenya into small subplots and subsequent sell-offs or gift to private individuals may create too many private holders of exclusive land rights, some of whom are absentee landlords. The new private agricultural landowners may hold different economic aspirations from the indigenous community. Since the private land rights are guaranteed and protected by the Constitution of Kenya (2010) and various legal systems, the new agricultural landowner may decide to fence off his land and leave it undeveloped for future trade in the value of the property (speculation purposes). Whenever too many such owners acquire land in a particular locality, agricultural land is fragmented and tragedy of the spatial anticommons may arise.

Agricultural land subdivisions into small sizes in drylands seem to ignore the productive potential of the dry agricultural land resource. Sometimes these subdivisions occur in remote areas that lack basic infrastructure to support alternative land uses or the resultant subplots are too small to support agricultural production. Therefore, the small agricultural land parcels remain largely vacant or 'undeveloped' since too many agricultural landowners hold plots of agricultural land that cannot individually support agricultural land use or alternative land uses, with potential to result to a tragedy of the spatial anticommons. Besides, this scenario may produce many agricultural subplots under dissimilar land uses whenever some are converted into other uses or in cases of absentee agricultural landlords.

When agricultural landowners compare the profits realized from sale of portion of their land and the time it would take to earn such profits from use of the land, it's only sensible that a rational owner will subdivide and sell-off a portion of his land to a willing buyer. Such decisions are based purely on profit-maximization motives (neo-liberalism propensities). As Robson (2012) opines, these decisions may appear harmless to the agricultural landowner but over time may produce too many small agricultural subplots that may not guarantee optimal agricultural productivity.

Agricultural production depends on use of land as a key input hence the size of agricultural land and distribution will impact agricultural productivity (Krugman, 1991). Thus, many small agricultural subplots may yield less output due to problems of diseconomies of scale and synergy, which may subsequently lead to increased cost of agricultural production. Large agricultural land or farms are likely to experience reduced average production costs as the overhead costs are spread over a large farm area. The marginal returns are likely to occur in such a scenario. Besides, farm mechanization is possible in large farms thus increasing agricultural productivity.

Big farms in one area are expected to experience economies of synergy (Marsden *et al.*, 2002). This is because it is possible to share information and knowledge, network and form cooperatives. Such an arrangement is likely to draw capital, markets for agricultural produce and infrastructure hence benefiting the landowners. When the sizes of farms are small and fragmented, however, economies of synergy are not possible.

Dry agricultural lands in Kenya are mostly used for livestock production whereby many communities practice extensive pastoralism system. As such, large tracts of land are required to sustain this system. Besides, the easiest way to expand the system is by way of acquiring more land to support the increased flock. A pastoralist who wants to increase livestock production by acquiring more land from the surrounding small fragmented plots is likely to incur more transaction costs since the small plots would be expensive to purchase, unlike buying one adjoining large parcel. If the pastoralist decides to operate several disjointed small farms, the farmer will likely experience more operational costs. In addition, the pastoralist may find it difficult to get land for sale near his farm.

Efficient livestock production and crop farming operate under economies of scale and synergy, which in turn reduce production costs. These requirements are usually possible when the agricultural land size is large and contiguous. Small and fragmented farm sizes may increase production costs and lower agricultural productivity, leading to a tragedy of the spatial anticommons.

In view of the preceding discussion, the tragedy of the spatial anticommons theory seems to provide the most compelling explanation on the likely impact of the phenomenon of agricultural land subdivisions into small land sizes on agricultural productivity. This is because subdivision of agricultural land into two or more small units which are eventually owned by different exclusive owners may be too small to support agricultural economies of scale or may be located in remote rural areas lacking basic infrastructure services to support alternative land uses. When this scenario happens, the small agricultural subplots remain 'undeveloped' and do not benefit either the exclusive agricultural landowner or the rural community at large, hence may lead to economic loss in form of underproduction resulting to a tragedy of spatial anticommons.

While the theory of the tragedy of the spatial anticommons explains the impact of the agricultural land subdivisions on the agricultural productivity, the urban land use theories and the neoliberalism seem to provide some explanation on the 'why' agricultural land subdivisions occur (possible trends and drivers of the phenomenon). Land development, however, is decided by many factors and some may not be presented by a universal abstraction.

From a global perspective, many governments have promoted exclusive private ownership of agricultural land, including drylands. Some governments, for example, have regarded pastoralism as a primitive way of life thus adopting exclusive land tenure system to stop the practice by limiting livestock's mobility in search of pasture and water. In Twentieth Century, Hardin's (1968) theory of the tragedy of the commons appeared to prove the misconceptions concerning pastoralism and effects of collective land tenure in agricultural lands/grazing fields. Hardin further suggested that the best cure for the tragedy of commons in agricultural land (collective/communal property land rights) was to create exclusive private property rights, through subdivisions of agricultural land and individualization of land tenure, so that the private property owners could equally bear negative effects of common property (overgrazing).

Moreover, Hardin's (1968) theory and the Sahelian drought of 1970s which led to death of many livestock and famine misled governments to believe that pastoral communities were indeed incompetent of communally managing their agricultural lands. Thus many governments, without knowledge and experience of managing delicate dry agricultural lands, usurped the powers of rural communities in management and administration of dry agricultural lands, a process that turned many drylands into an open access property (Behnke & Freudenberger, 2013). This process led to further deterioration of the agricultural drylands and rural communities.

Therefore, after independence, most African land tenure restructurings were mainly in form of individual private or group property rights. Kenya is cited as the country that created many government-regulated group ranches in East Africa in 1960s. In 1970s, however, these group ranches/communal drylands were subdivided resulting to exclusive private titles (Rutten, as cited in Behnke & Freudenberger, 2013). It is believed that the rural communities in drylands supported subdivision and privatization of communal drylands because they assumed that individual titles would mean greater tenure security (Ntiati, as cited in Behnke & Freudenberger, 2013).

By year 2000, however, many studies had shown that communal tenure in agricultural drylands is more appropriate since it led to increased livestock production (Lawry, Ostrom, Plateau, as cited in Behnke & Freudenberger, 2013), yet governments were encouraging exclusive individual land rights. Private exclusive rights in agricultural land may not be a bad thing but when the land sizes are too small, a tragedy of the spatial anticommons may occur (Heller, 1998).

Therefore, it appears that individual land rights in agricultural land are appropriate when the minimum land size is adequate to ensure efficient, optimal and sustainable production and productivity. This arrangement would grant benefits of private individual ownership to the rural landowners without interfering with agricultural productivity. Indeed, content of private land rights is as important as the security, as Heller (1998) noted.

2.3 Drivers of Agricultural Land Subdivisions

Identifying the drivers of ALS requires an examination and understanding of how people make land use decisions and how various factors interact in specific localities to influence their decision making process (Lambin *et al.*, 2003). The drivers of ALS vary with localities, for instance, the Scottish government (2009) categorised the drivers in rural Scotland under environmental, demographic, economic, technological, policy, institutional, cultural and social factors while Chazan & Cotter (2001) categorised drivers of ALS in United States as population and household size, personal housing style preferences (demographic), government policies and economic stimulus. Jiang *et al.* (2013), Lo and Yang (2002) and Liu *et al.* (2004) identified the same drivers of land subdivisions in China.

Lambin *et al.* (2003) generalised the drivers and broadly categorised them into natural/environmental changes, economic and technological, demographic, institutional, cultural and social factors. They went on to clarify that these drivers are either direct or indirect and agricultural land subdivision into small sizes and subsequent conversions in a locality is usually occasioned by a combination of several factors. Olson *et al.* (2004) concluded that agricultural land subdivisions and subsequent conversions of use in East

African countries, Kenya included, are generally occasioned by drivers such as government policies and laws, economic factors, population growth and migration, land tenure arrangements, market access and environmental conditions.

From these broad categories of drivers of agricultural land subdivisions, it seems that the following are the likely drivers in most localities.

2.3.1 Natural environmental factors

Physical or natural environmental changes have been observed to interact with the human decision making processes that cause ALS. Highly variable environmental conditions, for instance, usually occasioned by changes in climate are likely to magnify the pressures of agricultural land subdivisions (Olson *et al.*, 2004). Although other drivers, such as socio-economic factors may operate independently, natural environmental changes may interact with other drivers to influence ALS (Lambin *et al.,* 2003). Environmental factors are especially important due to their influence on agriculture, the main rural land use activity.

Specific and important environmental factors that may influence agricultural land subdivisions have been observed to include quality/fertility of the land, terrain/topography, location (for example near road networks) and climatic conditions (rainfall and temperature) (Chazan & Cotter, 2001; GoK, 2017; 2016b; Olson *et al.*, 2004). When the quality/fertility and topography of land and climatic conditions (rainfall and temperature) are favourable, landowners may not be willing to subdivide their agricultural land since agricultural activities may be viable.

Similarly, when farms are located near transport networks they can transport their farm produce to the market with ease hence encouraging them to preserve the agricultural land. Concomitantly, these variables are also favourable to real estate development and may encourage real estate developers to buy land from the local landowners for real estate development hence fuelling agricultural land subdivisions.

2.3.2 Economic and technological factors

Broadly speaking, economic factors influence agricultural land subdivisions through market forces; supply and demand for agricultural land (Lambin *et. al.* 2003). Since supply of land is usually static demand for it becomes important in influencing the phenomenon of ALS. Economic drivers may also interact with institutional factors and policies (McDonagh, 1997; Thuo, 2013; Olson *et al.*, 2004).

In particular, economic factors that are likely to influence ALS have been noted to include per capita income/poverty, demand for urban housing, agricultural productivity or farm-income and none/off-farm incomes (Ayonga, 2008; Chazan & Cotter, 2001; GoK, 2017; 2016b; Henry *et al.*, 2012; Lee, 1999; McDonagh, 1997, Nkedianye *et al.*, 2009). In East Africa, privatisation of former communal or group ranches has been stated as an important economic factor (Olson *et al.,* 2004). Per capita income/poverty may influence agricultural landowners to subdivide their land and sell to the property developers, especially if the returns from the agricultural activities and none/off farm incomes are not adequate to support their livelihoods.

Similarly, per capita income growth of the urban dwellers may encourage them to look for housing in the suburbs and nearby rural areas (away from pollution, congestion and general poor quality of life associated with urban areas), thus influencing demand for housing and increasing the rate of ALS. Technology is also likely to influence agriculture by intensifying land use and irrigation practices thus making it possible to maintain agricultural production and productivity levels after subdivision of agricultural land.

2.3.3 Demographic factors

Changes, either positively or negatively, in local populations are likely to influence subdivision of agricultural lands. Important demographic factors in agricultural land subdivisions have been observed to include urban and rural populations' growth rates and may interact with government policies and economic drivers (GoK, 2017; 2016b; Henry *et al.* 2012; Jayne & Muyanga, 2012; Lambin *et al.* 2003; Lee, 199; Olson *et al.*, 2004).

Lambin *et al.* (2003) noted that growth of urban aspirations and urban-rural population distribution are important factors in regional ALS within major urban centres, in peri-urban areas and even in remote rural areas. Increase in urban population puts land in the surrounding rural areas under a lot of pressure to transform to urban use such as residential use (Thuo, 2013) while increase in rural populations, for instance, may increase subdivisions of agricultural land through inheritance practices.

2.3.4 Institutional factors

Institutional factors mainly influence ALS indirectly but are influenced directly by political, legal and economic drivers and their interactions with individual landowner decision making. The use of resources such as agricultural land is facilitated by local and national policies thus institutions play a great role in the designation of property rights (Ayonga, 2008; GoK, 2017; Lambin *et al.*, 2003; Olson *et al.*, 2004; Thuo, 2013).

Olson *et al.* (2004) postulated that some of the key institutional factors that may influence agricultural land subdivisions and transformations are technical capacity and involvement of the public in land development decision making processes. Besides, institutional arrangements create exclusive individual property rights in land which, if not managed well, may result to too many owners holding small pieces of agricultural land that cannot guarantee efficient and optimal agricultural production leading to a tragedy of spatial anticommons.

2.3.5 Cultural and social factors

Numerous cultural factors may influence decision making process of an agricultural landowner. These variables are often related to political and economic conditions (GoK, 2017; Lambin *et al.* 2003; Nkedianye *et al.*, 2009; Thuo, 2013; Scottish government, 2009).

Important sociocultural drivers of ALS in East Africa may include land inheritance practices and land tenure systems (for example customary rights), subdivision of group ranches/individualisation of titles and acceptability to sell agricultural land (commodification of land) (Mburu, 2009). Insignificant factors have been identified to include changing distribution of land, wealth and power and commercialisation of labour and water resources. Competition or cooperation between groups and changing gender roles and responsibilities may be relevant as well (Olson *et al.*, 2004).

2.3.6 Political and legal factors

Government policy, laws and regulations are important drivers of ALS. Policy is a course of action that is formulated and adopted to promote a desired future outcome hence inevitably an indirect driver of ALS (GoK, 2017; Olson *et al.*, 2004). The influence of policy on ALS can be more meaningful when observed in a historical perspective to show the outcomes of their interactions with other drivers.

ALS in East Africa, for instance, reflects the influence of both colonial policy and laws extending back to the 19th century, as discussed in section 3.4.11. Such regimes have shaped the land tenure systems with wide implications on the access and utilization of agricultural land. The colonial policies and legal frameworks used to enforce them led to alienation of land for Europeans settlements and large scale farming and ranching in the East African region (Partners News, Ogendo, as cited in Society for International Development, 2006). This affected the distribution of agricultural land between the native people and the colonial settlers in Kenya, Tanganyika and Uganda (Olson *et al.*, 2004). Such regimes included, for example, the treaties between the Maasai and British in 1911 and 1912 in Kenya (Koissaba, 2015).

Other land laws have granted natives private land rights with power to subdivide and transfer agricultural land. Essentially, spatial anticommons property rights are created by government policies, laws and regulations under political and economic constraints (Heller, 1998).

2.4 Chapter summary

This chapter has discussed the concept of agricultural land subdivision into small sizes and the potential economic transformation that may arise (as a result of spatial anticommons) and presented theories that explain this phenomenon. Negative economic transformation of private agricultural land into an under/unproductive or dead capital may occur when private agricultural land is subdivided into small sizes or when the resultant subplots are situated in areas without basic infrastructural services to support alternative land uses hence may lead to a tragedy of spatial anticommons. As a result, the theory of the spatial anticommons seems to present the most compelling explanation regarding the impact of agricultural land subdivisions on productivity while urban growth theories and neo-liberalism appear to shed light on the trends and possible drivers of ALS. Smart growth, new urbanism and the proposed new ruralism, however, provide broad explanations on how land development should occur to ensure sustainable development of the land resource.

The evolution of agricultural land tenure in Kenya seems to have presented opportunities and threats to the landowners. The landowners have taken economic advantage presented by the private land tenure but, as Heller (1998) opines, if the private powers bestowed upon a private user are not regulated, they can be misused thus creating a tragedy of the spatial anticommons. This is because market approaches to land management do not take into account interests of the community and are thus not sustainable in the long run.

Generally, the trends and drivers of ALS, from a land economics perspective, can be termed as factors influencing demand for and supply of agricultural land. In other words, these drivers explain the motivations and challenges of the agricultural landowners. Forces within and without a community, therefore, may play a key role in shaping the agricultural landowners' decision making process in regard to ALS. Factors affecting agriculture, the main rural land use, are also important potential drivers of ALS.

Box 2.1 below presents a summary of the possible drivers of agricultural land subdivision identified through the literature review carried out so far and through general understanding and experience of factors that are likely to influence demand for land in a particular area.

The summary of possible drivers in Box 2.1 below may not be exhaustive since ALS is a function of varied forces which fluctuate with local conditions and forces. There is need therefore to identify applicable drivers which are important in a particular locality to inform policy interventions. Most of the drivers identified through literature review, for instance, have been observed in arable agricultural lands. It would be important to determine whether they are also applicable in dry agricultural lands, whose main land use is pastoralism.

Each of the identified drivers below is explained further in chapter four. The objective is to show how the identified drivers are likely to influence ALS and the approaches used to measure them. The discussion in chapter four is also meant to provide a link up to chapter two and the conceptual framework.

Box 2.1: Typical drivers of agricultural land subdivisions

Natural/Environmental/Physical Factors

- Quality/fertility of agricultural land
- Topography
- Proximity to amenities and services (transport, schools etc.)
- Rainfall
- Temperature

Economic and Technological Factors

- Off-farm Income
- Price of the agricultural land
- Price of urban land
- Demand for urban housing
- Farm income
- Demand/market for agricultural products
- Cost of finance/Interest rates
- Availability of finance/credit /capital
- Supply of agricultural land
- Future expectations on value of agricultural land
- Technology used in farming (intensive agriculture, irrigation etc.)

Demographic factors

- Urban population growth rate
- Rural population growth rate

Institutional Factors

- Public participation in agricultural land development decision making
- Local land institutional technical capacity

Sociocultural factors

- Land inheritance practices
- Commodification of agricultural land (acceptability to sell agricultural land)
- Customary land tenure systems
- Individualization of titles

Political and Legal Factors

- Agricultural land use policies and laws

Source: Author's construct, 2016

CHAPTER THREE

AGRICULTURAL LAND SUBDIVISIONS: IMPLICATIONS ON PRODUCTIVITY AND POLICY INTERVENTIONS

3.1 Introduction

The previous chapter has discussed theories and drivers that explain and influence the phenomenon of ALS, which in turn lead to impacts, both positive and negative implications. This chapter discusses the impacts of agricultural land subdivisions into small sizes on the rural communities with emphasis on the agricultural productivity, the principal concern of agricultural land subdivisions. International and local/existing policy interventions used to manage ALS is also presented in this chapter.

As Lee (1999) noted, drawing of lines on a map (subdivision process) does not in itself lead to impacts per se. It is what happens after the subdivision process that causes impacts (Shaw, Upton, as cited in Lee, 1999). After the subdivision process, for instance, the new agricultural landowners may fence off their small subplots thus physically and legally excluding other users (community) from utilizing the land. The impact of fencing off small agricultural subplots may be important in a community which depends on livestock pastoralism as this may hinder movement of livestock and limit access to pasture lands. The effect of fencing off small agricultural subplots is expected to be the same ecologically, as wild animals may be affected in the same way.

Therefore, the rural communities may be denied physical access to utilize the agricultural land when the small agricultural subplots are fenced off. Besides, the agricultural subplots may be situated in a remote area without basic infrastructural services to support alternative land uses. Thus, when the small private agricultural land parcels are fenced off and are not utilized by the various many landowners such an agricultural land may be fragmented and the size may be too small to warranty efficient and optimal agricultural production thus such a land may be underutilized and may lead to the tragedy of the spatial anticommons. The land may thus not benefit the many exclusive owners nor does it benefit the community as whole. In addition, the land may produce less and less and transaction costs may be higher.

The impacts of subdivision of agricultural land into small units may become more pronounced when the resultant agricultural subplots are eventually developed with urban housing. The impacts, Henry *et al.* (2012) noted, arise due to clash of rural and urban lifestyles. Rural lifestyles are mainly agriculture based with main agricultural activities being crop, livestock and forestry production. These activities may be a nuisance to the urban dwellers who buy land and develop housing in the rural areas seeking tranquillity away from bustle and hustle of urban areas (Lee, 1999). The nuisance is usually in form of noise, bad odour, dirt, dust and traffic caused by livestock while crossing or grazing along the roads. Consequently, to a new rural dweller that came as a result of the subdivision of agricultural land may perceive that he/she is negatively impacted by the subdivision process. Momsen (as cited in Lee, 1999) has observed that such experiences may lead to social conflicts.

The focus of this study, however, is not on the urban dwellers in rural areas rather it is on the rural communities/agricultural landowners. It is assumed that the urban dweller that chooses to live in the surrounding rural areas is satisfied with the impacts of the subdivision process. In any case, such a person has benefited from the process.

In view of the above discussion, the perception on whether impacts are positive or negative, Chazan & Cotter (2001) observed will vary from one stakeholder to another. The potential impacts of agricultural land subdivision are usually broadly categorised as environmental, economic and societal. However, the scope of this study is mainly limited to the economic impacts since the study has taken a land economics perspective. Besides, the main national and global concern of agricultural land subdivisions is in regard to their impact on agricultural productivity, which is an economic function. Social impacts of agricultural land subdivisions, however, are highlighted in this section for general information purposes.

3.2 Economic Implications of Agricultural Land Subdivisions

3.2.1 Implications on agricultural productivity

Loss of agricultural land and farmlands through subdivision of agricultural land into small units may affect the farmers by reducing agricultural production thus affecting their income from agricultural activities (Henry *et al.*, 2012; Kelleher, *et al.*, 1998). Existing studies have shown, however, that this is not always the case. Previous research has shown that subdivision of agricultural land may not necessarily lead to reduced agricultural production.

Indeed, several studies in New Zealand have shown that subdivision of agricultural land may lead to increased agricultural production through intensification of agricultural production and alternative high value agricultural land uses such as horticulture (Lawn *et al.*, Mears, Meister & Knighton, Peacocke, as cited in Lee, 1999; Kelleher, *et al.*, 1998; Mearns, 1999). The production has been noted to increase due to agricultural land subdivision if the resultant agricultural subplots are considered together. When the subplots were, however, considered individually the agricultural production has been observed to reduce significantly and the agricultural land being used less productively (O'Connel, Veltman, as cited in Lee, 1999).

Several studies have been carried out in India, from 1960s up to date, on the relationship between farm size and agricultural productivity. Interestingly, many previous studies have found an inverse relationship between the size of agricultural land and agricultural productivity, whereby as the size of farms decrease, the agricultural productivity increases (Bardhan, Berry, Hanumantha, Khusro, Mazumdar, Saini, Sen, as cited in Chand *et al.*, 2011). Similarly, Sial *et al.* (2012), using econometric analysis, determined that farm size and agricultural productivity are inversely related. Other studies, however, have found a positive correlation between farm size and agricultural productivity in India (Bhalla & Roy, Chadha, Ghose, as cited in Chand *et al.*, 2011). Chand *et al.* (2011) established that indeed inverse relationship between farm size and agricultural productivity exists in India but found out that per capita output is lower compared to large farms due to lower per capita availability of land. Low per capita agricultural productivity may translate to lower per capita income which cannot sustain livelihoods. The findings have differed depending on the variables used in the correlation analysis.

The above previous findings suggest that subdivision of agricultural land into small sizes may actually lead to a tragedy of the anticommons (reduced agricultural productivity) on one hand. On the other hand, this relationship is not universal as anticommons properties are not necessarily tragic, especially depending on the measures adopted by the private exclusive landowners and policy makers to avert tragedy. Use of technology/mechanization, use of more variable inputs such as fertilizer, irrigation, high-yielding varieties and other agricultural practices are likely to increase agricultural output in smallholdings thus increasing productivity per hectare. As Rudra (as cited in Chand *et al.,* 2011) postulated, there is no a universal relationship between farm size and agricultural productivity. The previous studies, however, have focused more on the prime crop lands and not on the dry agricultural lands, the focus of this study.

Concerns about subdivision of agricultural land into small units in Kenya and world over have been about effects of such subdivisions on the productivity (GoK, 2009; 2010a; 2010b; 2012b; 2017; 2016b; Chand *et al.*, 2011). It is generally assumed that subdivisions of agricultural land into small sizes automatically leads to reduced agricultural productivity and thus may impact negatively on food security. Previous studies, however, have shown that this general assumption may not always hold. In other words, anticommons property are not necessarily tragic, as Heller (1998) suggested.

Agricultural land should be used as one large contiguous unit to ensure agricultural economies of scale (Robison, 2012). This is likely to reduce agricultural production costs and encourage higher production. Besides, in an area where crop production is practiced, large agricultural land will make mechanization possible and this may lead to increased productivity and commercialization of agriculture. Similarly, extensive livestock production systems like pastoralism require even bigger agricultural land for pasture purposes. The impact of ALS on extensive livestock production systems may be more severe if the resultant small private agricultural subplots are fenced off and the farmers rely on natural vegetation for pasture.

According to FAO (2006), dry agricultural lands in Kenya should produce approximately 6.7 bags of 90kg/ha or 603kg/ha in Agro Climatic Zone (ACZ) V and 2.2 bags of 90kg/ha or 198kg/ha in ACZs VI-VII (See appendix 4). On livestock production, average carrying capacity in Kenyan dry agricultural lands ranges between 0.5-1 cow/ha (Syagga, 1994; Syagga & Kimuyu, 2016). Previous research and case studies elsewhere has estimated average carrying capacity for goats/sheep at 5 goats & sheep/ha in dry agricultural lands (Byiringiro, 1995, Gul *et al.*, 2016; Rahmann, 2014). Thus, if subdivisions of dry agricultural lands are found to have reduced agricultural productivity below these benchmarks, then evidence of a tragedy of the spatial anticommons could be present.

Randall *et al.* (2005) studied the impacts of subdivision of group ranches in Kajiado District on quantity of wild animals and livestock, from an ecological perspective. Their study found out that the quantity of livestock was declining due to subdivision of group ranches in the district. The subdivision of agricultural land, however, did not stop with subdivision of group ranches' land in Kajiado County. Individual private landowners have continued to subdivide their agricultural land, sometimes below 0.05ha subplots. Indeed, it is on the private land where most of the subdivisions are now taking place yet extensive livestock systems are practiced (mainly pastoralism) which require large contiguous agricultural land to sustain. There is need therefore to understand the motivations and challenges being encountered by the private agricultural landowners and the impact such subdivisions may have on agricultural productivity.

After subdivision into small sizes, agricultural land, perhaps the most important factor in agricultural production may become more expensive and inaccessible by the farmers due to competition from urban land uses. Elsewhere, the price of agricultural land has been noted to rise beyond the reach of the farmers after subdivision process (Blackie, Edwards, Meister & Stewart, as cited in Lee, 1999). Thus, farmers who may want to increase their agricultural production by acquiring more agricultural land may find it difficult and almost impossible to do so due to high prices charged on the resultant small agricultural subplots. This may become one of the challenges that farmers face and eventually decide to exit the agricultural production, through subdivision and/or disposal of the agricultural land to property developers.

3.2.2 Determinants of agricultural productivity

There are generally four main factors of production including land, labour, capital and management/entrepreneurship. Land therefore is just one of the main factors of agricultural production. A recent research carried out in Taraba State, Nigeria has identified significant factors influencing agricultural productivity to be access to formal credit/capital, farm size, membership to farm based organization and level of education (Onogwu, Audu & Igbodor, 2017). In Pakistan, key factors determining agricultural productivity have been found to include land size/cropped area, land fertility/fertilizer application and demand/market prices for agricultural products (Chandio *et al.*, 2016). Other researches carried out in Sri Lanka and India have identified key determinants of agricultural productivity to include level of education of landowners, land sizes, rainfall, terrain, labour, soil fertility and social factors (Pinnawala & Herath, 2014).

Locally, studies have shown that labour, rainfall, government expenditure, extension services and socio-economic characteristics of farmers are significant factors in influencing agricultural productivity (Omache, 2016; Muraya & Ruigu, 2017). The international and local existing studies however have been carried out in arable land and not in dry agricultural land, the focus of this study.

From the existing research it is clear that the determinants of agricultural productivity are many and diverse, mainly due to varied natural and social characteristics of a given locality. It is therefore evident that there are no common factors influencing production and productivity of agricultural land. It is however evident that the size of agricultural land is a key predictor of agricultural productivity world over, thus subdivision of agricultural land becomes important. This study therefore sought to determine significant factors influencing agricultural productivity in the study area, with key interest being the relationship between agricultural land size and productivity.

3.2.3 Determinants of minimum agricultural land sizes

Generally, demand for land is influenced by its use to satisfy human needs and wants such as food and shelter. Therefore, the key determinant of minimum agricultural land sizes would be the minimum land required to produce food to support an average sized household in a given locality, assuming that all the food requirements are obtained from the agricultural land in question. Local existing research has shown that some of the key factors to consider in determining minimum agricultural land sizes include average size of household, land fertility, climate/rainfall, available land and per capita food requirement (Syagga & Kimuyu, 2016).

Internationally, previous studies carried out in Rwanda, Turkey, Iran and Greece have indicated that the size of agricultural land is likely to be influenced by size of agricultural production (number of livestock and size of crop production), availability of labour, land fertility and value of agricultural land. Other key factors include income and education of landowners (Bizimana, 2004; Gul et al., 2016; Kalantari & Abdollahzadeh, 2008; Sermos, 1995). From the existing research, it is evident that there are numerous and diverse determinants of minimum agricultural land sizes in a given locality.

The significant factors to consider in determining minimum agricultural land sizes are not universal and would depend on natural and social characteristics of a specified locality. Land is unique in terms of location and quality/fertility thus influencing productivity and minimum sizes differently in different localities. There is need therefore to identify significant factors influencing agricultural productivity and factors to consider in determining minimum/economical agricultural land sizes. This study hence sought to fill this gap in the study area.

3.2.4 Other economic implications

Agricultural land subdivision is a development process and many people are impacted economically as a result, either positively or negatively. In Kenya, the Physical Planning Act, the main physical planning law, recognises land subdivisions as a form of land development (GoK, 1996). Essentially, when agricultural land has been subdivided it is developed. Thus, the value of such agricultural land is also likely to rise thus landowners can fetch higher values for their rural land.

Local real estate professionals such as physical planners, valuers and estate agents earn income from the ALS process. Similarly, property developers make profits from agricultural land subdivisions, for example, after buying agricultural land from the local landowners and subdividing it into small subplots and then reselling them at a higher price. These impacts, however, are more likely to be experienced by people outside the rural community.

The local residents are likely to get employment near their homes from the ALS process (Wu, 2008). The employment is likely to be mainly in form of casual labour which may be needed in fencing off the resultant subplots or in construction activities if the agricultural subplots are eventually converted into alternative user and developed with urban housing.

ALS may bring services to the rural communities such as new roads, power and water (Henry *et al.*, 2012; Lee, 1999). This is because rural property developers may provide infrastructural services as a measure to add value to their rural land before selling it off. Thus, in an attempt to provide serviced subplots and earn higher prices for their agricultural land, the property developers may bring services to the rural areas hence benefiting the whole community.

On the negative side, the local authorities and county governments may incur higher costs of providing services to the new low density housing scattered developments. Such costs, for example in the United States of America, have been noted to be more than the taxes/fees that the property developers pay to obtain permission to put up the new housing developments (Arend *et al.*, as cited in Chazan & Cotter, 2001). The scattered developments make people rely on cars to reach destinations such as shopping centres and places of work leading to increased negative environmental consequence of air pollution. As a result, ALS may put pressure on the existing infrastructure services hence leading to unmet demand for services in the rural communities.

3.3 Social Implications of ALS on the Rural Communities

It is generally known that the individuals who make up a community have basic needs for personal fulfilment and welfare such as shelter and sustenance. Studies have shown that usually people meet these needs more effectively by cooperating as a community than when operating alone and not connected to the larger social and political group (Chazan & Cotter, 2001; Wu, 2008). As Wu (2008) indicated, these impacts are rather subjective and difficult to measure. The preference for viewing nature, for instance, is subjective as people differ in their definition of 'nature'.

As more urban people move to the suburbs and rural areas they are likely to experience traffic congestion and more travel time, which may further impact negatively on the environment due to air pollution. People have to travel using cars to reach shopping centres which are usually scattered unlike in urban areas where people are likely to do their shopping under one roof. These impacts are likely to apply more to the urban dwellers who relocate to the rural areas than to the rural communities and are largely undesirable.

Agricultural land subdivisions and their associated activities may destroy scenic views and natural areas affecting negatively those who prefer to view nature and farmlands. What was once a natural area may become another urban area characterised by buildings and noise pollution. Destruction of landscapes has both social and environmental implications (Lee, 1999).

A community is likely to lose its character due to subdivisions of agricultural land into small sizes. As people live in scattered developments and use more time travelling to work and shopping centres, the frequency of meeting each other may be reduced. Chances of running into each other, as Chazan & Cotter (2001) observed, become less. This impact is likely to be more noticeable where ALS is accompanied by development of urban housing.

Agricultural land subdivisions may lead to community segregation. This impact was noted to be significant in New Zealand where lifestylers were perceived to work, spent their money and educate their children in the city, with little association with the rural community. In essence, lifestylers are likely to continue associating with previous urban connections rather than with the rural people (Lawn *et al.*, Moran *et al*, as cited in Henry *et al.* 2012; Lee, 1999). Basically, this affects a community's social capital.

If the process of ALS occurs without proper policy interventions, social conflicts related to incompatible rural land uses may be experienced by the local residents. Ayonga (2008) concluded that incompatible land uses in the peri urban and rural areas are occasioned partly by uncontrolled land subdivisions and conversions, and unless the two indicators are properly controlled, land use conflicts will continue to flourish. Baldessare & Wilson (as cited in Pallagst, 2007) established that the local communities may also revolt against their leaders in an attempt to pressure them to manage land development. Movements such as 'Not In My Backyard (NIMBY) have been witnessed in the USA.

3.4 Policy Interventions to Manage Agricultural Land Subdivisions

This section presents specific policy interventions that have been adopted by other countries to manage the issue of agricultural land subdivisions and minimise negative impacts on the rural communities. The Kenyan policy strategies are also discussed.

As discussed in chapter two of this study, the theories of urban land use and neoliberalism show that cities and urban areas are likely to grow and expand into the surrounding rural areas, if there are no effective policy interventions at the national and local/county government levels. Design and implementation of effective land administration and management policy interventions may be informed by knowledge and understanding impacts and drivers of ALS in a particular locality.

Different countries have used different policy interventions in managing the phenomenon of agricultural land subdivisions into small sizes. The possibility of adopting some of these measures, however, depends on the acceptability by the stakeholders to avoid constitutional, legal and political bottlenecks. In addition, the knowledge of impact and important drivers of ALS in a particular locality and local land institutional technical capacity to implement innovative policy interventions are necessary.

3.4.1 Large plot zoning

According to Brower (1976) large plot zoning is the establishment of a large minimum parcel size (such as 4ha or 8ha or more than 30ha) to limit development densities in areas where the land administrator's goal is to preserve agricultural land, rural character, forest or environmentally sensitive areas. Large plot zoning could be used as a barrier to intensive residential development or to ensure low density residential development. It can be used temporarily until the rural area is ready for residential development thus dictating time of development.

Alternatively, land administrators could use upgraded zoning to discourage development in the outlying agricultural lands while permitting more intensive use of land closer to the urban centres. This encourages urban land infilling and allows government control over the timing of agricultural land development, acting as an interim control device pending the formulation and adoption of permanent zoning controls (Freilich, as cited in Pallagst, 2007).

Large plot zoning also ensures that development proposals come under the community's review (public participation in land use decision-making process) as landowners and developers must petition for rezoning, a requirement that sets up a system for the city and rural areas to prohibit or allow growth on a case-by-case basis. Moreover, it can be used to establish the permanent character of undeveloped agricultural land thus prohibiting development which would otherwise encroach upon agricultural land.

Large plot zoning, however, is likely to consume a lot of agricultural land and increase its value and housing costs due to increased competition for the few large plots (Coke & Liebaum, as cited in Brower *et al.*, 1976). It appears that countries should set optimal/economic minimum agricultural land sizes and not large plot sizes. Nonetheless, large plot zoning has been used widely and successfully by various governments in an attempt to manage agricultural land development such as United States of America and

Canada. In New Zealand, 4-ha agricultural land holdings have been imposed on the agricultural landowners (Henry *et al.*, 2012; Lee, 1999).

Kenya is in the process of enacting a law to prescribe the minimum and maximum land holding acreages for different regions in the country (GoK, 2015b). Such a law may provide a legal backing to land administrators who decide to adopt large plot zoning/optimal minimum land sizes as a policy intervention to manage ALS. Besides, the Kenyan Constitution (2010) has provided for determination of minimum and maximum land holding acreages in Kenya (GoK, 2010a). This direct constitutional provision on the minimum land holding acreages may go a long way in addressing challenges of uneconomical subdivisions of agricultural land.

The proposed minimum and maximum land sizes in the Minimum and Maximum Land Holding Acreages Bill, nevertheless, were not based on a scientific study, a situation that has already triggered a heated debate and opposition from the members of the public. Establishment of the large plot sizes in a particular locality should be guided by scientific studies to determine optimal/economic minimum agricultural land sizes necessary to ensure efficient, optimal and sustainable agricultural productivity and other land needs. Failure to observe this requirement may lead to wastage of land resources as it happened in New Zealand after imposition of the 4-ha restriction which led to wastage of land and increased land prices (Lee, 1999). Adoption of large plot zoning would be more appropriate in areas with substantial amount of available land or low population density, in Kenya this would be mainly in the dry agricultural lands.

3.4.2 Adequate public facilities requirement

A law or a requirement that allows agricultural land only to be subdivided into small sizes (developed) once an area has adequate public facilities may be used. Several counties in the U.S.A, for example, have enacted the Adequate Public Facilities Ordinances (APFOs) in an effort to control the rate of urban development and manage ALS in their areas of jurisdictions. APFOs have been designed to slow the pace of agricultural land development or in extreme cases to delay development approvals in an area until adequate public service levels (water, electricity and roads) are put in place.

This can be achieved by limiting the issuance of subdivision and/or building permits to only those areas adequately served by public facilities (Brower *et al.*, 1976; Maryland Department of Planning, 2005; Pallagst, 2007). This way, each landowner can know when he will be able to develop his agricultural land hence the ordinance does not deny or avoid the problems of population expansion but seeks to channel land development into areas in which it can be accommodated.

APF requirement would be an appropriate policy intervention if the key driver of the ALS is urban population growth rate and in areas where ALS is accompanied by development of urban housing. This policy intervention would eliminate ALS in agricultural areas without basic infrastructure services and only allow it in areas which can support alternative land uses such as residential development. That way, the government may direct and dictate growth and expansion of urban areas and trends of ALS. Urban development theories and approaches such as smart growth, new urbanism and the proposed new ruralism all promote development in areas with adequate public facilities.

When adequate public facilities requirement is adopted at the local/county level, there may be a need to have such a policy intervention backed by legal provisions, probably at the national level. Without legal backing, the policy may prove to be litigious and may lead to court cases. In Kenya, the Constitution (2010) under article 40 gives every Kenyan a right to own property of any kind in any part of Kenya (GoK, 2010a). Thus, agricultural landowners who feel impacted negatively by adequate public facilities requirement policy may use such a provision to argue that their private property rights have been infringed.

Right to own, however, should not be confused with the right to develop or to use, as the theory of bundle of rights dictates. Indeed, the same Kenyan Constitution (2010) provides for regulation of land use and development. Besides, the Kenyan Constitution (2010) has provided for regulation on the minimum and maximum land holding acreages in Kenya.

Kenya does not have an explicit law or a policy requirement to enforce requirement of adequate public facilities to be in place before agricultural land can be subdivided into small sizes (developed). Experience shows that development permits (subdivision and building permits) are issued to property developers irrespective of existence of public facilities guided mainly by the Physical Planning Act and the Land Control Act.

Kenya is, however, amending the current planning law to ensure approval for subdivisions consider availability of public services (GoK, 2015a). This policy intervention remains a viable option that can be adopted by Kenya to manage ALS. It should be noted, however, that agricultural land will always remain indispensable component of the countries' economic development. Every agricultural land thus should not be seen as land for urban expansion. This policy therefore would be appropriate only in agricultural lands designated for urban expansion.

3.4.3 Development moratoria

Development moratorium is a form of extra-legal land development control approach. It is used to directly retard either particular types of development or the development process in general by banning certain agricultural land development activities such as subdivisions, conversions and issuance of development permits. By slowing down or stopping ALS within a jurisdiction, moratoria seeks to stop further development which cannot be supported by existing public services and safeguard community against serious adverse effects on food security, health and safety occasioned by unrestrained agricultural land development. Moratoria give land administrators a breathing space so as to enact a comprehensive development plan (Brower *et al.*, 1976; Pallagst, 2007).

Development moratoria would be applicable in agricultural areas under intense pressure to subdivide and convert use. Besides, the local land managers should use development moratoria in the process of formulating permanent policy interventions since moratoria are usually used as a short term intervention. When imposed over a long period the local land managers may face legal actions since moratoria are extra-legal interventions in nature.

Immediately after their institution in 2013, several counties in Kenya used moratoria to control land development in their areas of jurisdictions. These were Kajiado, Kiambu, Elgeyo Marakwet, Nyandarua, Uasin Gishu and Lamu Counties. The suspended rural land development activities which mostly lasted for six months included sale/transfer, subdivisions and issuance of development permits, among others. There was, however, a lot of outcry and pressure from the landowners to the county governments to cancel the ban. Nevertheless, this approach could be adopted as a temporary intervention by the various counties in Kenya.

3.4.4 Land banking

Since it is assumed that the phenomenon of ALS is influenced by expansion of urban areas (urban population growth rate), this strategy may be used to control growth and sprawl of the urban areas hence protecting agricultural lands surrounding the urban areas from untimely or unsustainable transformations. Land banking refers to public acquisition and holding of undeveloped land in anticipation of either future public use or resale to accomplish community goals (Clawson, 1962). As Heeter (as cited in Clawson, 1962) noted, effective development control and management of ALS cannot be achieved by relying solely upon land development control tools such as zoning regulations.

Land banking is therefore suitable in combating urban sprawl and suburbanization where land speculators near urban areas refuse to sell their land at reasonable prices to the property developers. When this happens, property developers are forced to purchase and develop less expensive land further away from the urban areas (agricultural lands). Moreover, land banking is not vulnerable to litigation problems since adequate and prompt compensation is paid to the landowner when government purchases private land for land banking purposes. However, limitations of finance for purchasing private land rights may restrict adoption of this strategy in managing ALS (Bosselman, 1968; Kamm, 1970; Parsons, 1972). This may be a significant challenge to the developing countries.

The Kenyan National Land Policy (2009) has cited land banking as an appropriate land development approach. Both the national and various county governments are in the process of formulating policies to implement land banking strategies.

3.4.5 Property taxation

Among all the tools and techniques for controlling land development, probably none can achieve direct social and economic effects as property taxation policy does. Generally, taxes are imposed by various levels of government (national and local/county governments) for the purposes of acquiring revenue to finance government operations and the regulation of social and economic activities. Raising revenue has been cited as the legally and constitutionally permissible purpose for the exercise of the power to tax. In many cases, however, the intended objective of tax was regulation as demonstrated by various case laws like McGray V. United States and Bailey V. Drexel Furniture (United States, 1904;1922, respectively).

Due to the potential capabilities of the governments' power to tax, some observers and scholars have suggested that property taxation be used as an intervention to influence land development patterns (Brower *et al.* 1976). Hardin (1968) proposed taxation as a cure to the problem of commons property. Instead of denying property developers permits to subdivide agricultural land into small sizes (develop), they may be required to pay a development fee to the county governments for the right to build within their jurisdictions. The money collected from the agricultural land development taxation could then be used to provide public services occasioned by the approved agricultural land development. The amount of development fee is usually related to the type and amount of agricultural land development.

In Kenya, rural land developers pay approval fees to the respective land control boards and land development fees to the county governments before they are issued with development permits. For a developer to obtain development permit for land subdivision, for example, he/she is required to pay an application fee of Kshs. 1,500 to the land control board for consent. As to whether such fee is adequate to provide public facilities and/or regulate development of agricultural land remains debatable. Such low fees may not deter landowners from subdividing their agricultural land into small sizes. Probably, a differential property development taxation policy would be more effective so that where uneconomical ALS occur in an area without basic services the property developers are taxed more.

3.4.6 Land subdivision regulations

Land subdivision regulations provide the procedures and standards for dividing a large parcel of land into smaller parcels for sale and development (Ohm, 1999). Subdivision regulations require a developer to meet certain conditions in order to be allowed to subdivide land. As with zoning, subdivision regulation is a land use control tool used to carry out a community's plan. The regulations governing the division of land, however, are different from zoning regulations in two primary areas. First, while zoning regulations are meant to control the use of property, subdivision regulations address the quality of development such as the availability of public services, services the landowner must provide and the layout of the site and the minimum land sizes allowed.

The way in which agricultural lands are divided plays a key role in the orderly development of a community. Ohm (1999) observed that properly administered subdivision regulations can be more useful in achieving agricultural land development goals than zoning regimes. Failure to plan for the subdivision of land is felt in many areas such as loss of agricultural land, tax burdens, the high cost of extending public facilities and loss of a community's character. Countries have mostly managed ALS through legal provisions (Henry *et al.*, 2012; Lee, 1999).

Kenya does not have an explicit subdivision law that directly provide guidelines on what minimum sizes agricultural land should be subdivided into. The Land Control Act requires the land control boards to consider the effect of subdivision of agricultural land on agricultural productivity before granting consent for subdivision (GoK, 1967). This requirement appears subjective since the land control boards do not have capacity to determine the effect of agricultural land subdivision on productivity. With enactment of the Minimum and Maximum Land Holding Acreages Act, however, it is hoped that untimely agricultural land subdivisions into small sizes may be reduced.

3.4.7 Agricultural land zoning

Agricultural land zoning refers to designating land for agricultural purposes to protect farmlands and farming activities from incompatible non-farm uses. Agricultural zoning can specify aspects such as the uses allowed, minimum farm sizes and the number of non-farm buildings allowed (Montgomery County Planning Department, 2013; Nelson *et al.*, 2011).

In Montgomery County, the 37,637 ha (380 km^2) zone, for example, was created in 1980 by the Montgomery County Council to preserve farms and agricultural space in the north-western part of the county from transformation due to suburbanization. This farmland protection program has been characterized as one of the most successful program of its kind in the United States (Nelson *et al.*, 2011). Agricultural land zoning may be more appropriate in agricultural areas with prime agricultural land which can be zoned for agricultural purposes only. Such a policy intervention would need to be tailor-made for Kenya since majority of Kenya's agricultural land is mainly dry.

In Kenya, the policy intervention of agricultural zoning is not explicitly stated but there is policy and legal provision for agricultural land. The draft National Land Use Policy has called for acknowledgement and protection of pastoralism, the main economic activity in dry agricultural lands (GoK, 2017). Similarly, the National Spatial Plan has provided for containment of urban growth, smart growth and protection of prime agricultural land (GoK, 2016b). Most of Kenya's agricultural land (over 80 per cent), however, is dry thus protecting prime agricultural land may not be enough for Kenya to be food secure. Protection of agricultural land may thus need to be extended to the dry agricultural lands. Moreover, the Agricultural Sector Development Strategy calls for proper management of agricultural land, the most important factor in agricultural production (GoK, 2010a). The above rather new policy provisions may be steps in the right direction in trying to manage the phenomenon of subdivision of agricultural land into small sizes.

The Agriculture Act, chapter 318 (repealed) was the main regulation governing the agricultural land up to year 2013, when a new agriculture law was enacted, the Agriculture, Fisheries and Food Authority Act of 2013 (GoK, 2013a; 1955). These regimes do not strictly designate some lands for agricultural purposes. The Land Control Act provides for subdivision of agricultural land to be prohibited if such subdivision leads to negative impact on productivity. The land control boards are supposed to implement this requirement (GoK, 1967). There has not been a local scientific study, however, determining the impact of subdivisions of agricultural land on productivity.

3.4.8 Purchase and/or transfer of development rights (PDRs/TDRs)

Purchase and/or transfer of development rights (PDRs/TDRs) have been observed to be effective elsewhere whereby in exchange for the commitment to forgo development at a certain parcel of agricultural land, a landowner will obtain additional property development rights such as higher density at some alternative land. Landowners of prime agricultural farms in the agricultural areas, for instance, could be given alternative less prime lands for development purposes. The alternative land could be serviced to encourage such landowners with prime agricultural land to participate in this exercise (Huibert *et al.*, 2007).

This policy intervention has been noted to face a lot of challenges in its actual implementation, basically due to lack of appropriate land to swap with the prime agricultural land. Besides, Kenya is mainly ASAL thus such a policy intervention would probably be more difficult to implement.

3.4.9 Ballots prior to the approval of large scale agricultural land development projects

This instrument will accord the local communities an opportunity to participate in agricultural land use decision making since the rational voter hypothesis implies that opponents of development will be more likely to vote (Huibert *et al.*, 2007). Indeed, when land administrators adopt this approach, it has been observed, public participation in land development decision making is highly enhanced.

The Kenyan Physical Planning Act of 1996 requires property developers to initiate public participation in property development processes, including subdivisions of agricultural land, but members of the public do not take a vote in deciding the final outcome (GoK, 1996). Besides, the Kenyan Constitution (2010), the National Land Policy (2009) and the draft National Land Use Policy (2016) all require the public to be involved in land development decision making process (GoK, 2010a; 2009; 2017). Voting by public on large-scale land development projects in agricultural areas would be necessary in ensuring that anticipated negative impacts of the projects are minimized. This, for instance, may ensure that untimely large-scale agricultural land subdivisions into small sizes are accompanied by necessary infrastructural facilities to support alternative land uses, such as residential development.

3.4.10 Agricultural land consolidation

Most of the land administration and management policy interventions discussed previously mainly emphasize on prevention of agricultural land subdivision and not the cure. Consolidation of agricultural land is critical in reversing trends of agricultural land subdivisions and ensuring sustainable rural development in line with installed base theory (Mburu, 2009). Consolidation of agricultural land is usually viewed as the entry point for rural development essentially due to its positive influence on improved agricultural productivity. Agricultural land consolidation is mainly the reallocation or grouping of agricultural land parcels to achieve larger and contiguous ones. The forms of agricultural land consolidation may thus include comprehensive land consolidation covering large agricultural area, voluntary group consolidation and individual consolidation, which is largely informal and random (FAO, n.d).

Kenya is currently in the process of developing a land consolidation policy to guide consolidation of prime agricultural land into large, contiguous and economically viable units. The policy would encourage rural settlements to be near the shopping centres to free up agricultural land for sustainable and efficient farming. The existing land consolidation Act would also need to be amended since it only applies to trust/community land (special areas) and not to private land (GoK, 1959). Besides, the initiative of consolidating the trust land is made by the respective local authority/county government but meaningful agricultural land consolidation efforts need to be approached proactively by the rural land administrators and managers.

While private ownership of agricultural land is not a bad land tenure system, it has been blamed for failing to bring the much expected positive impact on land productivity, partly due to overemphasis on the security over the content of tenure (Adams, *et al.*, 1999; Heller, 1998). Several researches have shown that individualization of agricultural community land has marginalised pastoralists by denying them access to critical rural land resources during drought (Mackenzie, Njeru, Williams, as cited in Adams, *et al.* 1999).

The specific interventions that land administrators can adopt in managing agricultural land subdivisions are many and diverse. The strategies that have been discussed under this section are in no way exhaustive. Some tools, such as development moratoria, are extra-legal and may pose constitutional, legal, political and technical difficulties in their implementation. It is important, therefore, that impact and significant drivers of ALS in a particular locality are established. The goal of managing ALS in a certain agricultural area may also influence the choice of a particular tool.

3.5 Chapter Summary

The discussion in this chapter has shown that impacts of ALS do not arise out of the process of subdivision of agricultural land rather they occur due to what happens after the subdivisions. The impacts are either positive or negative, depending on the various stakeholders' viewpoints. Some of the impacts, especially societal ones, are subjective in nature and difficult to measure quantitatively.

The local policy interventions have been largely in form of legal provisions which from observation seem to produce little success. Besides, most of the local policy interventions have been designed at the national level to address a local problem. Lee (1999) and Henry *et al.* (2012) have noted that effective policy interventions to manage ALS are usually designed at the local level but supported at the national level by way of national policies and laws. In other words, a one-size-fits-all policy intervention may not work due to unique local conditions. Thus, while there are many policy interventions globally, Kenya has primarily used legal provisions to manage ALS. Other countries, however, have used a combination of policy interventions, with laws being among them. The existing legal system guiding subdivision of agricultural land do not provide a clear direction on how and to what extent agricultural land should be subdivided. Most of the existing laws and policies recognise that unregulated subdivision of agricultural land may lead to negative agricultural productivity but do not regulate to what extent subdivisions should be done.

The existing policies on the issue of agricultural land subdivisions seem to be vague. The policies recognize and attribute subdivisions to be always undesirable or negative (leading to a tragedy of spatial anticommons). Previous studies elsewhere have, however, proved otherwise (Lee, 1999; Kelleher *et al.*, 1998). Indeed, some studies have shown that subdivisions of prime agricultural land have led to increased agricultural productivity through intensification of land use (Kelleher *et al.*, 1998).

Heller (1998) also contends that anticommons properties are not necessarily tragic. It is the assumption of this study that perhaps, for land administrators and managers to adopt effective interventions, there is need to first understand the drivers and implications of ALS on productivity. The determination of the applicable economic/optimal minimum agricultural land sizes for various zones in Kenya is outside the scope of this study since this pursuit would require a multidisciplinary approach. Recently, Syagga & Kimuyu (2016) attempted to determine minimum agricultural land sizes for maize production in various agro climatic zones of Kenya. Enactment of the Minimum and Maximum Land Holding Acreages Act would go a long way in addressing this quest. Since land development control in Kenya is now under the county governments, which have semi-autonomous powers and resources, there may be an opportunity for implementation of innovative policy interventions to manage ALS.

The significant factors influencing agricultural productivity and key factors to consider in determining minimum agricultural land sizes therefore are not universal and would depend on natural and socio-economic characteristics of a specified locality. Land, for instance, is unique in terms of location and quality/fertility thus influencing productivity and minimum agricultural land sizes differently in different localities. There is need therefore to identify significant factors influencing productivity and factors to consider in determining minimum/economical agricultural land sizes. This study hence sought to fill this gap in the study area, as indicated in chapter seven. Identification of key drivers of subdivision of agricultural land would help in identifying appropriate policy interventions to curb uneconomical transformations which may be detrimental to productivity.

CHAPTER FOUR

TOWARDS A THEORETICAL AND CONCEPTUAL MODEL

4.1 Introduction

Previous chapters have introduced the study and discussed theories, typical drivers and impacts of ALS. The urban theories and neoliberalism were found to explain 'why' or drivers of ALS while the theory of the spatial anticommons explains the main impact of this phenomenon (impact of ALS on land productivity). The drivers of ALS are many and diverse. Generally, these drivers can be considered as factors affecting demand for agricultural land and can be found within and outside the community.

Implications of ALS are either positive or negative, depending on the various stakeholders' perspectives. The central concern of ALS is its impact on land productivity, whereby it's generally believed that ALS automatically leads to decreased agricultural land productivity. Studies have shown, however, that this may not be the case always as ALS may actually lead to increased agricultural land productivity, especially where agricultural landowners intensify land use after subdivisions. Other impacts of ALS are largely societal and subjective in nature.

There are many policy interventions which have been adopted by various countries to manage ALS. A mix of policy interventions have been used worldwide. Kenya, though, principally uses legal provisions, mostly designed at the national level to address a local problem.

This chapter presents a summary of chapters two and three. This is necessary to conglomerate all the ideas so far discussed into a conceptual framework. The objective of this chapter is to show the applicable general abstractions and how the various variables relate to one another to achieve optimal, efficient and sustainable agricultural land production and productivity.

4.2 Summary of Theories of Agricultural Land Subdivision

Most of the urban growth theories mentioned in chapter two and neo-liberalism theory appear to explain the possible drivers of agricultural land subdivision, albeit from a broad perspective. Urban growth theories including the concentric rings and multiple nuclei, for instance, postulate that urban areas will always grow outwards into the surrounding rural areas thus explaining possible influence of urbanization on ALS. The urbanization process usually occurs through subdivision of agricultural land into small sizes and subsequent conversions of land use from agricultural to urban user.

The theory of neo-liberalism explains capitalist tendencies whereby individuals claim superiority of private property with minimal state regulation. Besides, individuals prefer market forces to regulate the property market, thus there is commodification of everything, including agricultural land. Thus, the theory of neo-liberalism provides further explanation to the possible drivers of agricultural land subdivision from a broad perspective.

The spatial anticommons theory provides explanation to the possible impact of private agricultural land subdivisions into small sizes on the productivity. This is because the theory of the spatial anticommons explains a scenario whereby too many rational profit-maximizing exclusive users or individuals, each acting separately, collectively wastes a scarce resource by blocking each other from use leading to underutilization of resources (Heller, 1998; Michelmann, 1982).

Basically, spatial anticommons describe land subdivisions when "each anticommons owner receives a core bundle of rights, but in too little space for the most efficient use in given time and space" (Heller, 1998). Efficient agricultural production, including extensive pastoralism systems, requires large contiguous land to enable economies of scale and synergy (Robson, 2012). These requirements may be absent when the agricultural land is privately owned in small sizes and fragmented by idle lands or non-agricultural land uses, leading to increased agricultural production costs and reduced agricultural productivity, a tragedy of spatial anticommons.

4.3 Summary of Drivers of Agricultural Land Subdivision

Box 2.1 in chapter two has identified the typical drivers that are likely to influence ALS. In this section, the drivers identified in chapter two are explained further.

4.3.1 Natural/environmental/physical drivers

i. Quality/fertility of agricultural land

Quality or fertility of agricultural land refers to the available nutrients or suitable conditions in the soil to support plants and animals. Quality or fertility of agricultural land is important because of its influence on agriculture. When the agricultural land is fertile it is likely to increase agricultural productivity by supplying crops with the necessary nutrients. Similarly, fertile agricultural land will support growth of vegetation which provides natural pasture. In an area where crop production is dependent on natural soil fertility and where livestock keeping is dependent on natural vegetation/pasture, soil fertility is an important driver of ALS. The less fertile the agricultural land is, the more ALS is likely to occur since lower quality of agricultural land will affect demand for agricultural land by the landowners/farmers. The reverse is true.

ii. Topography

Topography refers to the terrain or gradient of the land. The influence of topography on ALS may occur due to its influence on agriculture or suitability of land for urban development purposes. Level agricultural land will allow for mechanization of agricultural operations and is also likely to raise demand for such land by the property developers for urban development purposes. Topography is also likely to influence the fertility of the agricultural land as sloppy lands are more prone to soil erosion and inherent loss of nutrients.

iii. Proximity of agricultural land to amenities and services

When the agricultural land is located near infrastructural services such as transport networks, water, electricity, schools and shopping centres it is likely to raise demand for such land for urban development hence encouraging ALS, and vice versa.

iv. Rainfall

Natural rainfall is the most important factor influencing agriculture (both crops and livestock) in the tropics. This is because most of the small to medium scale agriculture (which form bulk of the agricultural activities) is mainly rain-fed with little irrigation. In Kenya, more than 80 per cent of the lands are ASALs (GoK, 2009). Therefore, rainfall has great positive influence on crops, vegetation and livestock thus the more the natural rainfall, the more agricultural land becomes attractive and less the ALS and vice versa.

v. Temperature

Temperature refers to the coldness or hotness of a place. Temperature has great influence on agriculture (both on crops/plants and livestock). Existence of urban land uses, especially residential development is also influenced by the temperature. Different agricultural activities are influenced by different levels of temperature, with most activities being suitable in areas with moderate temperatures. In the tropics, however, temperature is not a main limiting factor to agriculture.

4.3.2 Economic and technological drivers

vi. Off-farm income of the agricultural landowner

Income of the agricultural landowners may influence ALS in that the agricultural landowners may subdivide and sell off portions of their land as means of livelihood. In addition, when Off-farm income is more compared to farm-income, demand for agricultural land may be low. On the contrary, off-farm income may lead to more investment in agricultural production thus increasing productivity and attractiveness of agricultural land hence reducing subdivision of agricultural land.

vii. Price of the agricultural land

Demand for any commodity is considered in terms of the price of the commodity. In general economics, the more the price of a commodity the less of the commodity is demanded, and vice versa. In the same way, price/value of the agricultural land may influence its demand by both the agricultural landowners and the property developers thus influencing ALS. When the agricultural land is lowly priced, its demand is expected to be high by the property developers hence leading to ALS and vice versa. On the contrary, the price of agricultural land may be attractive to the rural land owner, especially when compared to the time it could take to earn the same profit from use of the agricultural land. A rational profit-maximizing exclusive owner may decide to sell his land and earn the lump sum profits now instead of continued utilization of it.

viii. Price of urban land

Generally, price of a related good or service is likely to influence demand for a good or service. The price of a 'related good' to agricultural land is price of urban land. Usually, increase of urban land prices is expected to influence increased demand for agricultural land hence encouraging ALS and vice versa.

ix. Demand for urban housing

Demand for urban housing is likely to influence ALS in the surrounding agricultural areas, especially if there is low supply of urban land in the urban areas. As the urban land use theories dictate, cities and urban areas will always grow and expand into the urban fringes and rural areas thus influencing ALS. This driver may be more dominant where there are no effective interventions to control urban sprawl and suburbanization.

x. Farm income

Agricultural productivity will influence returns/income from agricultural activities, which in turn is influenced by the physical factors and demand for agricultural activities. Demand for agricultural land by the agricultural landowners/farmers is likely to be good where the agricultural land is productive hence less ALS and vice versa.

xi. Demand for agricultural products

Good markets for agricultural output will earn farmers more profits and make agricultural activities attractive to the agricultural landowners/farmers and are likely to reduce ALS. Thus, the demand for agricultural commodities is likely to influence ALS.

xii. Availability of agricultural finance/credit

Availability of finance will affect access to capital for agricultural activities. Finance is required to fund agricultural operations including purchase of inputs and marketing functions. Acquisition of factors of production (more agricultural land, capital, labour and management) is heavily dependent on access to agricultural finance. It is expected that ALS will be less where the agricultural landowners/farmers have access to finance. The sources of agricultural finance may be borrowed capital or equity contribution.

xiii. Cost of agricultural finance/Interest rates

Where the agricultural activities are funded by borrowed capital, cost of agricultural finance becomes an important driver of ALS. Interest rates influence cost of finance and by extension availability of finance to the agricultural landowners/farmers. Low interest rates are expected to influence access and availability of agricultural finance thus leading to less ALS and vice versa.

xiv. Supply of agricultural land

In general economics, demand for a commodity is affected by its supply whereby the more supply of a particular commodity, ceteris paribus, the less the price and the more the demand for the commodity. The total supply of land is fixed, both in quantity and location. The supply of a particular type of land in a particular area may be flexible in the short run. A perception that agricultural land is plenty in supply in a particular area may influence landowners to sell part of it, thus leading to ALS.

xv. Future expectations on value of agricultural land

Generally, when producers expect a future rise in price of a commodity they are likely to hoard the commodity in the present waiting for a higher price in the future thus influencing current supply of the commodity. Similarly, agricultural landowners are likely to supply less agricultural land today waiting for future higher prices hence reducing ALS, and vice versa. Contrary, if the agricultural landowners/farmers expect agricultural activities to be less attractive in the future they are likely to sell of their land today hence increase ALS.

4.3.3 Demographic drivers

xvi. Urban population growth rate

Growth of urban population will influence demand for urban housing and general expansion of cities and urban areas thus putting pressure on the surrounding agricultural lands to transform into urban land uses. Urbanization, therefore, may play a key role in ALS. It is expected that the more urban population grow, the more ALS in the rural areas surrounding the urban areas, and vice versa.

xvii. Rural population growth rate

Growth of rural population is likely to influence local population densities and lead to ALS, especially if there are agricultural land inheritance practices.

4.3.4 Land institutional drivers

xviii. Public participation in agricultural land development process

Meaningful involvement of public in agricultural land development process is expected to reduce ALS by discouraging unproductive subdivisions. Research has shown that public participation is necessary in protecting the interests of the community, but only if the community is enlightened on the potential impacts of ALS.

xix. Local land institutional technical capacity

Decisions on agricultural land development require the decision makers to possess adequate technical capacity. Development of agricultural decisions should be made with guidance of technical advice from the physical planners and land surveyors, experts in land control matters (Ayonga, 2008). Where a local land institution does not have adequate technical capacity (for instance inadequate number of physical planners and land surveyors), its ability to make informed land use decisions may be negatively impacted thus influencing, albeit indirectly, ALS.

4.3.5 Sociocultural drivers

xx. Land inheritance practices

In areas with high rural population densities, agricultural land inheritance practices are likely to influence ALS (Jayne & Muyanga, 2012). In Kenya, the law of succession provides that land must be granted to both sons and daughters (GoK, 2008). This is likely to impact on ALS. Thus, the more agricultural land inheritance practices, the more the ALS, and vice versa.

xxi. Commodification of agricultural land

Previously, land in Kenya was not treated as a commodity that can be sold in the market. The existence of communal land rights and emotional attachment to land are further testimonies to this assertion. Acceptability to sell agricultural land (neo-liberalism tendencies) and homes, however, may influence ALS.

xxii. Customary land tenure systems

Customary land tenure systems that place control of use and disposal of land under the men may influence ALS. This is because the decision to sell agricultural land is bestowed on few individuals who sometimes may not promote the interests of the whole family. Women and children may lose out in such land tenure arrangements as the decision to sell agricultural land may be misinformed.

xxiii. Individualization of titles

The communal land rights ensure that the community does not suffer due to actions of a few members. The members of a community have usufruct rights which are inferior to the community's rights. Essentially, the community can control ALS. However, individualization of land rights through private individual land registration excludes all other interests, including the community's and may influence ALS. These facts suggest the applicability and influence of neo-liberalism and spatial anticommons theories in explaining the phenomenon of subdivisions of agricultural land.

4.3.6 Political and legal drivers

xxiv. Land use policies and laws

Land use policies and laws are necessary to direct development of agricultural land so as to achieve the desired outcomes. Therefore, lack of agricultural land use policies and laws are expected to have a negative impact on agricultural land development in general and ALS in particular. This is because when the land policy and legal frameworks are inadequate or ineffective, they tend to foster neo-liberalism tendencies hence may create a tragedy of spatial anticommons.

4.4 Summary of Implications of Agricultural Land Subdivision on Productivity

The impacts of agricultural land subdivisions on the rural communities have been discussed in chapter three of this study. Broadly, the impacts can be classified as economic, societal and environmental. The interest of the study is on the economic impacts since these are the main concern of ALS. Besides, the discipline of the land economics, the focus of this thesis, is on the economics of land use.

The main global and local concern of agricultural land subdivision is its impact on production and productivity. Generally, ALS is expected to reduce production and productivity of agricultural land mainly by negatively influencing agricultural economies of scale and synergy. Besides, the price of agricultural land is also expected to rise due to ALS hence making it difficult for farmers to purchase more land to expand their farming operations. Previous research has, however, shown that there is no universal law that can relate farm size and agricultural productivity. Subdivisions of agricultural land could thus lead to positive or negative change in agricultural production and productivity.

4.5 Summary of Policy Interventions to Manage ALS

Sample policy interventions have been discussed in chapter three of this study whereby strategies such as large plot zoning, adequate public facilities requirement, land banking, property taxation among others have been used in countries like the USA, Canada and other countries. The local policy interventions have been found to be largely in form of legal provisions. Besides, most of the local policy interventions have been designed at the national level to address a local problem. Lee (1999) and Henry *et al.* (2012) have, however, noted that effective policy interventions to manage ALS are usually designed at the local level but supported at the national level by way of national policies and laws.

4.6 Conceptual Model

A concept is an abstract or a representation of an object or its properties or a behavioral phenomenon (Nachmias & Nachmias, 2000). The importance of a concept is to allow researchers to develop a way of looking at empirical phenomena that can be shared with others thus enabling scientists to focus on some aspect of reality by defining its components and then by trying to discover whether that aspect is shared by different phenomenon in the real world (Nachmias & Nachmias, 2000; Rukwaro, 2016).

It is important to note that some concepts are complex ideas that cannot be observed directly thus researchers must infer their presence by measuring the empirical and observable behaviors or activities that indicate the extent of their presence. This is made possible by use of indicators, which represent operation definition of a concept.

The study has so far highlighted the likely typical drivers and socioeconomic impacts that may influence ALS. Theories explaining the phenomenon of agricultural land subdivisions and transformations have been discussed. Selected ALS policy interventions have been identified and discussed as well. Figure 4.1 below illustrates, in a summary, the main variables of the study.

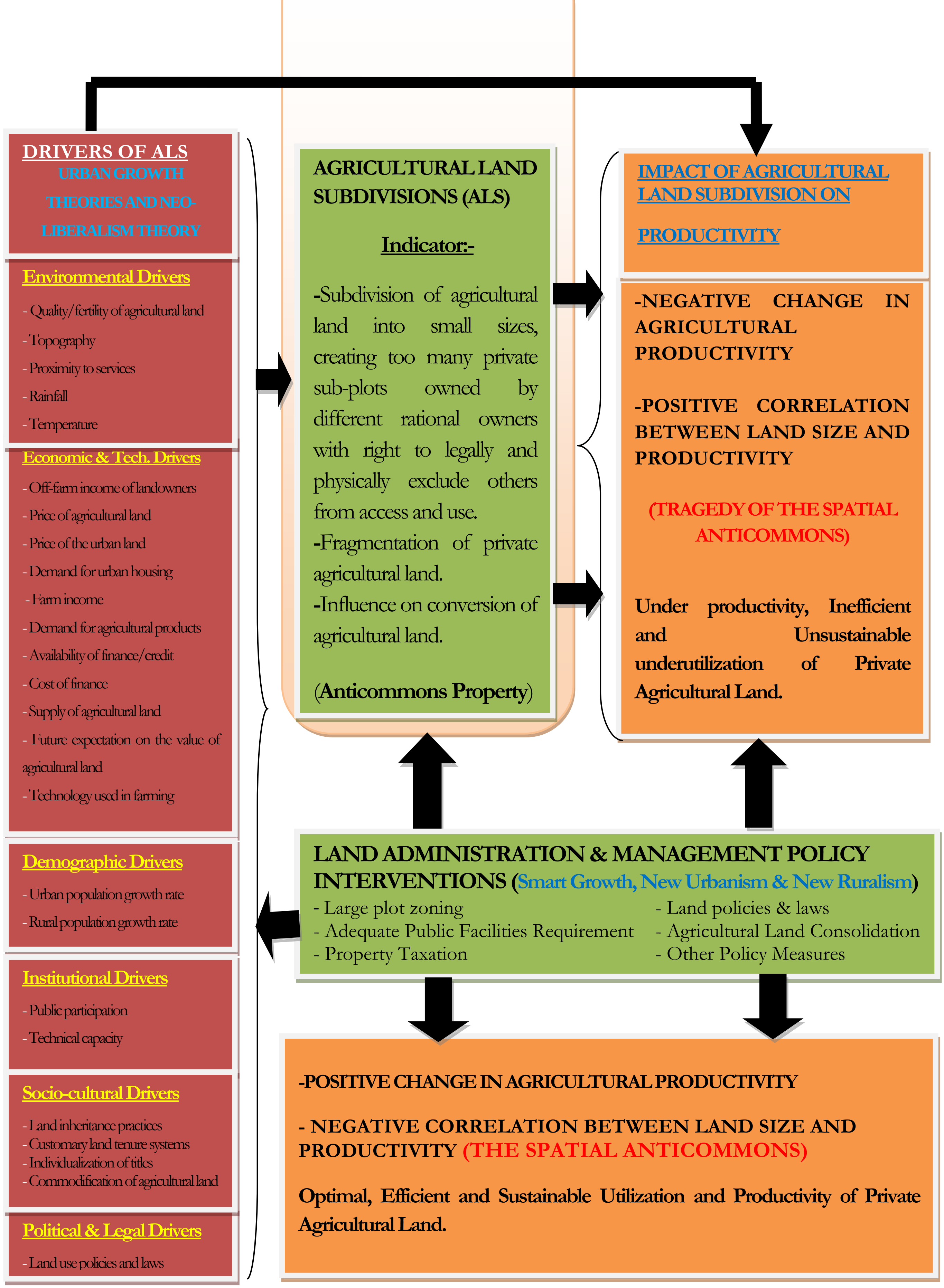

Figure 4.1: Conceptual Model (Source: Author's construct, 2016)

The drivers can be categorized as either micro or macro drivers. Micro drivers are factors that are present at the community or local level such as the physical characteristics of the agricultural land, economic factors of the local community and sociocultural factors. Macro drivers are factors such as political, legal and fiscal policies.

Figure 4.1 above represents the main concepts and theories of the phenomenon under study. The drivers (both micro and macro drivers) can also be broadly classified as environmental/natural/physical, economic, demographic, institutional, sociocultural and political/legal factors. These drivers are likely to influence subdivisions of agricultural land which then impacts on the trends of agricultural productivity. Besides, the drivers can directly influence agricultural productivity, as illustrated in the diagram, thus the size of agricultural land is just one of the many factors that are likely to influence productivity.

The trends of agricultural productivity in private land could either be negative, denoting a tragedy of spatial anticommons, or positive (spatial anticommons, which are not necessarily tragic). The correlation between agricultural land size and productivity would be positive since small land sizes would produce less output and vice versa. Land administration and management policy interventions can therefore influence the desired/positive change in agricultural productivity of private agricultural land by managing the trends and drivers of ALS. Therefore, agricultural land should not be underutilized in private land tenure (tragedy of spatial anticommons) but it should be optimally, efficiently and sustainably used (Spatial anticommons) leading to a positive change in productivity. Where the effect of subdivision of agricultural land is negative, the association between agricultural land sizes and productivity would be negative since small land sizes would produce more output. Appropriate land administration and management policy interventions should ensure this is achieved.

Thus the land administration and management authorities should put in place measures to prevent negative change in agricultural productivity (tragedy of spatial anticommons), guided by the concepts of smart growth, new urbanism and new ruralism. Essentially, land administration and management policy interventions should ensure that anticommons property do not become tragic.

4.7 Chapter Summary

This chapter has summarized chapters two and three on the trends, drivers and impacts of agricultural land subdivision on the productivity. The policy interventions have been summarized as well. The objective of this chapter was to use principles and best practices derived in chapter two and three, with a view to developing a conceptual model that enables us to understand the phenomenon of agricultural land subdivision. The model also offers policy approaches that may be adopted to control any adverse effects of subdivision of agricultural land.

The research methodology presented in the next chapter is based on the above conceptual model, which has identified the independent variable (ALS and other factors) and the dependent variables (agricultural productivity). The methodology used to measure the variables is discussed in chapter five. The study seeks to create knowledge on subdivisions of agricultural land in Kajiado County by establishing trends, drivers and implication of ALS on productivity.

CHAPTER FIVE

RESEARCH METHODOLOGY

5.1 Introduction

Chapter one introduced the study by presenting the purpose, problem statement and objectives of the study, among other introductory sections. Chapter two discussed relevant theories supporting the study whereby the theory of spatial anticommons was found to present the most compelling explanation on the implication of agricultural land subdivisions on the agricultural productivity on one hand. Urban growth theories and the theory of neo-liberalism appear to shed some light on the trends and drivers of this phenomenon on the other hand. Chapter three discussed the likely socioeconomic impacts of agricultural land subdivisions on the rural communities with key emphasis on agricultural productivity, the main concern of the phenomenon of subdivisions of agricultural land into small sizes. Finally, chapter four has presented a summary of chapters two and three and presented a conceptual framework to demonstrate how the various study variables interrelate to produce the desired outcome.

This chapter presents the research design and methodology that was used in conducting the research. The previous chapters have clarified the phenomenon of agricultural land subdivisions into small sizes and focused the study by identifying relevant variables which can be measured to test the study's hypotheses, leading to informed conclusions and recommendations. This section begins with an introduction of the study area to acquaint the reader to the characteristics of the study site.

5.1.1 Background to the study area: Kitengela division, Kajiado County

Kitengela Division is situated in Kajiado County, which is located in the Rift Valley region of Kenya. The County has a population of about 807,070 persons according to the 2009 national population and housing census. The annual population growth rate in this County is estimated at 5.5 per cent and has an average population density of 31 persons per square kilometres (KNBS, 2010). Climatically, the County is mostly arid and semi-arid, with temperatures ranging between 20 to 30 degrees Celsius and rainfall between 500 to 1,250 mm per annum. The main economic activity in the county is agriculture with livestock keeping and crop production being the main agricultural activities (KNBS, 2010). A map of Kenya showing location of Kajiado County is attached to this report as appendix 7.

Formerly, agricultural land in Kajiado County was owned under open communal arrangement, mainly in form of group ranches. Indeed, most of the Kitengela division was a group ranch (comprising of 215 Maasai members) which was formed in 1970s and occupied approximately 18,292Ha. The ranch was subdivided in 1988 and each member was allocated approximately 101.17 ha (250 acres) of agricultural land (Nkedianye *et al.*, 2009). Over the years, this trend of subdividing group agricultural ranches has been replicated in Kajiado County and other parts of dry agricultural lands in Kenya in an attempt to grant agricultural land to private individual owners. The government's objective of privatizing agricultural land was to promote livestock production and economic growth by enabling the agricultural landowners to access credit using agricultural land as collateral. By 2009, Nkedianye *et al.* (2009) report that all the group ranches had either subdivided and privatized agricultural land or were in the process of doing so.

Subdivision and sale of agricultural land in Kitengela area is reported to have commenced in 1980s whereby land owners started selling portions of their land to non-locals and non-farmers. Inheritance of agricultural land was also practiced in the area during this period. By 1992, Rutten (as cited in Nkedianye *et al.*, 2009), 75 per cent of the crop farmers were non-local. The subdivisions and sale of agricultural land in Kitengela area is likely to have economic implications on the local communities.

Kitengela Division, locally known as *Kitenkela,* is comprised of two locations (Kitengela and Olooloitikoshi), four sub-locations (Noonkopir, Kitengela, Olooloitikoshi and Ilkeek-lemedungi) and seventy eight villages. Out of the 78 villages 39 (50 per cent) fall under the urban area of Kitengela Township and the rest, which are the subject of this study, fall under the rural areas of the division. The division covers an area of approximately 192.1 square kilometres with a population of about 58,208 persons, representing a population density of 303 persons per square kilometre, according to the 2009 national population and housing census. The rural population in the division is approximately 49,830 persons. The male population in the division is 30,098 persons while females are 27,545 persons, translating to a ratio of 1:0.9 (KNBS, 2010).

Majority of the division's population fall between 15 to 64 years (labour force) age group at 61.91 per cent, with the productive age group (15 to 49 years) accounting for 57.7 per cent of the population. The 15 to 29 years' age group accounts for 34.92 per cent of the division's population (Kenya National Bureau of Statistics, 2010). In 2009, the division had 18,892 households (KNBS, 2010). The main urban area is Kitengela Township, situated approximately 30 kilometres south of capital Nairobi along the Nairobi-Namanga road (A104 road). According to the 2009 census, the township has a population of 8,378 persons.

Average annual rainfall in Kitengela Division is low and unpredictable ranging between 500 to 800 mm while temperature is almost similar to the County's average temperature. This makes crop farming uncertain. However, agricultural activities are the predominant economic activities in Kitengela division, with some pastoralists mixing livestock and crop production (agro-pastoralism) (GoK, 2017; Nkedianye *et al.*, 2009). The preferred crop in the region is maize production while the common livestock types kept include cattle, sheep and goats (Campbell, Campbell *et al.*, as cited in Nkedianye et al., 2009).

A study carried out in 2004 by Nkedianye *et al.* (2004) found out that the average size of agricultural land held by households in Kitengela area was 55.44ha with minimum agricultural land size being 0.809ha and maximum size being 352.08 ha.

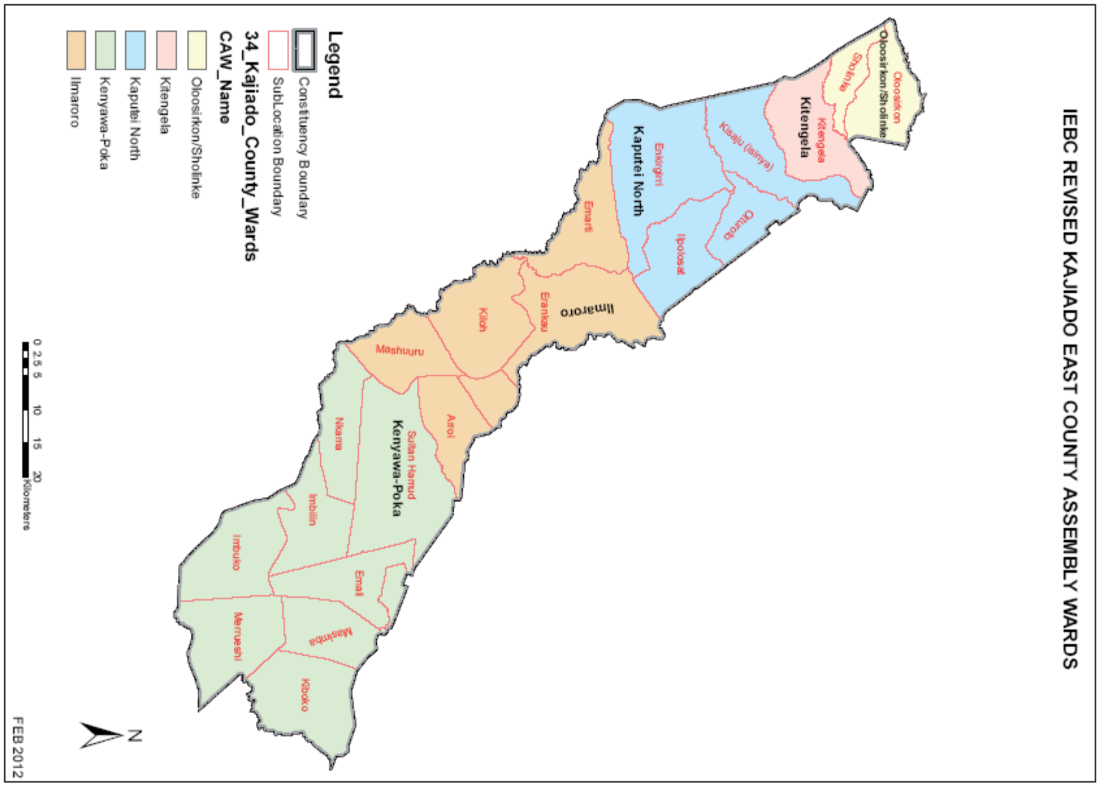

Figure 5.2: Location of Kitengela Division in Kajiado County

Source: Independent Electoral and Boundaries Commission [IEBC], 2012

5.2 Research Design

The research design is defined as a way in which a research problem is examined. Nachmias & Nachmias (2000) define research design as the blueprint which enables the researcher to answer questions such as whom to be studied? What to be observed? When will observations be made? How will the data be collected? Kerlinger, (as cited by Kumar, 2005) defines a research design as a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems while Thyer (as cited in Kumar, 2005) defines research design as a blue print or detailed plan for how a research study is to be completed. This includes operationalizing variables so that they can be measured, selecting a sample of interest to study, collecting data to be used as a basis for testing hypotheses and analyzing the results. Thus, in a summary, research design is concerned about the planning of a scientific inquiry by designing a strategy for finding out aspects of a phenomenon (Babbie, 1994). Research methodology is part of the research design.

A combination of research designs and qualitative and quantitative research methods were used in this study. This is necessary to ensure that the research takes advantage of strengths of each design/method, as recommended by Babbie (1994). This is because the collected data was both numerical and descriptive hence justifying the choice of the research strategies. Quantitative approach was essential in analysis of numerical data while qualitative approach is important to evaluate descriptive data. Use of these approaches was informed by the nature of data needed to meet the objectives of the study.

Firstly, cross-sectional survey design, which analyses data from a population or a sample at a specific point in time, was utilized in this study. Babbie (1994) postulates that this design is probably the best method available for studying social phenomena because it allows researchers to collect original data for describing a population too large to observe directly. Subdivision of agricultural land into small sizes is a social phenomenon and a survey approach is appropriate. The choice of the survey design is influenced by the nature of the data and the essence of meeting the study objectives in a cost efficient manner.

Secondly, case study design was adopted in order to make inquiry about the phenomenon of agricultural land subdivision in Kajiado County, Kenya. The case study method is an approach for studying a social phenomenon through a thorough analysis of an individual case. All data relevant to the case are gathered and organized in terms of the case to provide an opportunity for the intensive analysis of many specific details often overlooked by other methods (Kumar, 2005). Case studies are indispensable in studies of social change and informing management decisions since they deepen understanding of behaviour patterns of the concerned unit. Thus, use of case study approach enables use of more than one data collection methods and allows richer generalizations of knowledge to be made (Kothari, 2004). Thus, case study saves time and research resources and was used in this study. According to Hospice (as cited in Buckley, 2007), the use of multi methods and approaches helps to triangulate and in so doing create an increased understanding into the study topic in a holistic way. Besides, the two study designs enabled generalization of research results to other similar parts of Kenya and beyond.

5.2.1 Target population, sample size and sampling techniques

Nachmias & Nachmias (2000) define population as the aggregate of all cases that conform to some designated set of specifications. They further suggest that population should be defined in terms of content, extent and time. In other words, study population is a complete list of relevant units of analysis or data. Therefore, the target population includes all the individuals that are included in a study while the accessible population is a representative portion of the target population and is often available at the disposal of a researcher but largely represents the target population (Buckley, 2007).

For the purpose of this study, the total target population includes all agricultural land parcels and their respective owners /households in Kitengela division who were accessible as at the period of the study. Kitengela division represents similar parts of Kenya and beyond. Specifically, the study targeted agricultural landowners who have knowledge and experience on subdivision of agricultural lands and farming in the area (livestock and crop production). Since majority of rural population in the study area are farmers (agro-pastoralists), the study essentially targeted the entire agricultural land parcels and their owners in Kitengela division, excluding Kitengela Township.

Some data was also collected from real estate agents and property developers/contractors operating in the study area. Other respondents included Kajiado County land administration and management officials (County physical planners and surveyors; District physical planners and surveyors; County Land Management Board and Land Control Board).

Estate agents facilitate land sales by acting on behalf of buyers and sellers of agricultural land. Therefore, real estate agents and property developers operating in the study area provided information regarding trends of agricultural land prices in the area of study due to their interactions with the landowners in their operations. Property developers on the other hand influence demand for agricultural land by buying, reselling and developing agricultural land. The County land officials are directly involved in agricultural land development decision making processes hence were key informants of this study. Essentially, these respondents provided data and information which the landowners could not provide such as trends on value of agricultural land, challenges facing land officials/institutions, etc.

It is often impossible, impracticable and extremely expensive to collect data from all the units of analysis covered by the research problem or target population. As a result, sampling becomes necessary so that data can be collected from a subset of the population (sample). The essential requirement of any sample is that it be as representative as possible of the population from which it is drawn (Kumar, 2005). That is to say that if analyses are made using the sampling units, the results so obtained should be similar to those that would be obtained had the entire population been analysed.

For a researcher to determine a precise sample size to be used in a particular study, the sampling frame (complete listing of sampling units) should be known (Babbie, 1994; Kumar, 2005; Nachmias & Nachmias, 2000). While it is possible to access the entire population of all the county land management officials (county physical planners and surveyors and district physical planners and surveyors; county land management board and land control board), the exact total population (sampling frame) of the agricultural land parcels and landowners/households, estate agents and property developers in the study areas, however, is not known.

However, to estimate the population of the agricultural land parcels and their owners in the study area, the researcher used the number of households in the study area according to the latest Kenya's national housing and population census statistics of 2009. The total number of agricultural land parcels and their owners is estimated to be approximately 5,000.

The population of estate agents and property developers operating in the study area is difficult to establish due to lack of a complete list/sampling frame of these respondents. For the estate agents, for instance, there are some who operate without registration with the Estate Agents Registration Board [EARB] of Kenya and even those who are registered it is difficult to know their number in a particular locality. Moreover, not all the registered estate agents in Kenya are actually practising. Likewise, property developers in Kenya are registered by the National Construction Authority [NCA] but some contractors may operate without registration thus making it impossible to access a complete list of all property developers/contractors in a particular locality.

However, to estimate the population of estate agents and property developers in Kitengela Township, the researcher obtained data from all the accessible estate agents and property developers in the Township. The accessible population of estate agents was 26 while property developers were 16.

In practice, lack of a complete listing of sampling units/sampling frame is a common problem in research (Kumar, 2005). Kumar (2005) advises researchers to ensure that there is high degree of correspondence between a sampling frame and the sampling population to overcome this challenge. He further contends that even where there is no sampling frame the purpose of conducting a research is the main determinant of the accuracy required which in turn influences the sample size. Thus, in qualitative research, for instance, the issue of sample size becomes less important since the purpose of such studies is to describe a phenomenon. On the other hand, a researcher conducting a quantitative research should collect data until they reach saturation point in discovering new information and then stop data collection. The saturation point is influenced by the diversity of respondents, the greater the heterogeneity of the respondents, the bigger the sample size should be. In this study, the respondents were assumed to share some degree of homogeneity in terms of their agricultural practices and land use decision making processes.

In general terms, decisions concerning the sample sizes are complicated since sample sizes are likely to be influenced by many factors such as cost, time and precision of the sample results or the size of standard error that the researcher can accept and how the data will be analysed, among many other considerations.

According to the 2009 national census, Kitengela division had 18,892 households. Out of this number, the population of Kitengela rural households (excluding Kitengela Township) is approximately 16,694. Since not all the rural households own agricultural land, the total number of agricultural land parcels and their owners are estimated to be approximately 5,000, which is less than 10,000 cases. According to Mugenda & Mugenda (1999) when the population is more than 10,000 a sample size of 384 is adequate. When the population is less than 10,000 cases, however, the following formula should be used to estimate sample size.

Box 5.1: Sample size for agricultural landowners and land parcels

Nf = n/1+n/N Where:

Nf = Desired sample size when the population is less than 10,000
n = Desired sample size when the population is more than 10,000
N = Estimate of the population size.

Using the above formula sample size is calculated as follows:

Nf = 384/1+384/5,000 = 356.6 = 357 Agricultural land parcels & owners

Source: Adapted from Mugenda & Mugenda, 1999

Thus a total of 357 land parcels and owners were targeted in the survey. This sample size is believed to be adequate due to the following further justifications from different scholars.

Roscoe (as cited in Kieti, 2015), asserts that as a rule of thumb, sample sizes of between 30 and 500 are appropriate for most studies. In addition, in multivariate researches, sample sizes should be many times, for example ten times, the number of variables in the study. This study has 25 variables in form of drivers of ALS thus the sample size should be at least 250 cases. Therefore, a sample size of 357 cases is more than adequate. In addition, 357 cases fall between the range of 30 and 500 cases suggested by Roscoe (as cited in Kieti, 2015).

Gay (as cited in Kieti, 2015) suggests that for a population which is equal to or more than 5,000 cases, the population size is irrelevant and a sample of 400 cases would be adequate. Since the estimated population is about 5,000, a sample size of 357 is deemed adequate, given the challenges of accessibility/availability of respondents and constraints of cost.

The study used simple random sampling technique to access the targeted agricultural land parcels and landowners living in their land in the study area at the time of the field survey. This sampling technique was used to survey all the 39 villages in the study area.

Due to lack of sampling frames, purposive sampling technique was used in this study to access estate agents and property developers operating in the study area, as recommended by Babbie, 1994; Kumar (2005) and Nachmias & Nachmias (2000). They recommend use of a purposive sampling technique in situations where the researcher wishes to study a small subset of a larger population in which many members of the subset are easily identified but the enumeration of all of them would be almost impossible.

Table 5.1: Summary of study sampling techniques and sample sizes

S/No.	Accessible population	Sampling frame	Sampling technique	Sample size
1.	Agricultural land parcels and landowners in Kitengela division, Kajiado County.	Estimated number of agricultural parcels and landowners in the study area; about 5,000 which is less than 10,000 cases.	Simple random sampling. Mugenda & Mugenda (1999); populations less than 10,000 sample size should be: $$Nf = \frac{n}{1 + n/N}$$	**357**
2.	Estate agents operating in the study area	Estimated number of estate agents; 26 individuals	Purposive sampling of accessible population	All accessible population
3.	Property developers operating in the study area	Estimated number of property developers; 16 individuals	Purposive sampling of accessible population	All accessible population
3.	Chairman of Land Control Board (LCB)	1	Entire population considered	1
4.	Chairman of Kajiado County Land Management Board (CLMB)	1	Entire population considered	1
5.	Land Officials (County and district physical planners and surveyors)	4	Entire population considered	4

Source: Author's construct, 2016

5.2.2 Data types, collection tools and sources

In this study, collection of data was done using both qualitative and quantitative methods to collect information on agricultural land subdivision. The data sought was mainly primary and secondary data. Primary data was sourced from the survey respondents while secondary data was sourced from libraries, internet and public/government offices, mainly from Kajiado County Government and local land control board. Methods/tools that were used for data collection are as follows.

(i) Structured observation method

Non-participant direct observation of documents and the land parcels in the study area was done in a structured manner and data recorded in the process of observations using photography and note book. The unit of observation was the existing agricultural land sizes and their proximity to services, among other physical factors that may influence demand for agricultural land or the rate of subdivisions. Structured observation method is advisable since it eliminates bias and relates to current information which is not complicated by past events or future aspirations. Besides, they are not dependent with respondent's willingness to participate in a study, unlike in questionnaire method (Kothari, 2004). Consequently, structured observation was used to gather data relevant to the study objectives.

(ii) Semi-structured personal interviews

Interview method involves presentation of oral questions and responses given in the same way by the respondents. Structured interviews are more economical, easier to analyse for generalization purposes and ensures high response rate. In addition, they allow the interviewee to clarify questions hence the researcher is able to gather more data than is possible using observation method (Babbie, 1994; Kumar 2005; Kothari, 2004; Nachmias & Nachmias, 200). Thus structured interviews were conducted with the key study informants who included the county and district land officials (planners and surveyors), chairman of land control board and county land management board.

(iii)Semi-structured self-administered questionnaires/schedules

Questionnaire is a proforma with a set of well sequenced questions relevant to the study objectives. Schedules/self-administered questionnaires are more appropriate where the respondents are not well educated than use of questionnaires (Kothari, 2004). Schedules are faster and ensure that data collected is complete without omissions/unanswered questions. They also enable high response rates and enables combination of different methods and personal contact possible (Babbie, 1994; Kumar, 2005). This study used schedules due to the above reasons to collect data from the agricultural landowners, estate agents and property developers.

These multiple data collection instruments were adopted in order to get the required data to facilitate the quest for objectives of the study. A summary of the data types, sources, collection tools and methods of data analysis are as shown in table 5.2 below. A sample of the schedules is attached in appendix 5.

Table 5.2: Summary of Study Methodology

Objective	Data needs	Data sources	Data Collection Methods	Data Analysis Methods	Data Output
1(a) To establish the trends of agricultural land subdivisions over the last 10 years in Kajiado County.	Previous and existing agricultural land sizes in the study area. Acreage of land subdivided over the last 10 years Applications and consents for agricultural land subdivisions over the last 10 years.	- Google images - Kajiado lands office/land control board - Agricultural landowners.	Document observation Semi structured schedules.	Attach Google images Cross tabulations Bar graphs Means/minimum/maximum land sizes.	Show trends of ALS in Kajiado County.
1(b). To identify and rank drivers of the agricultural land subdivision in Kajiado	Identifying and ranking important drivers of agricultural land subdivision. In Kajiado County	Study respondents (agricultural landowners and Kajiado County land management officials).	Semi structured schedules and interviews.	Mean Scores; Z Scores	Determine important drivers of ALS in Kajiado County.
2. To determine the implications of agricultural land subdivision on agricultural productivity in Kajiado County.	Existing agricultural land sizes (data from objective No. 1 above). Average agricultural output/productivity for each land parcel under study	Agricultural landowners/ farmers Agricultural offices in Kajiado County	Semi structured schedules and interviews.	Cross Tabulations/ Graphs Descriptive Statistics (mean, median, standard deviation, etc.) Correlation Analysis Multiple Regression Analysis (MRA)	Determine the implications of ALS on agricultural productivity

3. To develop models to guide policy on subdivision of agricultural land in Kenya.	Appropriate policy interventions to manage agricultural land subdivisions	Literature review Field data analysis on important drivers and implication of ALS on agricultural productivity (findings from objectives 1 and 2 above)	Document review Study's findings from objectives 1 and 2 above.	As used in Objectives 1 & 2 above. Identification of appropriate policy interventions as per the study's main findings and conclusions – Results of MRA analysis	To develop models to guide policy on subdivision of agricultural land in Kenya.

Source: Author's construct (2016)

5.2.3 Study variables

The purpose of this study is to create knowledge on the phenomenon of agricultural land subdivision by examining trends, drivers and implication of this phenomenon on the productivity. It is assumed that findings of this study may inform future efforts in managing development of agricultural land. The previous chapters have established drivers of agricultural land subdivision (ALS) to be the independent variable and major dependent variable to be agricultural productivity. Drivers of ALS are broadly categorised as environmental, economic, demographic, institutional, socio-cultural and political and legal factors as listed under Box 2.1 in chapter two. These variables have been further conceptualised in chapter three and their interrelationships demonstrated. The table below presents a summary of the variables and how they were measured.

Measurement of variables at ratio level (variables with natural, absolute and fixed zero points) and interval allows data to undergo the most powerful statistical manipulation. Some of the drivers explaining agricultural land subdivisions, however, are qualitative in nature. Thus, these variables were measured at nominal and ordinal level by assigning them scores to reflect their importance in influencing the phenomenon of agricultural land subdivisions. This made ranking of all the drivers possible. Agricultural productivity (dependent variable) was measured using ratio level as described in table 5.3 below.

Table 5.3: Summary of study dependent and independent variables

Variable Name	**Variable Definition and measurement**	**Value**
Agricultural productivity	Number of 90kg bags of maize per ha; number of cattle per ha and number of goats/sheep per ha.	Quantitative
Agricultural Land Subdivisions (ALS)	Resultant sizes of agricultural land parcels in hectares.	Quantitative
Quality/fertility of land	Value of 1 for fertile land, value of 2 for relatively fertile land and value of 3 for infertile land	Qualitative
Topography	Value of 1 for level topography, value of 2 for gentle sloping and value of 3 for sloppy topography	Qualitative
Proximity to amenities and services	Distance from the services (water, motorable road and powerline) to each land parcel in kilometres	Quantitative
Rainfall	Amount of total annual rainfall in mm.	Quantitative
Temperature	Amount of total annual temperature in degree Celsius	Quantitative
Poverty/income of agricultural landowner	Total annual income in Kshs.	Quantitative
Price/value of the agricultural land	Average price of one ha of agricultural land in Kshs.	Quantitative
Price/value of urban land	Average price of one ha of urban land in Kshs.	Quantitative
Demand for urban	Value of 1 for high demand,	Qualitative

housing	value of 2 for moderate demand and value of 3 for low demand	
Farm income	Total annual income from agricultural activities in Kshs.	Quantitative
Demand for agricultural products	Value of 1 for high demand, value of 2 for moderate demand and value of 3 for low demand	Qualitative
Cost of finance/Interest rates	Average interest rate over the last 10 years	Quantitative
Availability of finance/credit/capital	Value of 1 for easily available finance and value of 2 for less available finance	Qualitative
Supply of agricultural land	Average amount of agricultural land in Ha owned by the agricultural landowners	Quantitative
Future expectations on value of agricultural land	Value of 1 for expectation of a higher price and value of 2 for expectation of a lower price.	Qualitative
Urban population growth rate	Annual percentage change in urban population	Quantitative
Rural population growth rate	Annual percentage change in rural population	Quantitative
Public participation in agricultural land development	Value of 1 for participating and value of 2 for not participating	Qualitative
Local land institutional technical capacity	No. of land surveyors and physical planners in the Kajiado County lands office	Quantitative
Land inheritance practices	No. of agricultural landowners who acquired land through inheritance	Quantitative
Commodification of agricultural land/acceptability to sell	Value of 1 for acceptance to sell and value of 2 for refusal to sell agricultural land	Qualitative

agricultural land		
Customary land tenure systems	No. of agricultural land parcels registered in the name of the male head of the household	Quantitative
Individualization of titles	No. of agricultural land parcels registered in the name of individual private owners	Quantitative
Land use policies and laws	Value of 1 for inadequate land use policies and laws and value of 2 for adequate land use policies and laws	Qualitative

Source: Author's construct, 2016

5.3 Data Analysis and Presentation

Raw data which was obtained from the survey was converted to a format that facilitated easy analysis. Before analysis, the raw data was classified into ordinal, nominal or scale variables and then coded. The methods of analysis were both qualitative and quantitative. The objectives as well as the nature of the data influenced the procedure used for data analysis. Qualitative analysis was used in descriptive data while the quantitative method was essential in the numerical data.

Use of qualitative analysis specifically targeted data from the interviews and also open ended questions and the secondary data from previous findings and document reviews. Grounded theory technic is important in areas where data collection and analysis go hand in hand to the themes and relationships in which information is obtained from the interviews and open ended questions. In addition, quantitative method (hypothetico-deductive model) used both descriptive and inferential statistics so as to offer analysis on the numerical data from the study respondents. The descriptive statistical methods included the frequency measures, mean score, mean, median, standard deviation, etc. Inferential statistical method involved the z scores, correlation and regression analysis in order to test the hypotheses for the study at 0.05 level of significance (95% confidence level).

5.3.1 Trends and drivers of agricultural land subdivisions

The necessary data to show trends of agricultural land subdivisions was analysed by use of descriptive statistics; percentages, mean, median, minimum and maximum land holding sizes. The total amount of agricultural land subdivided over the last 10 years was also determined from the respondents surveyed. The data was presented using tables and graphs. This was done to show trends of agricultural land subdivisions over the last 10 years.

The analysis of the drivers of ALS was carried out by presenting the typical drivers identified through literature review to the study respondents to select the ones that are applicable in the area of study. The respondents were then asked to use a numerical horizontal scale of 1 to 4 to rank the drivers in their order of significance whereby 1=Not Important; 2=Less Important; 3=Important and 4=Very Important. Several researchers have used and recommended a horizontal scale of 1 to 4 to represent two extremes; 'not important' and 'very important', respectively. This scale is appropriate to avoid confusion on the respondents (Alreck & Seattle, 1995; Masu, Murigu, Talukhaba, as cited in Kieti, 2015). In so doing, the significant drivers of agricultural land subdivisions were identified and ranked in their order of importance.

Testing of the first study hypothesis was done using the population mean score and the critical Z-value. Firstly, to further analyze and determine significant drivers of the ALS, the study used the population mean score ($\bar{X}$ = **2.5),** that is the middle point of the 1- 4 numerical score, to act as a decision point, whereby any driver whose mean score was found to be below this point was considered to be not significant and any driver with a mean score equal to or above this point was considered to be major or significant driver in influencing ALS. Masu, Murigu, Talukhaba, as cited in Kieti, 2015 have used similar approach.

Thus, all the 25 drivers had two assumptions; that all the drivers are not significant in influencing subdivisions of agricultural land and all the drivers are significant in determining the subdivisions of agricultural land in the study area. A driver with a mean score of about 2.5 is considered to be average and important. At this point, the insignificant drivers were dropped for purposes of subsequent further data analysis. Insignificant drivers are those with a mean score below 2.5.

Secondly, testing of the first study hypothesis was further carried out using z scores so as to accept or fail to accept the hypothesis. Z-test is a statistical test used to determine whether two means are different. This test is best used when the sample size is large (greater than 30 cases) because under the central limit theorem, as the number of samples gets larger, the samples are considered to be almost normally distributed, a requirement for z-test. Besides, for each significance level, the z-test has a single critical value which makes it more convenient to use than the t-test which has separate critical value for each sample size and is best suited for small sample sizes (Kingoriah, 2004).

Z-test was therefore used to test the first hypothesis of the study. This was carried out after setting the confidence level at 95%. According to Masu, (as cited in Kieti, 2015), confidence levels help in reducing chances of identifying a particular driver/factor to be significant when actually it is insignificant (Alpha error or type 1 error) or concluding that a particular driver is insignificant while it is actually significant (Beta error or type II error) (Harper, as cited in Kieti, 2015; Kingoriah, 2004).

Since the analysis of the drivers influencing subdivisions of agricultural land were only meant to provide policy direction to the land managers, confidence level was set at 95% to identify significant drivers. Thus z scores analysis provided a decisive way of either accepting or failing to accept the first null hypothesis of the study, given the data obtained. The testing of hypothesis using the z-value was performed only on the average/moderate and the major significant drivers as analyzed using the population mean score. The formula for computing z-value calculated for each average/moderate and the major significant driver is shown below, as suggested by Kingoriah, 2004.

$z = (\bar{X} - \mu) / (\delta / \sqrt{n})$;

Where z = Calculated z-value

$\bar{X}$ = Mean score for each driver

μ = Population mean score (x for this study is 2.5**)**

δ = Standard deviation

n = Sample size (n for this study is 357 cases)

Sirkin (as cited in Kieti, 2015) has provided the following critical z-values at different probability/confidence levels.

Table 5.4: Critical Z-Values at various confidence levels

Confidence Levels	**One-tailed critical *z*-value test**	**Two-tailed critical *z*-value test**
95%	**1.65**	1.96
99%	2.33	2.58
99.999%	3.09	3.29

Source: Sirkin (as cited in Kieti, 2015)

The z-value calculated for each driver was then compared with the critical z-value at 95% confidence level in one-tailed z-test. Where the z-value calculated for each driver was greater than the critical z-value at 95% confidence level, the study was confident that the particular driver was significant in influencing subdivision of agricultural land. Therefore, the critical z value (one-tailed test) at 95% confidence level is **1.65** (as shown in table 5.4 above) hence any driver whose computed z value was found to be less than 1.65 was decisively considered to be less significant in influencing agricultural land subdivisions and vice versa.

5.3.2 Implications of agricultural land subdivision on productivity

The implication of land subdivisions on agricultural production was carried out by use of cross tabulations, graphs, correlation analysis and multiple regression analysis. Generally, descriptive statistics were performed on all the data before further analysis using inferential statistics.

Descriptive statistics was performed on the data to summarize the variables influencing agricultural productivity to enhance understanding and further analysis. Murphy (as cited in Kieti, 2015) suggests that descriptive statistics should be performed on data before correlation and regression analysis to check for completeness of data sets and whether data obeys normal distribution curve. Data sets that obeys normal distribution curve should have small value of standard deviation, value of mean and median should be equal or almost equal, value of skewness should be <1 or 0 and value of kurtosis should be ≤ 3 or 0 (Kingoriah, 2004; Murphy, as cited in Kieti, 2015).

Thus, descriptive statistics performed on the data for this purposes included mean, median, standard deviation, skewness and kurtosis. Mean and median are averages whereby to obtain the mean one needs to add up all the values and divide the result with the number of the values while median is the middle number when the values are arranged from the smallest to the largest. Standard deviation, skewness and kurtosis all measure the amount of variation or dispersion from the mean value of a data sets thus they should be small to indicate that the data is normally distributed (close to the mean) and that there are no outliers (Kingoriah, 2004). The descriptive statistics was performed using a computer program known as Statistical Package for Social Sciences (SPSS) software.

Further to the above descriptive statistics, correlation analysis was also performed on the data. Correlation is used to determine the direction (positive or negative) and the strength (none, weak, moderate and strong) of linear association/relationship between variables (Kingoriah, 2004). Correlation analysis was also performed using SPSS software. Specifically, Pearson correlation (2-tailed) was performed to show how the agricultural productivity (dependent variable) is related to the factors influencing it (independent variables). This was necessary to demonstrate how the dependent and independent variables explain each other.

Besides, correlation analysis is necessary to check for multicollinearity or collinearity, a situation where high correlation exists between two or more variables thus affecting relative contribution of each independent variable to the final multiple regression model. Essentially, multicollinearity ensures that only independent variables that are correlated to the dependent variable are included in the final model (Murphy, 1989 in Kieti, 2015). Multicollinearity exists if; correlation coefficient between independent variables is very strong (0.7 to 1) or largest Variance Inflation Factor (VIF) is >10 or average VIF is significantly >1 and tolerance is big. Generally, values of tolerance of more than 5 and correlation coefficients of more than 0.7 among independent variables would indicate possibility of multicollinearity.

Finally, multiple regression analysis (MRA) was performed on the data to measure the marginal and relative contribution of the independent variables to the agricultural productivity and land size. This was necessary to develop models and check the marginal and relative contribution of land size on the agricultural productivity of sheep/goat, cattle and maize and thus test the second hypothesis of this study. MRA also helped in identifying significant factors influencing agricultural land size to inform policy guidelines regarding subdivisions of agricultural land.

A model, as defined by Kingoriah (2004), is a theoretical arrangements of relationships which attempts to capture only the main variables/elements in a real world condition. The purpose, accuracy, neatness or simplicity and the assumptions made by the researcher influences the number of variables to be included in a model (Kingoriah, 2004). The MRA was performed by use of SPSS software as well. Simultaneous/ENTER method was used in agricultural productivity models since it is preferred when there are relatively low number of variables under study as it can analyze both weak and strong independent variables (Brace *et al.*, as cited in Kieti, 2015). On the contrary, the Stepwise method was used in determining significant factors predicting agricultural land sizes since it automatically eliminates insignificant variables from the MRA model.

The general function of multiple regression equation is usually presented as follows;

$$\mathbf{Y = b_0 + b_1X_1 + b_2x_2 + \ldots b_nX_n + e;}$$

Where **Y** = Dependent variable (in this study = Agricultural productivity or land size)

$\mathbf{b_0}$ = Constant/Y-intercept or the value of Y when X = 0, i.e. other factors influencing agricultural productivity or land size which were not included in the model. This improves accuracy of the model by reducing human error and inefficiency.

$\mathbf{b_1 \ldots b_n}$ = Regression coefficients showing how much dependent variable Y (Agricultural productivity or land size) changes due to change in independent variables X (Factors influencing agricultural productivity or land size)

$\mathbf{X_1 \ldots X_n}$ = Independent variables (Factors influencing agricultural productivity or land size)

e = Error, denoting difference between actual measurement and calculated value. This error is reduced by $b_1 \ldots b_n$ in MRA.

Multiple regression analysis (MRA) was adopted in this study because it has many advantages; use of actual data, several variables can be analyzed at the same time, easy to apply and interpret hence widely used in scientific social research. Besides, MRA enables researchers to obtain more accurate estimations of the dependent variables by minimizing error between actual measurements and calculated values in the regression coefficients (Akinwumi, as cited in Kieti, 2015).

5.4 Validity and Reliability

Validity and reliability in research ensures that measuring errors are minimized. Measuring errors are differences in scores that are due to anything other than real differences. Respondents, for instance may require certain degree of intelligence and social awareness (Nachmias & Nachmias, 2000). The survey method used in this research asked respondents their level of education to ensure that they are intelligent and exposed enough to answer the survey questions. Other sources of measurement errors may arise due to temporary differences in condition of the respondents such as change in mood or health. The researcher, however, may not have control over such temporary differences. The age, race and sex of the interviewers and the setting/environment (poor lighting, noise etc.) of the interview may also influence the answers given by the respondents.

The survey data collected in this study were obtained during day time by mature Kenyan research assistants and there were no observed incidences related to age, race or sex that may interfere with reliability and validity of the study's findings. The interviews were contacted mainly in the respondents places of residences or work hence the environment was assumed to be conducive. This study utilized the following measures to minimize bias and ensure validity and reliability.

(i) Use of well formulated self-administered questionnaires/schedules: This was necessary so as to ensure there are no ambiguous questions and the data enumerators were present to clarify questions which the respondents could not clearly understand. Where the questions were structured, the tools were also flexible enough for the respondent to add any additional answer/option not provided. The questions asked were only relevant to the various respondents and to the study objectives.

(ii) Use of well-trained data collectors: Many of the validity and reliability issues arise during data collection process. The study used well-trained and experienced data enumerators to avoid biasness. The data collectors were also adequately supervised during data collection process.

(iii) Pre-test of data collection instruments: The schedules were first administered to a few respondents to check for ambiguity and omissions and amendments were later effected accordingly to make the questions clearer.

(iv) Appropriate data coding and analysis: The raw data collected from the field were appropriately coded and analyzed using appropriate statistical techniques, with the help of a computer program known as Statistical Package for Social Sciences (SPSS) version 22. This enabled proper coding and manipulation of data as well as appropriate tests of significance to ensure that study conclusions are well informed and valid.

(v) Proper Sampling design: Sampling validity checks whether a given population is adequately sampled by the subject measuring instrument. Generally, the larger the sample size, the greater the degree of reliability/accuracy of any study. Besides, in general terms, random sampling ensures validity of the results (Kingoriah, 2004). The target population of this study was estimated using Kenya's latest national housing and population census of 2009. The sample size was arrived at by using formula and methods developed by scholars such as Babbie (1994), Kingoriah (2004), Kumar (2005), Mugenda & Mugenda (2003), Nachmias & Nachmias (2000), among others. However, there were no sampling frames for some respondents such as for estate agents and property developers operating in the study area. In such instances, the available respondents were surveyed, according to Kumar (2005) and Nachmias & Nachmias (2000). This was necessary to ensure that the sample sizes are adequately representative.

(vi) Use of more than one data collection methods: The study used a mix of data collection tools in form of structured observation, semi-structured personal interviews and semi-structured schedules to achieve triangulation of results. The appropriateness of these tools has been discussed earlier in this section. Besides, both primary and secondary official data were collected. This was necessary to raise objectivity and minimize personal biases that might stem from reliance on a single method of data collection (Babbie, 1994; Kumar, 2005; Nachmias & Nachmias, 2000).

5.5 Chapter Summary

This chapter has introduced the study area and discussed in detail the research designs and data collection methods, sources of data and statistical tools used to analyze the data. The study variables have also been clearly identified and explained. The next chapter presents analysis of data collected which in turn informed study findings, conclusions and recommendations in the subsequent chapters so as to achieve the objectives of the study.

CHAPTER SIX

TRENDS OF AGRICULTURAL LAND SUBDIVISIONS IN KAJIADO COUNTY

6.1 Introduction

The preceding chapter has discussed the research design and methods which were used to collect and analyze data. This section presents and analyzes the data collected in regard to trends and drivers of agricultural land subdivision in the study area. The key objective in this chapter is to gain more knowledge on the trends and important drivers of agricultural land subdivisions in Kajiado County. The survey's response rate and important socio-economic characteristics of the respondents that are likely to influence the trends and impacts of agricultural land subdivisions are also discussed in this section. A brief description of the land administration and management practices in Kenya is first presented to give the reader an idea of the regulatory status of land management.

6.1.1 Land administration and management practices in Kenya

Land administration and management practices in Kenya dates back to pre-colonial period (before 1889) when agricultural land belonged to the community and was held and used for the advantage of all the community members. Thus, the traditional communities influenced land use practices based on their culture. This granted every community member equivalent rights to access and use of the community land (Wakoko, 2014). The collective land tenure during this period allowed distribution of agricultural land to be made according to the clear needs of individuals and families such as the size of the family. Customary law, exercised under collective land tenure, thus played a crucial role in administration and management of agricultural land (Behnke & Freudenberger, 2013; Njeru, 2017 Nyberg *et al.*, 2015).

It is important to note that during pre-colonial period population density was low. There were thus less concerns of limited access to land and subdivisions of agricultural land were not as harmful. Besides, communities were then more close-knit and informal/local arrangements could be made to access another community's agricultural land to overcome challenges of drought. This enabled pastoralism to thrive since communities could avoid tragedy of the anticommons created by group/community ownership of agricultural land.

During the colonial period (1889 – 1962), agricultural land administration issues in Kenya have been mainly about security of tenure, especially for pastoral communities since many communities in the drylands lost a good chunk of their ancestral land through expropriation by the colonial government. During the early Twentieth Century (1901 - 1911) the Maasai community in Kenya, for example, lost more than 50% of their ethnic land to white settlers (Rutten, as cited in Behnke & Freudenberger, 2013). The colonial period could be summarized as struggle for the Kenyan natives to access their land. In a nutshell, most of the land laws enacted by the colonial masters between 1901 and 1962 were largely meant to give the colonists more powers over the natives in respect to land, a process that led to marginalization of many citizens (Wakoko, 2014).

The key turning point of land administration in Kenya, which is important to this thesis, happened in 1955 following the recommendations of Swynnerton's plan and the East African Royal Commission's report which suggested individualization of communal land tenure in Kenya to spur economic development through improved agricultural production. To this end, the Indian Transfer of Property Act of 1882 was instrumental in administration of land tenure regimes and registration while the Land Order in Council of 1960 allowed conversion of leasehold titles owned by Africans to freehold interests. These regimes granted natives complete rights over land (Wakoko, 2014). Besides, land, including agricultural one, became a commodity that could be merchandized in the market. For the first time since the commencement of colonial tenet, natives acquired power to sustain customary land tenure and inheritance practices within the precincts of the written English law.

In a nutshell, after independence in 1963 the government of Kenya picked from where the colonial masters had left and continued to encourage privatization and individualization of agricultural land. The main objectives of this approach were to secure land rights and encourage economic development of the rural communities since individual title deeds could be used to access credit. In dry agricultural lands, group ranches were created and registered under the Group (Land) Representatives Act and the Trust Land Act (now repealed and replaced by the Community Land Act of 2016). In 1963, the Registered Land Act chapter 300, laws of Kenya (repealed in 2012 and replaced by the Registration of Land Act of 2012) was enacted to register individual private freehold tenure with its rights and privileges of absolute ownership, giving Africans the right to lease, subdivide and sell off land.

In addition, the independence Constitution of 1963, under sections 19 and 26 (repealed in 2010 and replaced by the current Constitution, 2010) provided for rights over land and land use, respectively. The freedom conferred by absolute exclusive ownership of land has partly influenced further subdivision of the communal/group ranches leading to creation of exclusive private individual tenure in agricultural land, a practice which is likely to threaten agricultural production and productivity.

Some of the existing important policy, legal and institutional frameworks include the Constitution of Kenya (2010), the National land Use Policy (2017), the National Land Policy (2009) and the National Spatial Plan (2016), all of which provide that land should be used in an efficient, productive and sustainable manner, thus discouraging uneconomical subdivision of agricultural land (GoK, 2017; 2016; 2010; 2009). Other policy frameworks include the Kenya Vision 2030, the Agricultural Sector Development Strategy and the Sustainable Development Goals (GoK, 2010b; 2007; United Nations Development Programme [UNDP], 2015). These policies acknowledge the importance of agricultural land and promote its preservation from unsustainable development. There are also myriad of land laws which discourage uneconomical subdivision and unsustainable development of land in Kenya such as The Physical Planning Act, The Land Control Act, The

Agriculture, Fisheries and Food Authority Act, The Land Act, The Land Registration Act, The County Governments Act and The Community Land Act (GoK, 2016a; 2013a; 2012a; 2012b; 2012c; 1967).

The Land Control Act, chapter 302, laws of Kenya, has important provisions on control of agricultural land development. Under this Act, the land control boards have powers to control transactions in agricultural land. Transactions affecting agricultural land (subdivision, sale, mortgage etc.) must be approved by the respective land control board. The registrar of titles should ensure that consent from the relevant land control board is obtained before registration of any transaction affecting agricultural land.

Among other considerations, the land control boards should consider the effect of subdivisions on the agricultural land productivity and prohibit subdivisions where productivity is likely to be negatively affected (GoK, 1967). Determination of effects of subdivisions on the land productivity, as provided for in this Act, appears subjective and may explain why agricultural land continues to be subdivided into small sizes despite existence of the land control boards. Absence of a law that prescribes the minimum and maximum land holding sizes for various land uses further complicates the situation.

The Act also does not provide for public participation, which is necessary to manage ALS (Ayonga, 2008; Baba et al., 2006). Moreover, the composition of the land control boards (district commissioner, 2 other public officers, 2 members nominated by the county government and between 3 to 7 local residents) suggests inadequate technical capacity of the boards to carry out their duties effectively. This may explain why the land control boards have been generally ineffective. Thus, the Minimum and Maximum Land Holding Acreages Bill proposes to replace local land control boards with the county land management boards. Currently, however, the functions of the county land management boards are rather confusing since the land control boards are also in existence, as per the Land Control Act which is still in operation.

Additional land laws are being enacted to strengthen and seal loopholes in the existing ones. These include the Physical Planning Bill and the Minimum and Maximum Land Holding Acreages Bill (GoK, 2015a; 2015b), among others.

6.2 Survey Response Rate

Table 6.1: Response rate

S/No.	Respondents	No. of schedules & interviews	Responses	Response rate (%)
1.	Agricultural landowners	357	203	57%
2.	Land officials (District & County land surveyors and physical planners)	4	4	100%
3.	Land Control board	1	1	100%
4.	County land management board	1	1	100%
5.	Estate agents	26	26	100%
6.	Property developers	16	16	100%
Total		**405**	**251**	**62%**

Source: Field Survey, 2016/2017

A good response rate improves representativeness of results to the target population thus influencing the accuracy of an inquiry. According to Mugenda & Mugenda (2003), a response rate of at least 50% is considered as satisfactory. Table 6.1 indicates that the study achieved an overall response rate of 62% from the accessible population which is good enough to make conclusive judgments about the phenomenon under the study.

Historically, many communities in Kenya (including the Maasai community) lost their ancestral land during the colonial rule. After independence, some political elites and other individuals/agencies have continued with expropriation of ancestral land, to the disadvantage of the local communities (Koissaba, 2015). This and other factors have made land to be an emotive issue in Kenya. Therefore, the survey response rate from the agricultural landowners/parcels was negatively affected by hostility from some of the respondents who mistook the data collectors to be land grabbers.

Besides, the data for this study was collected during a dry season when some of the community members were out searching for pasture and water for their livestock hence they were not available to participate in the study. In addition, the study was conducted in a rural area where the households and villages are distant from each other and are connected with poor access roads. Nevertheless, the researcher acquired research permits from all the relevant authorities and used experienced data collectors (some from the local community) to create rapport with the respondents and overcame the above challenges thus a response rate of 62 percent was achieved which is adequate enough for generalization purposes.

6.3 Socioeconomic Characteristics of Agricultural Landowners

There are some socio-economic characteristics of the agricultural landowners/farmers which are important to trends and drivers of agricultural land subdivisions. Similarly, some socio-economic characteristics of the agricultural landowners may influence agricultural productivity. Age, level of education and income of the agricultural landowner as well as the number of mature family members are likely to influence agricultural productivity as explained in the succeeding discussion.

6.3.1 Age of agricultural landowners

Age of the agricultural landowner is likely to influence agricultural productivity since older landowners are expected to have experience and thus use better methods of farming. In pastoralism practice, for example, old pastoralists are likely to know patterns of livestock disease and weather. They are thus likely to adopt appropriate measures to avert agricultural loses hence increasing productivity. Thus, the older the agricultural landowner, the more agricultural productivity is expected from a particular piece of land, and vice versa. Similarly, old landowners are likely to influence subdivisions of agricultural land by propagating socio-cultural practices such as land inheritance practices.

From the findings, 28 landowners (14%) stated that they were aged between 20-30 years; 67 landowners (33%) stated that they were aged between 31-40 years; 53 landowners (26%) stated that they were aged between 41-50 years; 44 landowners (22%) stated that they were aged between 51-60 years and 11 landowners (5%) stated that they were aged over 60 years. Thus, a total of 164 landowners were aged between 31-60 years (81%) while additional 11 landowners (5%) were aged over 60 years. This is a good age bracket since most of the landowners were mature enough to understand and to have experienced the phenomenon of subdivisions of agricultural land in the study area. Age of the agricultural landowners was thus correlated against the agricultural productivity to determine how the two are related. In addition, age of landowners was regressed against the agricultural productivity to establish its relative contribution to the productivity model.

6.3.2 Level of education of agricultural landowners

Educated agricultural landowners are likely to secure formal employment and earn income from non-agricultural/off-farm activities. This is important since it may lower demand for agricultural land and agricultural land subdivisions. Alternatively, educated landowners are likely to adopt better methods of farming (technology) and increase agricultural productivity, and vice versa.

The findings showed that 12 landowners (6%) had university education; 33 landowners (16%) had diploma education; 7 landowners (3%) had certificate education; 56 landowners (28%) had secondary education; 29 landowners (14%) had primary education and 66 landowners (33%) did not have formal education. The Kajiado County illiteracy level stands at 35% which is higher than the national's at 28.6% (County Government of Kajiado, 2013). Thus, a total of 137 landowners (68%) had some formal education while the rest (32%, which almost equals the County's illiteracy level) did not have formal education.

Use of experienced and some local data enumerators as well as assistance/interpretation by the respondents' educated children enabled collection of the relevant data for this study. It should be noted, however, that provision of formal education is one of the ways to increase off-farm incomes (for example from formal employment) hence reducing poverty in society and overreliance on on-farm incomes. This has potential of reducing the threat of livelihood arising from agricultural land subdivisions. The findings of this study, however, suggest that the local landowners without formal education (32.5%) could result to subdivisions and selling off of agricultural land as one of the key sources of income generation to support their livelihoods, thus fuelling subdivisions of agricultural land.

The education level of the landowners was therefore correlated with agricultural productivity to establish the relationship between the two variables. In addition, the level of education of the landowners was regressed against the agricultural productivity of livestock (sheep/goat and cattle) and crop productivity (maize) to determine its relative contribution to agricultural productivity.

6.3.3 Income of agricultural landowners

Occupation of the landowners is expected to have a positive influence on the level of their income. The landowners who are engaged in non-agricultural activities are likely to have less demand for agricultural land and are likely to subdivide and sell off their agricultural land, and vice versa. On the contrary, income from non-agricultural activities could be invested in agricultural production and increase productivity.

The findings show that 45 landowners (22%) were subsistence farmers; 22 landowners (11%) were pastoralists; 25 landowners (12%) were formally employed; 11 landowners (5%) were informally employed; 6 landowners (4%) were unemployed; 92 landowners (45%)

were in business; and 2 landowners (1%) were home makers. This means that majority of the respondents were in business. The low levels of formal employment (12%) could be explained by the high levels of illiteracy at 33%. According to the Kenya National Housing and Population Census of 2009, 8% of the County's population was employed. It is encouraging to note, however, that only 4% of the respondents were not engaged in any income generating activities while majority (45%) were operating various businesses.

Off-farm income generating activities (formal and informal employment and businesses) are likely to reduce overreliance on agricultural land for survival thus reducing the risk associated with reduced agricultural productivity arising from subdivisions of agricultural land. The mean off-farm income bracket for this study was reported as between Kshs. 101,000 – 120,000/- per annum while farm income bracket was Kshs 141,000 – 160,000/- per annum.

Income from agricultural activities (farm income) and non-agricultural activities (off-farm income) of the landowners were correlated and regressed against agricultural productivity to determine the relationship between the two variables. Besides, farm income was used to measure viability of agriculture, the main land use activity in the study area.

6.3.4 Number of adult family members

In African and Kenyan agriculture, most of the farm work force usually comes from the family thus a large family is likely to lead to higher agricultural productivity, and vice versa. The responses on the number of mature family members who could provide farm work force show that 9 landowners (4%) had 1 adult family member, 22 landowners (11%) had 2 mature family members, 27 landowners (13%) had 3 adult family members, 41 landowners (20%) had 4 mature family members and 48 landowners (24%) had 5 mature family members. In addition, 27 landowners (13%) had 6 mature family members, 19 landowners (9%) had 7 mature family members, 7 landowners (3%) had 8 adult family members, 2 landowners (1%) had 9 adult members and 1 landowner (1%) had 11 mature family members. Therefore the mean size of mature family members was 4.5 which is close to the 2009 national population and housing census's figure of 5 members (KNBS, 2010).

6.4 Trends of Agricultural Land Subdivisions in Kajiado County

An enquiry was made on the landowners who have been involved in agricultural land subdivisions in the area in regard to the year and the size of land size that they subdivided and land size sold off after subdivision. The results are shown in table 6.2 and figure 6.1 below.

Table 6.2: Trends of Land Subdivisions in the Study Area

Year	Total size of agricultural land subdivided from the sample data (Ha)	Size of agricultural land subdivided and sold off (Ha)	Size of land left after subdivision (Ha)	% of size of agricultural land left after subdivision
2006	135.57	82.96	52.61	**39%**
2007	445.16	149.74	295.42	**66%**
2008	256.58	72.44	184.14	**72%**
2009	271.95	61.51	210.44	**77%**
2010	898.83	163.90	734.93	**82%**
2011	570.62	180.09	390.53	**68%**
2012	866.45	158.64	707.81	**82%**
2013	1,023.88	283.29	740.59	**72%**
2014	875.35	227.84	647.51	**74%**
2015	336.30	93.48	242.82	**72%**
Total acreage over 10-year period	**5,681**	**1,474**	**4,207**	**74%**
Average/ Year	**568**	**147**	**421**	**74%**

Source: Field Survey, 2016/2017

The total acreage of agricultural land subdivided and sold off in the study area between 2006 and 2015 is 5,681ha and 1,474ha, respectively. The rate of agricultural land subdivided and agricultural land subdivided and sold off in the study area over the last 10 years is thus estimated at 568ha and 147ha per year, respectively.

Fig. 6.1 below graphically presents the data in table 6.2 for illustrative purposes. The pattern of agricultural land subdivision trends appear to increase over the years peaking in 2013, before establishment of Kajiado County government, and then declining immediately in 2014 and 2015, as shown in fig. 6.1 below. The decline could be explained by the extra-legal measures (development moratoria) that the County government of Kajiado put in place immediately after its establishment in 2013 to ban subdivisions of agricultural land, among other land transactions. It also points to the influence of county governments on rural/agricultural land management.

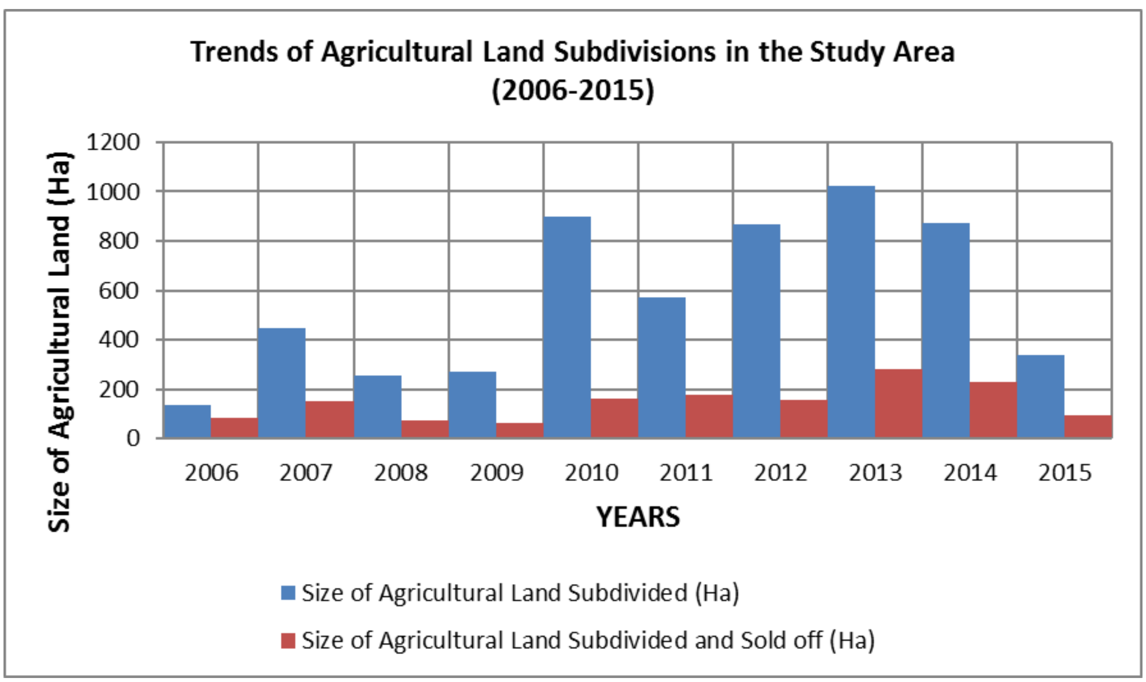

Figure 6.1: Trends of Land Subdivisions in the Study Area

Source: Field Survey, 2016/2017

Table 6.3 and figure 6.2 below show the crop landholding acreage per landowner in the study area. It is clear that most of the landowners (22%) hold between 0.05-6.07ha of agricultural land currently, which might be bare minimum size, as proposed by Syagga & Kimuyu (2016), required for rain-fed production of maize to support an average sized household in Kajiado County. On medium to high quality agricultural land, crop farmers would require at least 1ha (2.5 acres) of agricultural land to support their livelihoods. It is worrying to note that some landowners (8%), however, have less than 1ha of dry agricultural land. Besides, arable land in Kajiado County is only 3,468.4 km^2 (16%) out of the total area of 21,900.9 km^2. The GoK (2015b) and many other countries including Egypt, Rwanda, India and the Philippines have pegged minimum agricultural land sizes at 1ha (Syagga & Kimuyu, 2016).

The study also revealed that majority of landowners (61 landowners out of 72 or 85%) with small land parcels (0.05-12.14ha) are relatively young and educated. The findings indicate that a total of 39 landowners out of 61 (64%), with small agricultural land parcels, were aged between 31-40 years and majority (41 landowners out of 61 or 67%) had either diploma or university education. In addition, the study revealed that majority of the landowners (45 landowners out of 61 or 74%) with small agricultural land parcels have fewer adult family members of between 1-3 persons and majority (40 landowners out of 61 or 66%) reported their average annual income to be between KSh 151,000 – 200,000/=. These statistics show that subdivisions of agricultural land (as measured in agricultural land sizes) are likely to be perpetuated by the old and less educated landowners with less income and more family members/dependants.

Table 6.3: Land holding acreages per landowner in the study area

Agricultural Land Size (Ha)	No. of Respondents (N=203)	Percentage (%)
0.05 – 6.07	44	21.67%
6.48 – 12.14	28	13.79%
12.55 – 18.21	10	4.93%
18.62 – 24.28	31	15.27%
24.69 – 30.35	23	11.33%
30.76 – 36.42	14	6.90%

36.83 – 42.49	8	3.94%
42.90 – 48.56	4	1.97%
48.97 – 54.63	1	0.49%
55.04 – 60.70	11	5.42%
Over 60.70	29	14.29%
Total	**203**	**100**

Source: Field Survey, 2016/2017

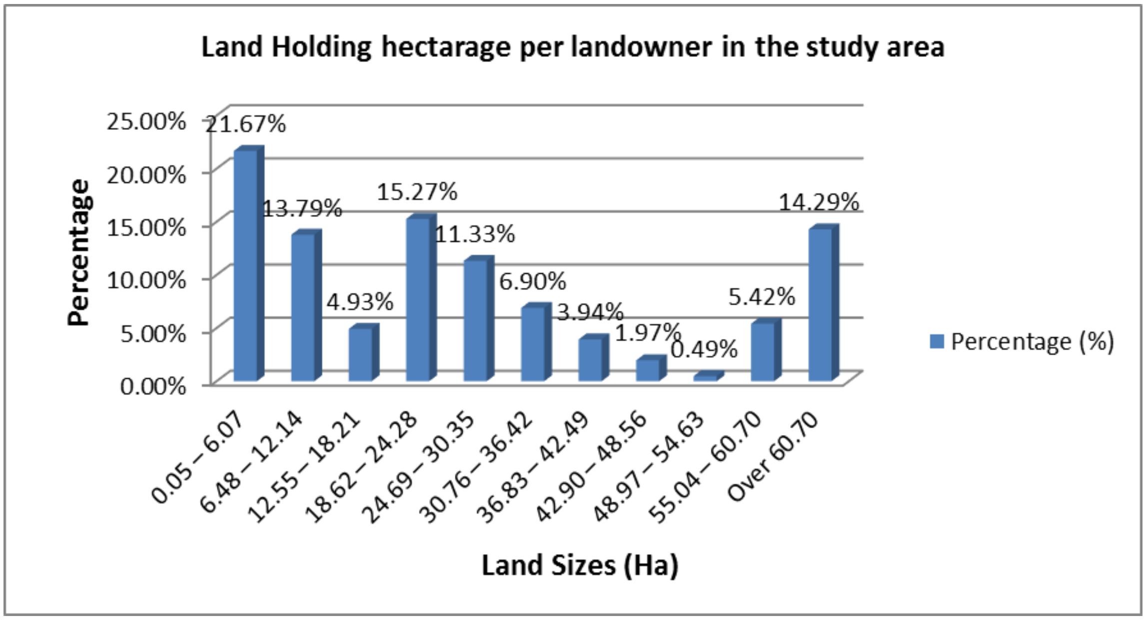

Figure 6.2: Land Holding Acreages per Landowner in the Study Area

Source: Field Survey, 2016/2017

Personal observation revealed several adverts for small plots (0.05ha) located 5 or more than 10 kilometers from the main road and other basic services. In the study area and most rural areas in Kenya, such a location may lack basic services to support alternative land uses such as residential development. Indeed, new guidelines on subdivision of land in Kajiado County has indicated that land located between 1-5 kilometres from the main roads should be used for agricultural purposes and minimum land sizes in such locations should not go below 1ha (County Government of Kajiado, 2018). Consequently, small agricultural plots located in the remote rural areas may remain 'undeveloped' for a long time thus taking agricultural land out of production prematurely. Indeed, Google images of the study's site reinforces this observation (see appendices 6 & 7).

Besides, existence of small private 'undeveloped' agricultural land units may fragment agricultural land and increase agricultural production costs hence hampering agricultural production and productivity in the long run. This is likely to happen where the small private land units are physically fenced off thus physically and legally excluding others from access and use. This is because movement of livestock may be restricted while expansion/large scale crop production is likely to be expensive or impossible due to the fact that acquiring many small private individual land units and amalgamating them for large scale farming would be more expensive than buying one large contiguous parcel. Consequently agricultural production and productivity is likely to be negatively affected and/or lead to land use conflicts.

Syagga (1994) and Syagga & Kimuyu (2016), estimated that the cattle carrying capacity in dry agricultural lands of Kenya is approximately 0.5-1 cow/ha. In Mexico, 1.6ha parcel is required to support 1 cow or 0.625 cow/ha. This is the minimum land size/pasture land on rain-fed dry agricultural land (see table 2.1). Besides, previous research has estimated goat/sheep carrying capacity in dry agricultural lands to be approximately 5 goats & sheep/ha (Byiringiro, 1995; Gul *et al.*, 2016; Rahmann, 2014). The study findings show that the total number of cattle in the study area was 12,180 while the number of goats and sheep was 20,503. The number of farmers/landowners (n) was 203, translating to an average of 60 heads of cattle and 101 heads of goats and sheep per landowner. Given the average cattle herd size in the study area of 60 heads per landowner and the approximate cattle carrying capacity of 0.5 cow/ha, then the average rain-fed land size (natural pasture) required is at least 120 ha per landowner. The average herd size of goats and sheep of 101 heads would require at least 20.2ha per landowner.

The study findings, however, show that only 13 landowners (6%) own more than 120ha of agricultural land while the majority, 187 landowners (94%) own less. Indeed the average agricultural land size per landowner in the study area is 34.225ha (see table 6.5). This average land size per landowner may however be adequate for goat & sheep farming which would require approximately 20.2ha. It appears that there is thus a mismatch between the current cattle herd size and land requirement to support it. The strategies adopted by the livestock keepers to enable them keep, on average, 60 cattle and 101 goats/sheep per landowner are discussed in chapter seven of this study.

Table 6.4: Land under crop production in the study area

Crop Land Size (Ha)	No. of Respondents (N=203)	Percentage (%)
0.00	49	24.04%
0.04 – 0.40	85	41.87%
0.45 – 0.81	46	22.67%
0.85 – 1.21	11	5.53%
1.25 – 1.15	5	2.45%
1.66 – 2.02	5	2.45%
Over 2.02	2	0.99%
Total	**203**	**100%**

Source: Field Survey, 2016/2017

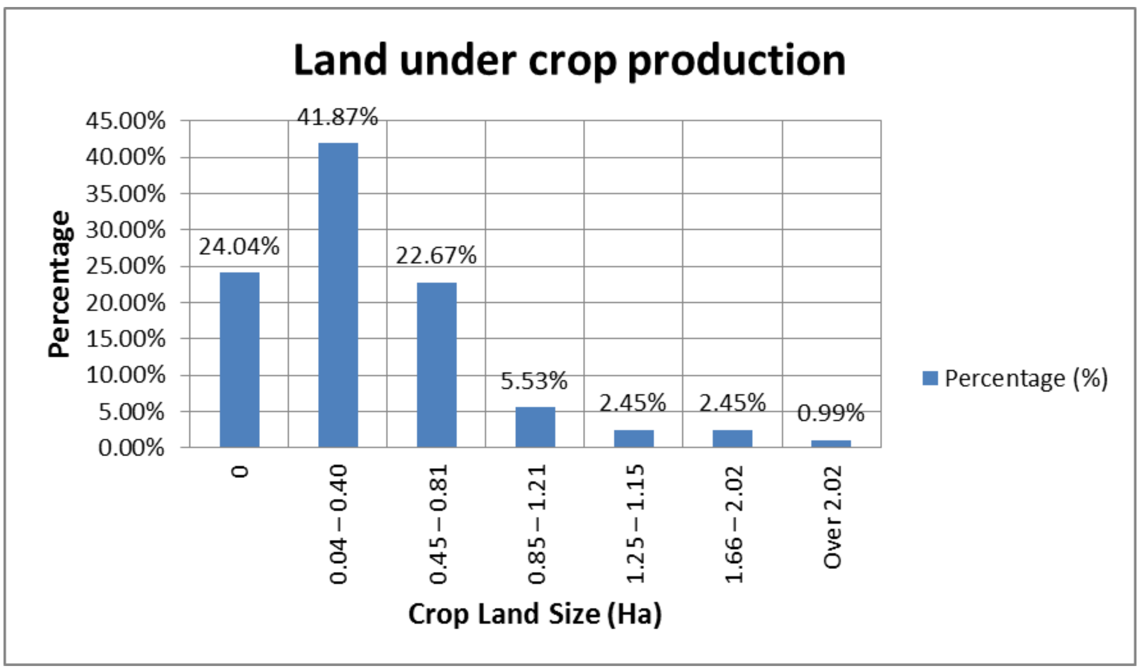

Figure 6.3: Land under Crop Production in the study area

Source: Field Survey, 2016/2017

From figure 6.3 above, majority of the landowners (42%) practice crop farming on about 0.0405 - 0.405ha plots, which is less than the recommended 1ha minimum ceiling for crop production. Besides, the agricultural land is dry meaning more land may be required to support a household. It is interesting to note that a total of 49 (24%) of the landowners do not practice crop farming at all. These are actually households with large parcels of agricultural land who mainly rely on extensive livestock production system, mainly semi-nomadism. Thus, this trend shows that as the agricultural land size decreases, more and more landowners are venturing into crop production to compliment livestock production efforts since the landowners with smaller land sizes are the ones practicing agro-pastoralism or pure crop production.

A total of 154 landowners (76%) are practicing crop farming or agro-pastoralism in the study area. This finding indicates that crop production is gaining popularity in the dry agricultural lands of Kenya, which account for over 80% of Kenya's landmass.

Table 6.5: Summary of Land Holding Acreage in the Study Area in 2016

Descriptive statistics	**Land size in Ha**
Mean/Average total land size	34.255
Median total land size	20.235
Standard deviation for total land size	0.430
Minimum total land size	0.054
Maximum total land size	283.286
Mean/average crop land size	0.476
Median crop land size	0.405
Standard deviation for crop land size	0.548
Minimum crop land size	0.000
Maximum crop land size	4.047

Source: Field Survey, 2016/2017

The average total land size per landowner is 34.255ha, which may be less than the average land size required to support an average sized cattle herd in the study area (60 heads of cattle). Given the average agricultural total land holding acreage of 34.255ha per landowner and minimum land requirement of at least 0.5 cow/ha or 2ha per cow, it appears that average cattle herd size should be approximately 17 heads of cattle per landowner and not 60 as is the case currently. It is encouraging, however, to note that the average total land size, however, is more than adequate to support crop and goat/sheep farming. Table 6.6 below presents the trend of agricultural land sizes in the study area.

Table 6.6: Trends of agricultural land sizes per landowner in the study area

Year	**Total average maximum land size per landowner (Ha)**	**Total average minimum land size per landowner (Ha)**	**Average crop land size per landowner (Ha)**
2003	60.700	1.600	1.012
2004	55.440	0.810	0.850
2016	34.255	0.051	0.476

Source: Field Survey, 2016/2017; Nkedianye *et al.*, 2009

In a study of only 100 households near the Nairobi National Park in 2009, Nkedianye (as cited in Nkedianye *et al.*, 2009) established that the average land size per household in Kitengela area was 55.44ha in 2004 down from 60.70ha in 2003. The minimum land size per household has also decreased from 1.6ha in 2003 to 0.81ha in 2004 and 0.051ha in 2016. This finding confirms that the average agricultural land size per landowner in the study area is decreasing over the years.

The average crop land size in the study area was 0.476, as shown in table 6.5 and 6.6, which again is less than the global minimum ceiling of 1ha. This is also a decline from 0.85ha in 2004 (Nkedianye, as cited in Nkedianye *et al.*, 2009). Tables 6.7 and 6.8 below act as pointers as to why average land size per household is declining over the years.

Table 6.7: No. of Subdivision Consents Issued in Kajiado East Sub-County

Year	No. of Agricultural Land Subdivision Consents Issued in Kajiado East Sub-County in eight years
2010	2,711
2011	3,972
2012	4,879
2013	4,011
2014	3,800
2015	2,147
2016	1,771
2017	912
Total	**24,203**

Source: Kajiado County, 2017

Data available at the lands office show the pattern of the consents for subdivision of agricultural land in Kajiado County over the years. This confirms the trend of the agricultural land subdivisions in the study area as earlier shown in table 6.2 and figure 6.1. Table 6.7 and Figure 6.4 presents the trends of land subdivision consents in Kajiado East Sub-county, under which the study area falls.

At the Sub-County level, it appears that the number of consents issued increased from 2010 to 2012 then started declining from 2013 up to date. This could be explained by the introduction of moratorium by the Kajiado County in 2013 immediately after its establishment which banned land subdivisions and conversions, among other land developments efforts.

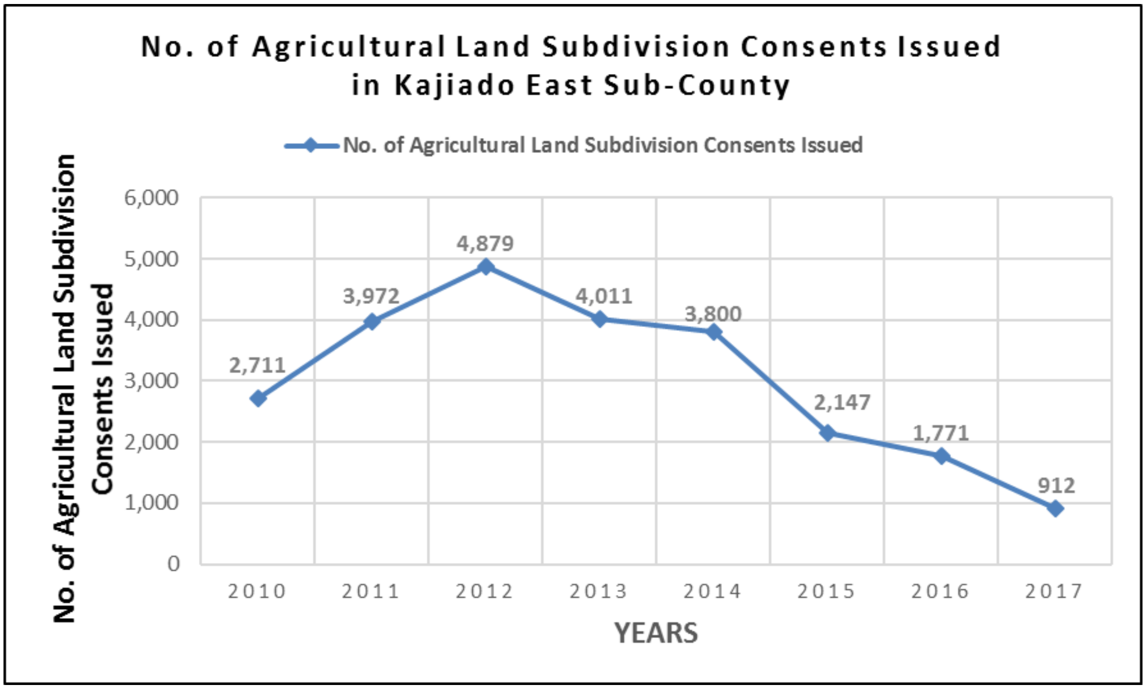

Figure 6.4: No. of Consents Issued in Kajiado East Sub-County

Source: Kajiado County, 2016/2017

On one hand, it could be argued that the actions of the Kajiado County are restricting development but on the other hand it could be used as an indication that County governments are critical players in management of agricultural land in their areas of jurisdiction and that their policy directives have great potential to promote sustainable land development practices or otherwise.

Table 6.8: Applications V. Consents for Subdivisions in Kitengela Division

Year	No. of Applications for Agricultural Land Subdivision	No. of Consents Issued	Percentage (%)
2008	1,104	1,007	91%
2009	1,110	988	89%
2010	1,107	1,050	95%
2011	1,175	1,120	95%
2012	1,221	1,184	97%
2013	1,378	1,340	97%
2014	1,204	1,167	97%
2015	1,406	1,342	95%
Total	**9,705**	**9,198**	**95%**

Source: Local Land Control Board, 2016

The available data on applications and consents for subdivision of agricultural land issued by the local land control board further confirm the trends of agricultural land subdivisions in the study area. The number of applications and consents for subdivision of agricultural land in the study area has been rising over the years to peak in 2013 and then decline in 2014, after establishment of the Kajiado County government which imposed development moratorium on subdivisions of agricultural land. Table 6.8 and Figure 6.5 compares the number of applications and number of consents for subdivision of agricultural land in the study area.

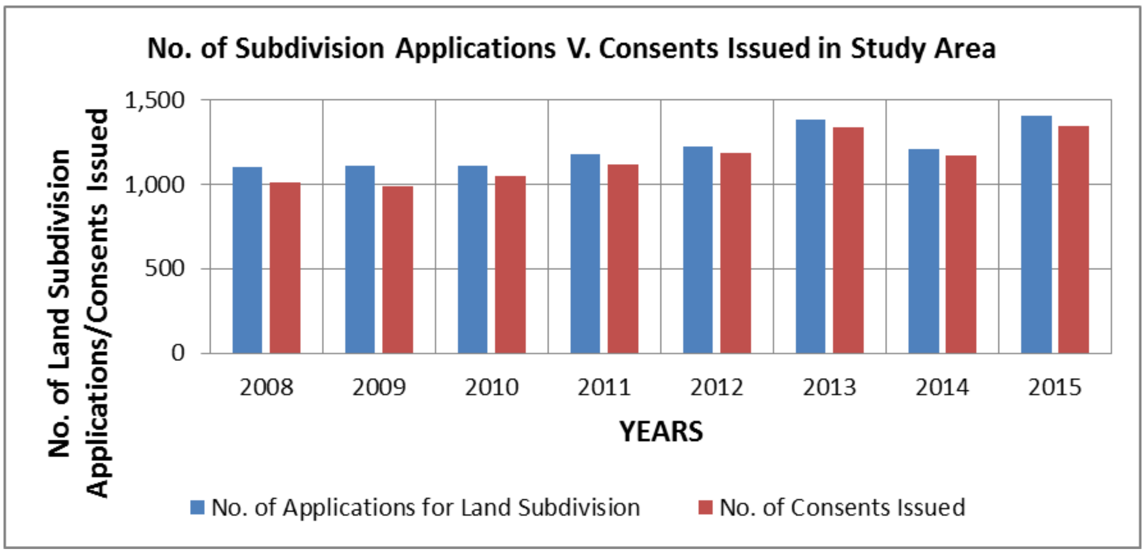

Figure 6.5: Applications V. Consents for Subdivisions in Kitengela Division

Source: Local Land Control Board, 2016

Trends of land subdivisions at the divisional level indicate that the number of applications for land subdivisions is almost equal to the number of consents issued, denoting a less restrictive process. The trends shown in figure 6.4, however, indicate the potential of County governments in managing agricultural land in their areas of jurisdiction.

6.5 Drivers of Agricultural Land Subdivisions in Kajiado County

The trends of agricultural land subdivisions show that the phenomenon is on the increase in the study area. It is important to note that Kenya relies largely on rain-fed agriculture which would usually require large continuous tracts of land to thrive. This requirement may be more critical in dry agricultural lands. Interestingly, the average land holding acreage per household is declining over the years thus raising a research interest. Theoretically, it is expected that the farmers would maintain large tracts of land (without subdivision of their private parcels).

It is out of the above observations that the study sought to establish the factors behind the phenomenon of subdivisions of agricultural land in the study area. Through the literature reviewed, 25 typical drivers were identified to be possible drivers behind the phenomenon of agricultural land subdivisions in the study area (see box 2.1 in chapter two and table 5.3 in chapter 5). The drivers of agricultural land subdivisions in Kajiado County were hypothesized to be a function of demand and supply of agricultural land, which is in turn influenced by various physical, economic, demographic, sociocultural, institutional and political/legal factors. In a nutshell, these are the drivers that either motivate or block farmers from subdividing their land into small pieces. The study respondents were asked to identify applicable drivers in the study area and rate each factor, using a scale of 1 to 4, whereby 1 represented 'not important' and 4 represented 'very important'. The mean score of each driver was then determined.

The population mean score (middle point of 1 to 4, arrived at by adding 1, 2, 3, 4 = 10, and dividing by 4) was calculated to be $\overline{X}$ **= 2.5.** This point was set to be the decision-making point, whereby any driver whose mean score is less than 2.5 was considered to be insignificant in influencing subdivisions of agricultural land in the study area. This way, the significant drivers (drivers with mean score value of more than 2.5) were determined and ranked according to their significance as shown in table 6.9 below.

Table 6.9: Significant Drivers of Agricultural Land Subdivisions in Kajiado County

Driver	Rating	Percentage (%)	Mean Score ($\bar{X}$)	Type of Driver
				Socio-cultural factor
Land inheritance practices	Not important	0.0%		
	Less important	0.5%		
	Important	10.7%		
	Very important	86.8%		
	Total		**($\bar{X}$ = 3.8)**	
Individualization of titles	Not important	0.5%		Socio-cultural factor
	Less important	0.0%		
	Important	7.6%		
	Very important	87.8%		
	Total		**($\bar{X}$ = 3.7)**	
Price/Value of agricultural land	Not important	6.6%		Economic factor
	Less important	4.6%		
	Important	34.7%		
	Very important	50.0%		
	Total		**($\bar{X}$ = 3.2)**	
Demand for urban housing	Not important	6.1%		Economic factor
	Less important	10.7%		
	Important	32.7%		
	Very important	48.0%		
	Total		**($\bar{X}$ = 3.2)**	
Future expectations on value of agricultural land	Not important	10.2%		Economic factor
	Less important	6.6%		
	Important	22.4%		

	Very important	56.1%		
	Total		**($\overline{X}$ = 3.2)**	
Customary land tenure systems	Not important	5.1%		Socio-cultural factor
	Less important	4.6%		
	Important	30.5%		
	Very important	54.3%		
	Total		**($\overline{X}$ = 3.2)**	
Off-farm income	Not important	6.1%		Economic factor
	Less important	8.7%		
	Important	42.3%		
	Very important	40.8%		
	Total		**($\overline{X}$ = 3.1)**	
Price/Value of urban land	Not important	6.1%		Economic factor
	Less important	8.7%		
	Important	42.9%		
	Very important	38.3%		
	Total		**($\overline{X}$ = 3.1)**	
Local / rural population growth rate	Not important	8.7%		Demographic factor
	Less important	6.7%		
	Important	34.4%		
	Very important	45.1%		
	Total		**($\overline{X}$ = 3.1)**	
Urban population growth rate	Not important	6.2%		Demographic factor
	Less important	11.3%		
	Important	51.8%		
	Very important	25.6%		

	Total		**($\bar{X}$ = 2.9)**	
Supply of agricultural land	Not important	10.7%		Economic factor
	Less important	8.7%		
	Important	43.4%		
	Very important	31.6%		
	Total		**($\bar{X}$ = 2.8)**	
Proximity of agricultural land to services	Not important	12.8%		Natural/Physical factor
	Less important	21.4%		
	Important	48.5%		
	Very important	15.3%		
	Total		**($\bar{X}$ = 2.6)**	
Agricultural land use policies and laws	Not important	20.8%		Political/legal factor
	Less important	17.8%		
	Important	35.0%		
	Very important	21.8%		
	Total		**($\bar{X}$ = 2.5)**	

Source: Field Survey, 2016/2017

The factors that had a value rating with a mean score of less than **2.5 (population mean score)** were considered to be statistically less significant in agricultural land subdivisions and included: temperature ($\bar{X}$ = 1.1), topography ($\bar{X}$ =1.2), rainfall ($\bar{X}$ =1.3), Cost of agricultural finance / interest rates ($\bar{X}$ =1.5), demand for agricultural products ($\bar{X}$ =1.6), availability of agricultural finance / credit / capital ($\bar{X}$ =1.6), public participation in agricultural land development decision making process ($\bar{X}$ = 1.6), Farm income ($\bar{X}$ =1.7) , Off-farm income ($\bar{X}$ =1.7), local land institutional technical capacity ($\bar{X}$ =1.9), quality / fertility of land ($\bar{X}$ = 2.0) and commodification of land ($\bar{X}$ = 2.3).

It is interesting to note that most of the natural/physical/environmental factors (land fertility, topography, rainfall and temperature) were considered by the respondents to be insignificant drivers of agricultural land subdivisions. This could be explained by the fact that the study area, and most of the agricultural land in Kenya, is arid and semi-arid thus the environmental factors are generally constant, especially high temperatures and low amount of rainfall. This finding is contrary to findings of many previous studies (see Chazan & Cotter, 2001; Lambin *et al.* 2003; Olson *et al.* 2004) which found environmental factors to be important in influencing subdivision of agricultural land. These previous studies were however conducted in arable land. Besides, the government of Kenya has considered natural factors to be significant drivers of agricultural land subdivision (GoK, 2017; 2016b). It appears that physical or environmental factors are important in influencing subdivision of agricultural land in arable lands but not in dry agricultural lands.

The economic factors (cost of agricultural finance/interest rates, availability of agricultural finance and income from agricultural activities) were poorly rated by the respondents. Some previous studies (see for example Olson et al., 2004; Thuo, 2013) have considered farm income to be important driver of subdivision of agricultural land. These factors were however found to be insignificant drivers of agricultural land subdivision in the drylands, possibly denoting the subsistence nature of agricultural sector in the study area whereby agriculture remains largely small scale.

Some of the institutional factors were also poorly rated by the respondents such as local land institutional technical capacity ($\overline{X}$ =1.9) and public participation in agricultural land development decision making process ($\overline{X}$ = 1.6). This could be due to lack of awareness by the respondents on their role and that of the land institutions in agricultural land management. Responses from the Kajiado land officials indicates that the key drivers/challenges facing administration and management of agricultural land in Kajiado County is inadequate institutional capacity mainly in form of inadequate technical staff and finances to carry out proper and effective control of land development. The local land control board, for instance, has no physical planner and has got only one land surveyor. Similarly, the Kajiado County Land Management board is facing similar technical staff deficiency since it has no physical planner and has got only one land surveyor.

It should be noted, however, that all the 25 drivers were considered by the respondents as being important drivers of agricultural land subdivision. This is due to the fact that all the drivers had a mean rating score ($\overline{X}$) above **1.0**, implying that they are statistically important drivers of agricultural land subdivisions in the study area. These findings suggest that as a way of addressing the issue of subdivisions of agricultural land, it is essential for the policy makers to place focus on all of these drivers that have been identified but emphasize on the factors that have a mean score rating of above **2.5** (population mean score).

The analysis of 25 factors by the use of population mean score failed to conclusively isolate the significant factors of agricultural land subdivision in the study area. The reason was due to the fact that confidence level had not been put into consideration. This would help in lowering the errors that come with identification of the significant factors. The errors include type I and type II error. The likelihood of committing any of these errors can be reduced by using Z value test for the statistical significance on these factors to further identify the significant ones.

The use of Z test provides a conclusive way of accepting or rejecting the null hypothesis; the drivers whose mean score rating were equal or more than the population mean score ($\overline{X}$ **= 2.5**) are significant in influencing subdivisions of agricultural land in the study area. In this study, Z value test was done on the factors which were significant and also average in terms of their influence on the agricultural land subdivision and included: agricultural land inheritance practices ($\overline{X}$ = 3.8), individualization of titles ($\overline{X}$ = 3.7), price of the agricultural land ($\overline{X}$ = 3.2), demand for urban housing ($\overline{X}$ = 3.2), future expectations on the value of agricultural land ($\overline{X}$ = 3.2), customary land tenure systems ($\overline{X}$ = 3.2), Off-farm income ($\overline{X}$ = 3.1), price of urban land ($\overline{X}$ = 3.1), local/rural population growth rate ($\overline{X}$ = 3.1), urban population growth rate ($\overline{X}$ = 2.9), supply of agricultural land ($\overline{X}$ = 2.8), proximity of agricultural land to services ($\overline{X}$ = 2.6) and agricultural land use policies and laws ($\overline{X}$ = 2.5).

The Z value for every factor was computed and then the critical Z value was determined at **1.65** for one tailed Z test at 95 % confidence level as calculated by Sirkin (as cited in Kieti, 2015) (see table 5.4 in chapter 5). Where the Z value calculated related to every factor was found to be greater than the critical Z value for the specified confidence level, then the conclusion would be made that the specific factor was significant in influencing agricultural land subdivisions in the study area. The table below indicates the results for Z test for each of the factors with mean score rating equal or more than the population mean score (**2.5**).

Table 6.10: Hypothesis Testing Using Critical and Calculated Z values

Variable	**Critical Z value at 95% confidence level (one-tailed test)**	**Calculated Z value**	**Remarks**
Agricultural land inheritance practices	1.65	42.32	Factor is significant
Individualization of titles	1.65	32.06	Factor is significant
Price of the agricultural land	1.65	30.89	Factor is significant
Demand for urban housing	1.65	26.54	Factor is significant
Future expectations on the value of agricultural land	1.65	25.89	Factor is significant
Customary land tenure systems	1.65	22.56	Factor is significant

Off-farm income	1.65	22.09	Factor is significant
Price of urban land	1.65	21.67	Factor is significant
Local/rural population growth rate	1.65	20.78	Factor is significant
Urban population growth rate	1.65	16.52	Factor is significant
Supply of agricultural land	1.65	1.254	Factor is not significant
Proximity of agricultural land to services	1.65	0.89	Factor is not significant
Agricultural land use policies and laws	1.65	-1.53	Factor is not significant

Source: Field Survey, 2016/2017

From the above analysis, it is clear that 10 out of the13 factors have the calculated Z values greater than the critical Z value at 95% confidence level. The ten factors were found to be significant in influencing agricultural land subdivisions. The remaining factors are ranked in their order of significance in influencing agricultural land subdivisions in table 6.10 above.

Supply of agricultural land ($\bar{X}$ = 2.8, Z =1.254), proximity of agricultural land to services ($\bar{X}$ = 2.6, Z = 0.89) and agricultural land use policies and laws ($\bar{X}$ = 2.5, Z = -1.53) were thus found to be insignificant drivers of agricultural land subdivisions even though their mean score ratings were equal to or above the population mean score. It is evident that the farmers perceived to own large tracts of agricultural land and thus they could afford to subdivide and sell off a portion, as dictated by general economics that the more the supply of a commodity, the less the demand for the commodity. The available field data, however, has determined that average land holding size per landowner is approximately 34ha. This land size may be inadequate to support the average herd size of 60 cattle and 101 goats/sheep per household on natural pasture in dry agricultural land. Proximity of agricultural land to services was also perceived to rate highly but most of the land parcels were observed to be situated far away from the basic services such as roads, water and power.

According to the Kajiado County Government (2013) and KNBS & SID (2013), average distance to a water point in the County is 10 kilometres while average distance to a health facility is 14 kilometres. Besides, most of the students (68.1%) walk more than 5 kilometres to the nearest school while only about 40% of the households are connected to electricity in Kajiado County. This could partly explain the challenges of the agricultural landowners in their attempt to use their land for agricultural purposes or alternative uses such as residential development. Thus, lack of basic services may reduce demand for agricultural land hence may influence farmers to subdivide and sell off portions of their land.

Lastly, agricultural land use policies and laws as a driver of agricultural land subdivisions could be attributed to the lack of a national land use policy and lack of a clear legal provision prescribing the minimum and maximum agricultural land holding acreages in the study area and Kenya in general. Lambin et al. 2003; Olson *et al.*, 2004 have all found policy and legal provisions to be key drivers of agricultural land transformation in East Africa, Kenya included. The government of Kenya has also considered policy and legal frameworks to be important drivers of subdivision of agricultural land (GoK, 2017; 2016b).

A summary of responses from the Kajiado land officials indicates that the key drivers/challenges facing administration and management of agricultural land in Kajiado County is inadequate institutional capacity mainly in form of inadequate technical staff and finances to carry out proper and effective control of land development. The local land control board, for instance, has no physical planner and has got only one land surveyor. Similarly, the Kajiado County Land Management board is facing similar technical staff deficiency since it has no physical planner and has got only one land surveyor. This may affect negatively development control efforts in the area. The chairman of the local land control board also lamented lack of clarity on the role of the National Land Commission (NLC) or the newly established county land management boards and the local land control boards, citing unnecessary interference from the County government.

In addition, the chairman of the local land control board, the local land institution under which agricultural land subdivision falls directly, cited government's limited role in control of private property development. This challenge could be based on the erroneous assumption that ownership right, as guaranteed in the Kenyan Constitution 2010, is equal to user rights hence private landowners are expected to use their private property as they deem fit, without state interference (neoliberalism tendencies). These frustrations could also imply inadequate land administration and management policy and regulatory guidelines.

The entire Kajiado County has got only one qualified physical planner and one land surveyor, who are required to cover an approximate area of 21,290 square kilometers. This number may be inadequate to handle all the development control needs in the County.

Responses from the local estate agents and property developers on the possible drivers of agricultural land subdivision in the study area confirmed the above observations. Local estate agents and property developers revealed that possible drivers of subdivision of agricultural land in the study area are rural population growth rate, individualization of titles, demand for urban housing, location of agricultural land near road network, low income of the landowners/poverty, customary land tenure and land inheritance practices.

The agricultural officer in the Kajiado East Sub-county revealed that private property developers/investors are the main drivers of agricultural land subdivision in the area. The officer noted that these agents buy large pieces of agricultural land and subdivide for sale to buyers who may wish to develop the small plots with residential houses or speculate on them.

The claim by the Kajiado East Sub-county is supported by responses from the local residents/landowners. A total of 77 local residents (38%) reported that the County Government of Kajiado needs to protect the locals from exploitation by unscrupulous land investors in the region. Indeed, majority of the local landowners 110 (54%) believe that the government should put in place better land management interventions and guidelines to ensure sustainable land development in the area. This view was also supported by the chairman of the Kajiado Land County Management Board who observed that there is need to control unsustainable and uneconomical agricultural land subdivisions to cater for the increasing population and future generations.

6.6 Discussion of the Main Drivers of Agricultural Land Subdivision

1. Land inheritance practices

Agricultural land inheritance practices was rated as the most significant driver of agricultural land subdivisions in the study area ($\overline{X}$ = 3.8, Z = 42.32). Indeed, a total of 120 landowners (59%) had acquired their land through inheritance while 19 landowners (9%) reported to have subdivided their agricultural land among their sons without selling a portion. This finding concurs with findings of a previous study by Mburu (2009) who found land inhertaice practices to be key driver of agricultural land subdivision in Gatundu district, Kenya. Thuo (2013) also established land inheritance to be an important driver of agricultural land subdivision in Kiambu County. Similarly, the Kenya draft NLUP and NSP have all identified land inheritance to be important driver of subdivision of agricultural land (GoK, 2017; 2016b). Elsewhere (Lambin *et al.*, 2003; Scottish Government, 2009) socio-cultural factors have been found to be important drivers in agricultural land subdivision. Subdivision of agricultural land for inheritance purposes without enclosures/fencing off may not be a bad thing as it may not hinder large scale agricultural production and movement of livestock. This is made possible by the close relationship of the family members thus enabling land to be used as a whole and avoiding tragedy of the spatial anticommons (Heller, 1998).

Families are sometimes however not close-knit. Besides, private property rights grant landowners exclusive right of access and use. Moreover, some agricultural land may be idle or owned by non-agricultural owners. All these scenarios are likely to reduce cooperation in the community. Essentially, in the long run agricultural production may be curtailed due to increased transaction costs/cost of agricultural production (for example the time spent in informal negotiations and informal land management efforts).

2. Individualization of titles

Individualization of titles was ranked as the second most significant driver of agricultural land subdivisions ($\bar{X}$ = 3.7, Z = 32.06). A total of 198 landowners (98%) had reported to have private titles to their land. A similar finding was determined by Ayonga (2008) who found private title deeds without restrictions on the use of land to be important driver of land subdivision and land use conflicts in the peri-urban areas of Nairobi and Kajiado County. Thuo (2013) also found individualization of land ownership to be an important factor in influencing land subdivisions in urban fringes of Kiambu County while Olson *et al.*, 2004 established private titles to be key driver of agricultural land transformation in east Africa. As discussed in the literature review, previously the agricultural land in Kenya was mainly communally owned and issues of land subdivisions were not very common.

The land tenure in Kenya, however, has changed for most of the communal agricultural land to private ownership, making it easier to transact with agricultural land. This has largely been facilitated by the Registered Land Act, cap. 300 (repealed) which granted agricultural landowners freehold interest, with powers to subdivide and transfer land. The government intended to foster economic development by ensuring that agricultural landowners could access finance using their land as collateral. The private individual titles, however, do not have provisions on the allowable minimum land sizes, a situation that has partly led to the phenomenon of agricultural land subdivisions into small/uneconomic sizes. Therefore, private land rights in agricultural land appear to have promoted neo-liberalism tendencies by promoting superiority of private property, market forces, commodification of agricultural land and entrepreneurial character of landowners.

3. Price/value of agricultural land

The third most significant driver of agricultural land subdivisions is price/value of the agricultural land ($\overline{X}$ = 3.2, Z = 30.89). This is an economic factor which signifies presence of neo-liberalism through market forces of demand for agricultural land. Some previous studies have found a positive correlation between price of agricultural land and rate of subdivision (Chazan & Cotter, 2001; Lee, 1999; Henry *et al.* 2012; Olson *et al.*, 2004). Locally, Thuo (2013) has determined price of agricultural land to be important in influencing subdivision of agricultural land, especially in the urban fringes of Nairobi City and Kiambu County. Nkedianye *et al.* (2009) also found price of agricultural land to be an important driver in agricultural land subdivision in some parts of Kitengela area near the Nairobi National Park. Data from the estate agents in the study area revealed that the average price of the agricultural land in the study area has been increasing over the years from an average of about 1 million per ha in 2006 to an average of 7.5 million per ha in 2015, translating to approximately 650% increase over a period of 10 years.

On one hand this positive trend in agricultural land value is likely to entice the landowners to subdivide and sell off portions of their agricultural land. The increasing average agricultural land value coupled with the perception that there is plenty supply of land in the study area could be motivating farmers to subdivide and sell off part of their land. These trends may also create favourable environment for private individuals to speculate on agricultural land as land investors expect to reap higher prices in the future. Lack of effective taxation instruments and a regulation on the minimum and maximum land holding acreages are likely to further fuel these trends over time. On the other hand, however, high price/value of agricultural land is likely to restrain expansion of agricultural production since land would be expensive to acquire in the future. Economies of scale would thus be absent or expensive to attain for the farmers who would wish to expand their operations.

4. Demand for urban housing

Demand for urban housing was ranked as the fourth most significant driver of agricultural land subdivisions in the study area ($\overline{X}$ = 3.2, Z = 26.54). Previous studies which have identified this factor to be important in agricultural land subdivision elsewhere include Lee, 1999; McDonagh, 1997; & Thuo, 2013. Demand for urban housing could signify expansion of urban areas, pointing to a possibility of application of the urban growth theories such as concentric rings, sector and multiple nuclei or residential location theory.

This driver, however, could easily be confused with speculation on the agricultural land. In-depth interviews with key informants and some landowners revealed that some developers were buying land from the farmers then subdividing into small sub-plots to sell to private individuals for housing development yet the area may be lacking basic services to support real estate development. From personal observations, some developers have constructed earth access roads to hoodwink land buyers that the agricultural land is ripe for development. From observations it was evident, however, that after the small sub-plots are sold no housing development takes place, possibly due to lack of supporting services. This leaves the small sub-plots 'undeveloped' for a long time thus taking agricultural land out of production prematurely.

Google images of the study area show that no major housing development has taken place from 2006 and 2015 (see appendices 8 & 9). Besides, all agricultural land should not be considered as future urban land. Agricultural land will continue to be important to both rural and urban dwellers thus vital agricultural land should be protected from subdivision into small sizes and subsequent conversion into urban use.

5. Future expectations on the value of agricultural land

Demand for urban housing and the increasing average price/value of agricultural land could explain why the respondents ranked future expectations on the value of agricultural land as the fifth most significant driver of agricultural land subdivisions ($\overline{X}$ = 3.2, Z =

25.89). This finding is similar to some previous studies (see Ayonga, 2008; Chazan & Cotter, 2001; Henry *et al.*, 2012; Thuo, 2013). This driver, an economic factor, again shows application of neo-liberalism theory since change in market prices and values indicates market forces to be important market regulator.

Land investors are likely to influence high demand for agricultural land in the hope of reaping higher prices in the future. This seems to have created a 'buy-and-wait' trend in the agricultural land, making agricultural land not to be used productively and sustainably as per the prescriptions of the Kenya Constitution and the National Land Policy (GoK, 2010a; 2009). This is because once agricultural land is subdivided into bare minimum sub-plots it is likely to influence future land use patterns and may hinder agricultural production or proper future urban development by creating incompatible land uses (Ayonga, 2008).

The 'buy-and-wait' trends in agricultural land appear to assume that residential development is the only urban development necessary both currently and in the future. Through personal observations, for instance, there were no many 'industrial or institutional land for sale' adverts in the study area. This may create problems in the future as urbanization engulfs the rural areas by making it difficult to plan for the various urban land uses. This has been evident in the peri-urban areas in Kenya (Ayonga, 2008).

6. Customary land tenure systems

Customary land tenure systems (men owning land on behalf of family) was ranked as the sixth most significant driver of agricultural land subdivisions in the study area ($\overline{X}$ = 3.2, Z = 22.56). Olson et al., 2004 & Nkedianye *et al.*, 2009 have found customary land tenure systems to be important drivers of agricultural land subdivision in east Africa. This was mainly so because most of the decisions regarding land, including ownership and transfer of agricultural land, were found to be a prerogative of the male gender. Out of the 203 agricultural land parcels surveyed, 187 (92%) were registered in the name of the male head of the household and only 6 parcels (3%) were registered under the female head of family, mostly the female headed households.

Interviews with the land officials revealed that sometimes the men, under whom the agricultural land is registered, make decision to subdivide and sell/transfer portions of their land without consulting their wives and children. This allegation was further verified by existence of cases and caveats/prohibitions on land sales at the Kajiado lands office. Customary land tenure system is a sociocultural factor which could be used by landowners to achieve economic self-gratification, as per the dictates of the neo-liberalism theory. Besides, a total of 19 landowners (9%) reported to have subdivided their agricultural land among their sons.

7. Income of the agricultural landowner

Poverty/per capita income was ranked as the seventh most significant driver of agricultural land subdivisions in the study area ($\overline{X}$ = 3.1, Z = 22.09). The respondents reported that sometimes they sell agricultural land to meet their immediate domestic needs like buying clothes and paying school fees for their children. This finding concurs with some previous research (see Chazan & Cotter, 2001; Henry *et al.*, 2012; Nkedianye *et al.*, 2009; Thuo, 2013). The government of Kenya has also taken income of the landowner to be an important driver of agricultural land subdivision (GoK, 2017; 2016b). The total average annual income bracket (from both farm and off-farm ventures) for majority of the landowners (51%) were reported to be between Kshs. 201,000 – 250,000, mainly from agricultural activities.

This finding suggests that majority of the households could be living below the international poverty line of US$ 1.90 per day, considering the average size of the household of 5 members. According to the County Government of Kajiado (2013), and KNBS & SID (2013), almost 50% of the Kajiado County's population lives below poverty line. Thus, agricultural landowners are likely to subdivide and sell portions of their land as a source of livelihood, yet majority derive their livelihood from the agricultural land through agricultural activities. Given the tendencies of neo-liberalists, market forces are bound to control the property market where the property owners are poor.

8. Price/value of urban land

Price of urban land was ranked as the eighth most significant driver of subdivisions of agricultural land in the study area ($\overline{X}$ = 3.1, Z = 21.67). Ayonga (2008) established that high price of urban land in Nairobi City has forced urban dwellers to look for cheaper land in the urban fringes of Nairobi and Kajiado County. Similarly, Thuo (2013) identified increase in price of urban land in Nairobi City to be an important driver of land subdivision in Kiambu County. Elsewhere (see Chazan & Cotter, 2001; GoK, 2017; 2016b; Lee, 1999; McDonagh, 1997; Olson *et al.*, 2004) previous studies have found value/price of urban land to be important driver of subdivision of agricultural land.

This finding could be explained by the rising prices/value of urban land in Nairobi City (the largest and capital city/urban area of Kenya) and the surrounding/satellite urban areas. According to a property price index published by the HassConsult Limited (2016), the average price per acre of urban land in Nairobi increased from Kshs. 30.3 million in December, 2007 to Kshs. 178.6 million/acre in June, 2016 translating to an increment of 7.12 fold over the stated 9-year period.

Similarly, the price of urban land in the satellite urban areas, including Kitengela Township, went up from an average of Kshs. 2.4 million/acre to 15.8 million (6.47 fold) per acre over the same period. The increasing prices of urban land is making land within the urban areas to be way beyond the reach of the low and middle urban income earners, forcing them to look for affordable land in the surrounding rural areas hence fuelling subdivisions of agricultural land. Market land price/value is function of the market forces of demand and supply. Therefore, price of urban land is an indicator of neo-liberalism tendencies.

9. Rural population growth rate

Rural population growth rate ($\overline{X}$ = 3.1, Z = 20.78) was ranked the ninth most important factor in influencing subdivision of agricultural land. This finding coincides with Jayne and Muyanga's (2012) who found rural population growth rate to be significant driver of agricultural land subdivision in the densely populated areas of central parts of Kenya. Lambin *et al.*, (2003) and Olson *et al.*, (2004) have also determined rural population growth rate to be significant driver of agricultural land transformation.

Positive growth of rural population coupled with agricultural land inheritance practices likely to fuel subdivisions of agricultural land in the study area. Indeed, this is likely to be the future trend, if policy interventions are not put in place by the rural land managers. The population of Kajiado County, as well as the Kenyan population, has been growing over the years. The current population growth rate in Kajiado County is at 5.5% per annum which is almost twice higher than the national's population growth rate of 2.9% per annum (Kajiado County Government, 2013). Rural population growth rate is a demographic factor which is likely to be influenced by the economic and other factors.

10. Urban population growth rate

Urban population growth rate was ranked as the last/tenth most significant driver of agricultural land subdivisions in the study area ($\overline{X}$ = 2.9, Z = 16.52). This driver signifies application of the urban growth theories which postulate that urban areas will always expand into the surrounding rural areas. Kenyan urban population has changed from 7% in 1960 to 26% in 2016 with an annual urban population growth rate of 4.2%. Kajiado County is, however, mainly rural with 76.2% of its population being rural while urban population stands only at about 23.8% up from 19.8% in 2009. This is an indication that Kenya is urbanizing over the years and urban land uses are likely to push away agricultural land use through agricultural land subdivisions and subsequent conversions. Increasing urban land prices appears to have aggravated the situation.

Urban population growth rate has been assumed to be an obvious and important driver of subdivision of agricultural land in many parts of Kenya (GoK, 2017; 2016b; Lambin *et al.*, 2003; Olson *et al.*, 2004). Previous studies in New Zealand have also found urban population growth rate to be significant driver of subdivision of agricultural land (Henry *et al.* 2012; Lee, 1999). The finding of this study has however shown that even though this is a significant driver in the study area it is not the most important. This could be due to the location of the study area which focused on the rural areas only. It appears thus urban population growth rate may be most significant in rural/agricultural lands near urban areas but not in remote rural areas.

6.7 First Hypothesis Testing

The first hypothesis of this study was as follows;

Null Hypothesis (HO) 1: Population growth rate is not the most significant driver of agricultural land subdivisions in Kajiado County.

Alternative Hypothesis (H_A) 1: Population growth rate is the most significant driver of agricultural land subdivision in Kajiado County.

Data analysis has shown that the most significant driver of agricultural land subdivision in the study area is land inheritance practices (a socio-cultural factor) with a mean score of $\overline{X}$ = 3.8 and calculated z value of 42.32. Rural population growth rate was ranked ninth with a mean score of $\overline{X}$ = 3.1 and calculated z value of 20.78 while urban population growth rate was ranked tenth with a mean score of $\overline{X}$ 2.9 and calculated z value of 16.52. Therefore, population growth rate is not the most significant driver of agricultural land subdivisions in Kajiado County. Consequently, the null hypothesis (Ho) 1 has been supported by the data collected and analyzed while the alternative hypothesis (HA) 1 is not supported by the data hence has been rejected.

This finding concurs with a previous research carried out in Gatundu district in the central part of Kenya which found land inheritance practices to be the most significant driver of subdivision of agricultural land in the region (Mburu, 2009). Agricultural land in Gatundu district and central part of Kenya is however arable but it appears that the cultural practice of land inheritance cuts across the country. Thuo (2013) also found cultural practices of land inheritance to be key driver of agricultural land subdivision in parts of Kiambu County, Kenya. Jayne & Muyanga (2012), however, determined that rural population growth rate was a key factor in subdivision of agricultural land in high populated areas of central region of Kenya. Lambin et al., (2003) have also found rural population growth rate to be important drivers of agricultural land subdivision. High rural population growth rate and land inheritance practices are thus expected to exacerbate trends of agricultural land subdivision in Kenya.

Urban population growth rate has been assumed to be an obvious and important driver of subdivision of agricultural land in many parts of Kenya (GoK, 2017; 2016b; Olson *et al.*, 2004). Previous studies in New Zealand have also found urban population growth rate to be significant driver of subdivision of agricultural land (Henry *et al.* 2012; Lee, 1999). The finding of this study has however shown that even though this is a significant driver in the study area it is not the most important. This could be due to the location of the study area which focused on the rural areas only. It appears thus urban population growth rate would be most significant in rural/agricultural lands near urban areas but not in remote rural areas.

6.8 Chapter Summary

This chapter has established that the dry agricultural land size in the study area is decreasing over the years. This trend is likely to continue in the future if the phenomenon of agricultural land subdivisions persists and the drivers are not addressed. Inadequate control of agricultural land development is expected to further exacerbate this trend thus threatening productive and sustainable use of agricultural land, contrary to the provisions of the Kenyan Constitution and the National Land Policy (GoK, 2010a; 2009). This calls for proper policy interventions to address the phenomenon of agricultural land subdivisions since land supports agriculture, the backbone of the Kenya's economy, and it is vital for survival of urban areas.

Knowing significant drivers of agricultural land subdivisions is important in understanding the phenomenon of agricultural land subdivisions in the study area. Consequently, the study has determined the significant drivers of this phenomenon whereby sociocultural and economic drivers have been found to be the most important in influencing agricultural land subdivisions.

Therefore, the most applicable theory explaining the drivers of agricultural land subdivision in the study area appears to be neo-liberalism. This finding may inform future interventions in management of agricultural land development in the country.

CHAPTER SEVEN

IMPLICATIONS OF AGRICULTURAL LAND SUBDIVISION ON PRODUCTIVITY IN KAJIADO COUNTY

7.1 Introduction

Chapter six has identified and determined important drivers influencing subdivision of agricultural land in the study area. This chapter investigates the implication of agricultural land subdivision on productivity, the main global and local concern of agricultural subdivisions into small sizes. The general assumption is that subdivision of private agricultural land into small sizes results to reduced agricultural productivity, a tragedy of spatial anticommons. Elsewhere, however, previous researches have shown that this is not always the case, confirming that anticommons properties are not necessarily tragic. The study's second hypothesis is thus tested in this chapter.

Presence of tragedy of the spatial anticommons would be shown by reduced agricultural productivity after subdivision of agricultural land and positive correlation between agricultural land size and productivity. Besides, a positive relative contribution of agricultural land size to the agricultural productivity would point to a tragedy of the spatial anticommons in the study area. The reverse would prove that anticommons properties are not necessarily tragic.

7.2 Implications of Agricultural Land Subdivisions on Productivity in Kajiado County

Cross tabulation/comparison analysis of various land sizes and their corresponding agricultural productivity was carried out to determine the implication of agricultural land subdivision on agricultural productivity in the study area. This was necessary to compare agricultural productivity of small land sizes against that of large agricultural land sizes.

Presence of a tragedy of the spatial anticommons would be manifested by a lower agricultural productivity from the small agricultural land sizes compared to the larger land sizes and vice versa. The results are shown in table 7.1 below.

7.2.1 Cross tabulation analysis

Table 7.1: Agricultural land sizes vs. agricultural productivity in 2016

Agricultural Land Sizes (Ha)	**Average Agricultural Productivity (Output/Ha)**		
	No. of Sheep & Goat/Ha	**No. of Cattle/Ha**	**No. of 90Kg Bags of Maize/Ha**
0.05 – 6.07	10.03	7.31	21.65
6.48 – 12.14	5.05	3.58	18.38
12.55 – 18.21	6.23	2.00	25.33
18.62 – 24.28	3.95	2.99	17.30
24.69 – 30.35	4.08	3.01	25.20
30.76 – 36.42	2.89	1.61	16.95
36.83 – 42.49	4.10	2.79	4.89
42.90 – 48.56	3.39	1.73	5.93
48.97 – 54.63	2.84	1.14	9.86
55.04 – 60.70	2.03	1.75	12.97
Over 60.70	1.95	1.38	11.34
Average	**4.23**	**2.66**	**15.44**

Source: Field Survey, 2016/2017

The data in table 7.1 above is graphically represented in figure 7.1 below for comparison and illustrative purposes. This was necessary to visually compare agricultural productivity of smaller land parcels with larger agricultural land sizes.

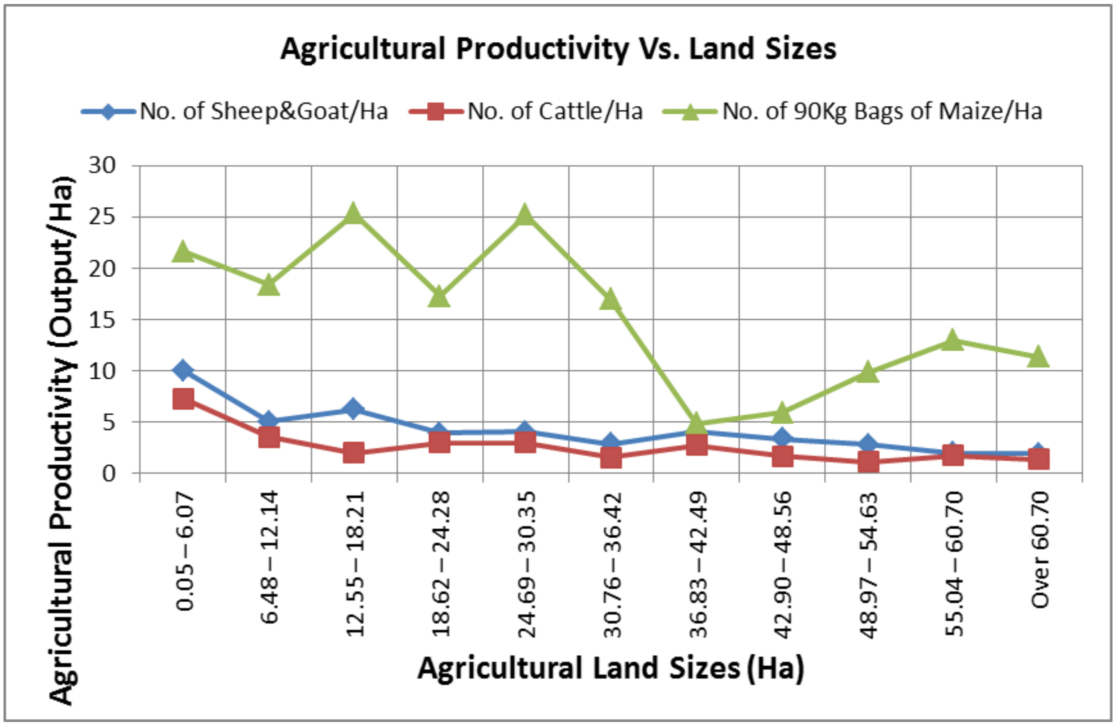

Figure 7.1: Agricultural Land Sizes V. Agricultural Productivity

Source: Field Survey, 2016/2017

Table 7.1 and Figure 7.1 above compare agricultural productivity against agricultural land sizes. The data shows that agricultural productivity is increasing with decreasing agricultural land sizes, signifying a possible inverse relationship between the two variables. The above trends show that as the agricultural land sizes increase from 0.05 – 6.07ha plots to over 60.70ha parcels, agricultural productivity decreases. The average agricultural productivity for goats/sheep, cattle and maize for 0.05 – 6.07ha agricultural plots is 10.03, 7.31 and 21.65 respectively compared to 1.95, 1.38 and 11.34 for over 60.70ha agricultural parcels, respectively.

According to FAO (2006), maize productivity in this area (agro climatic zone V) should be approximately 6.7 bags of 90kg/ha. The small agricultural parcels are producing an average of 21.65 bags of 90kg/ha, 3.2 times higher than the expected productivity. Only 36.83 – 42.49ha and 42.90 – 48.56ha agricultural land parcels are producing less than

6.7 bags of 90kg/ha at 4.89 and 5.93 bags/ha, respectively. The overall maize productivity for all land parcels sizes in the study area, however, is 15.44 bags of 90kg/ha, which is 2.3 times higher than the likely productivity.

Cattle productivity in ACZ V is expected to be approximately 0.5-1 cow/ha (Syagga, 1994; Syagga & Kimuyu, 2016). The small agricultural land parcels are however, on average, supporting 7.31/ha. This is again almost 7 times higher than the probable productivity. Besides, the overall cattle productivity for all land parcel sizes in the study area is 2.66/ha, which is almost 3 times the expected productivity. The productivity of sheep/goat is 4.23/ha, which is slightly less than the expected carrying capacity of 5/ha (Byiringiro, 1995; Gul *et al.*, 2016; Rahmann, 2014).

The above findings may be a pointer to absence of tragedy of the spatial anticommons since small land sizes are producing more output per ha compared to the larger agricultural land sizes. There was thus need to compare the above findings with official data from the agricultural offices in the County and to carry out further data analysis.

The next data analysis was thus carried out to compare agricultural production and productivity trends over the years using official data from the agricultural office. This was necessary to check the response of agricultural production and productivity as subdivision of agricultural land increases and land sizes decrease over time.

Table 7.2 Livestock production and productivity trends in Kajiado East Sub-County

Year	Approximate Total Agricultural Land Size (Ha)	Cattle Population	Sheep/Goat Population	Agricultural Productivity (Output/Ha)	
				Cattle	Sheep/Goat
2010	390,000	733,600	1,789,900	1.88	4.59
2011	390,000	745,800	1,690,689	1.90	4.34
2012	390,000	577,000	1,987,408	1.48	5.10
2013	390,000	600,221	2,001,641	1.53	5.13
2014	390,000	638,976	1,890,312	1.63	4.85
2015	390,000	598,765	1,798,143	1.53	4.61
2016	390,000	548,987	1,678,265	1.41	4.30

Total	**390,000**	**4,443,349**	**12,836,358**	**11.09**	**32.92**
Average	**390,000**	**634,764**	**1,833,765**	**1.58**	**4.70**

Source: Agricultural Office, Kajiado East Sub County, 2017

The livestock production data available at the agricultural office was for only seven years. The production and productivity trends, however, can be observed from table 7.2 above and figure 7.2 below whereby the sheep/goat production and productivity seem to decline from year 2010 to 2011 then increase up to 2013 and drops consistently thereafter. Cattle productivity appears to remain almost constant between year 2010 and 2011 then decreases in 2012 before a slight improvement in 2013 and 2014 then declines up to 2016.

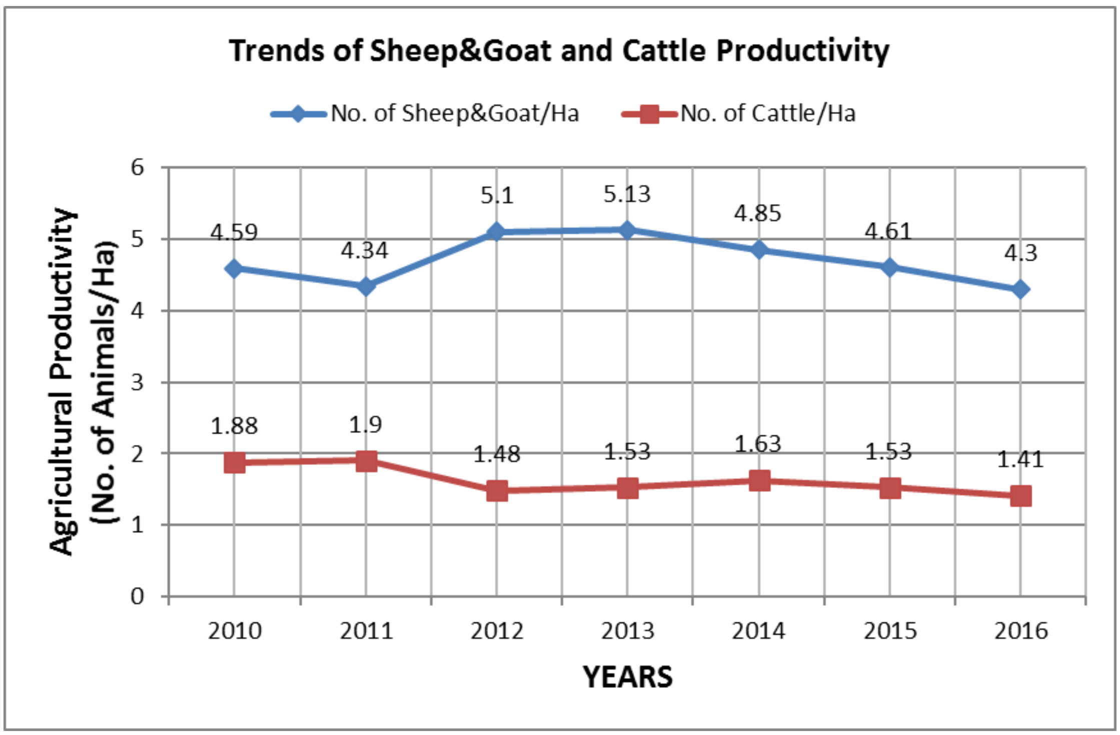

Fig. 7.2 Livestock Production and Productivity Trends in Kajiado East Sub-County

Source: Field Survey, 2016/2017

The overall average productivity for goats/sheep and cattle is 4.7 and 1.58 per ha, respectively. The productivity of sheep/goat is almost equal to the expected carrying capacity in the dry agricultural lands while the productivity of cattle is almost 2 times of the expected carrying capacity (Byiringiro, 1995; Gul *et al.*, 2016; Rahmann, 2014; Syagga, 1994; Syagga & Kimuyu, 2016), which is approximately 0.5-1/ha.

The rather unstable livestock production and productivity trends presented in table 7.2 and demonstrated in figure 7.2 above could be explained by many factors, subdivision of agricultural land (land size) being one of them. Other important factors could be rainfall, fertility of the agricultural land, level of education and income of the farmers, among other factors thus there was need to carry out further data analysis to determine the correlation of agricultural land size and livestock productivity in the study area.

Table 7.3 Maize production and productivity trends in Kajiado East Sub-County

Year	Approximate Total Agricultural Land under Maize Crop (Ha)	Actual Total Production (No. of 90Kg bags)	Agricultural Productivity (No. of 90Kg Bags/Ha)	Agricultural Productivity (No. of 90Kg Bags/Acre)
2007	550	13,750	25	10.12
2008	350	7,000	20	8.09
2009	400	8,800	22	8.90
2010	420	10,500	25	10.12
2011	500	12,500	25	10.12
2012	550	13,750	25	10.12
2013	600	13,800	23	9.31
2014	610	10,980	18	7.28
2015	650	6,500	10	4.05
2016	750	5,250	7	2.83
Total	**5,380**	**102,830**	**200**	**80.94**
Average	**538**	**10,283**	**20**	**8.10**

Source: Agricultural Office, Kajiado East Sub County, 2017

The maize productivity trends in table 7.3 above are graphically presented in figure 7.3 below for illustrative purposes. The production and productivity trend declines from year 2007 to 2008 then improves in 2009 and 2010 and remains almost constant up to 2012 before dropping steadily thereafter.

Overall average maize productivity is 20 bags of 90kg per ha. This figure is almost 3 times higher than the FAO's (2006) estimate of 6.7 bags of 90kg/ha for Agro Climatic Zone (ACZ)

V represented by the study area, signifying overall greater maize productivity. Several factors, including agricultural land size and weather patterns could be responsible for this trend.

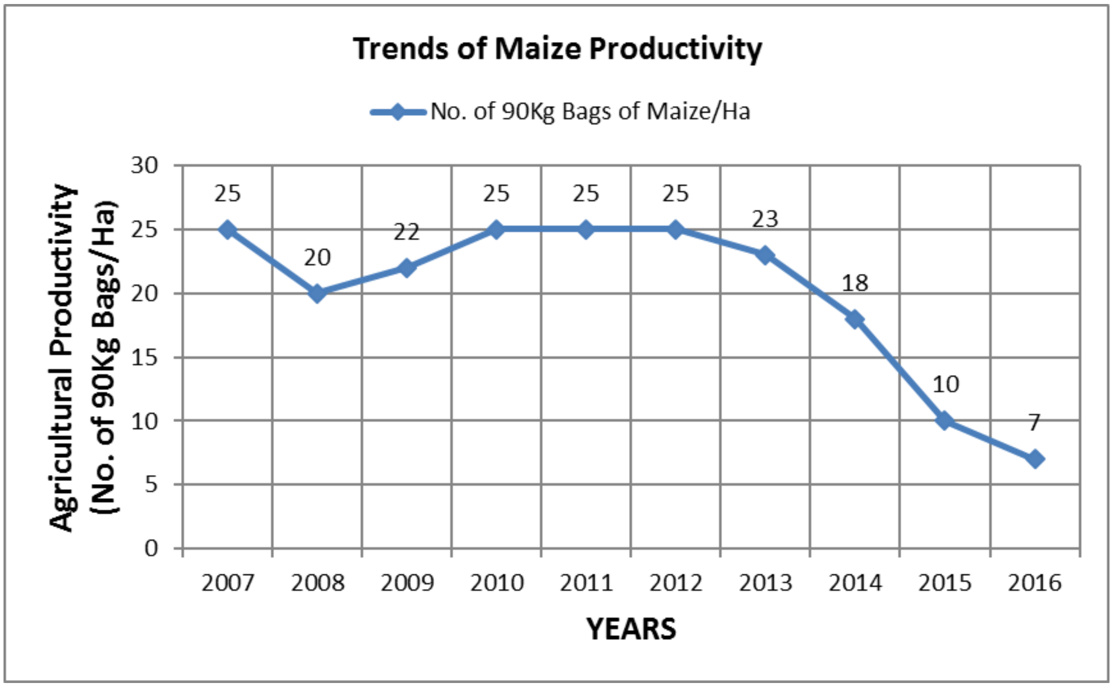

Fig. 7.3 Maize Production and Productivity Trends in Kajiado East Sub-County

Source: Agricultural Office, Kajiado East Sub County

The next analysis performed on the data to determine implication of agricultural land subdivision on the agricultural productivity was comparison of agricultural productivity before and after subdivision of land. The agricultural productivity before subdivision of land was an average productivity over the ten year period while the agricultural productivity after subdivision of land was taken as the latest (2016) output per ha. This was carried out to check whether the change in productivity is positive or negative. It is expected that where the tragedy of the spatial anticommons is present the agricultural productivity would decline after subdivision of the agricultural land. A reduction in agricultural productivity is expected to happen due to inherent possible higher agricultural production costs occasioned by the resultant small private subplots (Heller, 1998; Robson, 2012). As discussed in chapter three of this study, owners of small private agricultural land parcels are likely to physically and legally exclude others from using the land thus restricting movement of livestock and general expansion of agricultural operations. This land use arrangement is expected to have a negative impact on agricultural production and productivity.

The first comparison was performed on the change in productivity of goats/sheep after subdivision of agricultural land. The results are shown in table 7.4 and figure 7.4 below.

Table 7.4: Change in Goats/Sheep Productivity after Agricultural Land Subdivision

Agricultural Land Sizes (Ha)	**Average Agricultural Productivity for Sheep/Goat (No. of Sheep & Goats/Ha)**	
	Before Subdivision of Agricultural Land	**After Subdivision of Agricultural Land**
0.05 – 6.07	4.35	10.03
6.48 – 12.14	2.57	5.05
12.55 – 18.21	3.34	6.23
18.62 – 24.28	2.25	3.95
24.69 – 30.35	2.89	4.08
30.76 – 36.42	1.95	2.89
36.83 – 42.49	2.03	4.10
42.90 – 48.56	2.59	3.39
48.97 – 54.63	2.15	2.84
55.04 – 60.70	0.89	2.03
Over 60.70	1.24	1.95
Overall Average	**2.39**	**4.23**

Source: Field Survey, 2016/2017

The trend of sheep/goat productivity as shown in table 7.4 above and illustrated in figure 7.4 below shows a remarkable increase of goats/sheep productivity after subdivision of agricultural land (reduction of agricultural land size). For 0.05 – 6.07ha agricultural plots, for example, average agricultural productivity for goat/sheep increased from 4.35/ha to

10.03/ha after land subdivision. This trend is replicated even in the large agricultural parcels. For the over 60.70ha agricultural parcels, for instance, average agricultural productivity for sheep/goat improved from 1.24/ha to 1.95ha after land subdivision. In addition, the overall average sheep/goat productivity improved from 2.39/ha before subdivision to 4.23 after subdivision of agricultural land, which is slightly less than the expected carrying capacity in this area.

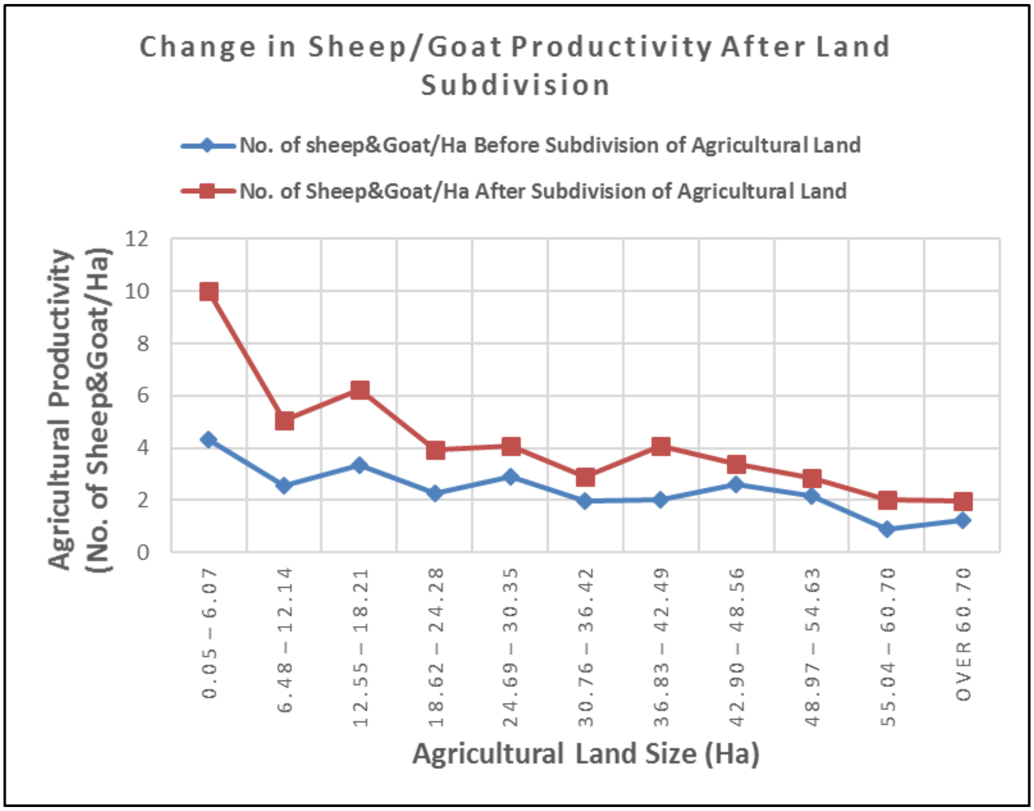

Fig. 7.4: Change in Goats/Sheep Productivity after Agricultural Land Subdivision

Source: Field Survey, 2016/2017

This finding further supports the observation that agricultural productivity is increasing with decreasing agricultural land size. The second comparison was performed on the change of cattle productivity after subdivision of agricultural land. The sheep/goat productivity trend is comparable to that of goats/sheep as shown in table 7.5 and figure 7.5 below.

Table 7.5: Change in Cattle Productivity after Agricultural Land Subdivision

Agricultural Land Sizes (Ha)	**Average Agricultural Productivity for Cattle (No. of Cattle/Ha)**	
	Before Subdivision of Agricultural Land	**After Subdivision of Agricultural Land**
0.05 – 6.07	1.80	7.31
6.48 – 12.14	1.66	3.58
12.55 – 18.21	1.06	2.00
18.62 – 24.28	1.66	2.99
24.69 – 30.35	2.40	3.01
30.76 – 36.42	1.11	1.61
36.83 – 42.49	1.51	2.79
42.90 – 48.56	0.99	1.73
48.97 – 54.63	0.82	1.14
55.04 – 60.70	0.82	1.75
Over 60.70	0.89	1.38
Overall Average	**1.34**	**2.66**

Source: Field Survey, 2016/2017

The cattle productivity has changed positively after subdivision of agricultural land. For 0.05 – 6.07ha parcels, the average cattle productivity changed from 1.80/ha to 7.31ha while for over 60.70ha parcels productivity changed from 0.89/ha to1.38/ha after subdivision of agricultural land. Indeed, the overall average cattle productivity changed from 1.34/ha before subdivision to 2.66/ha after subdivision of agricultural land, both of which are higher than the expected productivity of 0.5-1 cow/ha. This observation appears to reinforce the negative relationship between agricultural land size and agricultural productivity, a possible indication of absence of tragedy of the spatial anticommons.

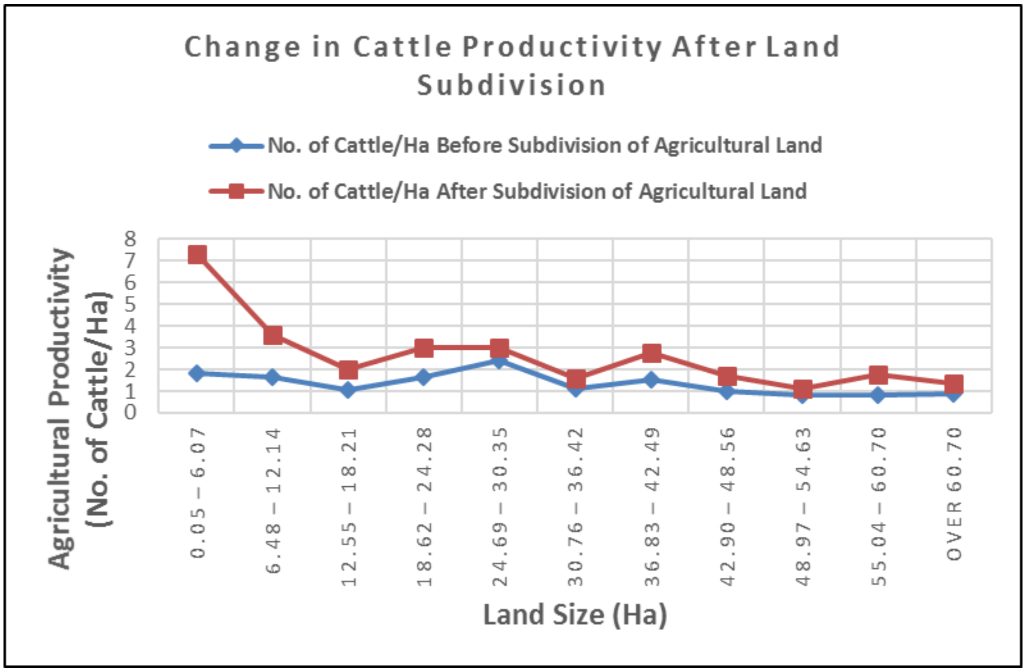

Figure 7.5: Change in Cattle Productivity after Agricultural Land Subdivision

Source: Field Survey, 2016/2017

The positive change in both sheep/goat and cattle productivity after subdivision of agricultural land could be explained by a revelation from the landowners that they use capital raised through subdivision and sale of agricultural land to purchase more livestock. Besides, the farmers were noted to be practicing semi-nomadism which enables them to move to other areas with pasture, especially during the dry seasons. Education and age of the farmer are thus likely to have a positive influence on the agricultural productivity.

The third and final comparison of change in productivity was performed on the maize productivity. Agricultural productivity for maize, however, was found not to change considerably after subdivision of agricultural land, as shown in table 7.6 and figure 7.6 below.

Table 7.6: Change in Maize Productivity after Agricultural Land Subdivision

Agricultural Land Sizes (Ha)	Average Agricultural Productivity for Maize (No. of 90Kg Bags/Ha)	
	Before subdivision of agricultural land	**After subdivision of agricultural land**
0.05 – 6.07	20.76	21.65
6.48 – 12.14	17.05	18.38
12.55 – 18.21	24.46	25.33
18.62 – 24.28	14.83	17.30
24.69 – 30.35	22.24	25.20
30.76 – 36.42	13.34	16.95
36.83 – 42.49	4.45	4.89
42.90 – 48.56	3.71	5.93
48.97 – 54.63	7.41	9.86
55.04 – 60.70	8.90	12.97
Over 60.70	9.64	11.34
Overall Average	**13.34**	**14.52**

Source: Field Survey, 2016/2017

The change in maize productivity before and after subdivision of agricultural land nevertheless is positive, albeit marginally. For small agricultural land parcels of 0.05 – 6.07ha, the average maize productivity changed from 20.76/ha before subdivision to 21.65/ha after subdivision of agricultural land. Similarly, average maize productivity for over 60.70ha changed from 9.64/ha to 11.34/ha after agricultural land subdivision. Besides, the overall average maize productivity changed positively from 13.34/ha to 14.52/ha after subdivision of agricultural land.

Both the overall average maize productivity before and after subdivision of agricultural land are well above the expected productivity rate of 6.7 bags of 90kg/ha in the study area. This, again, could be an indication that the size of agricultural land is negatively associated with agricultural productivity in the study area.

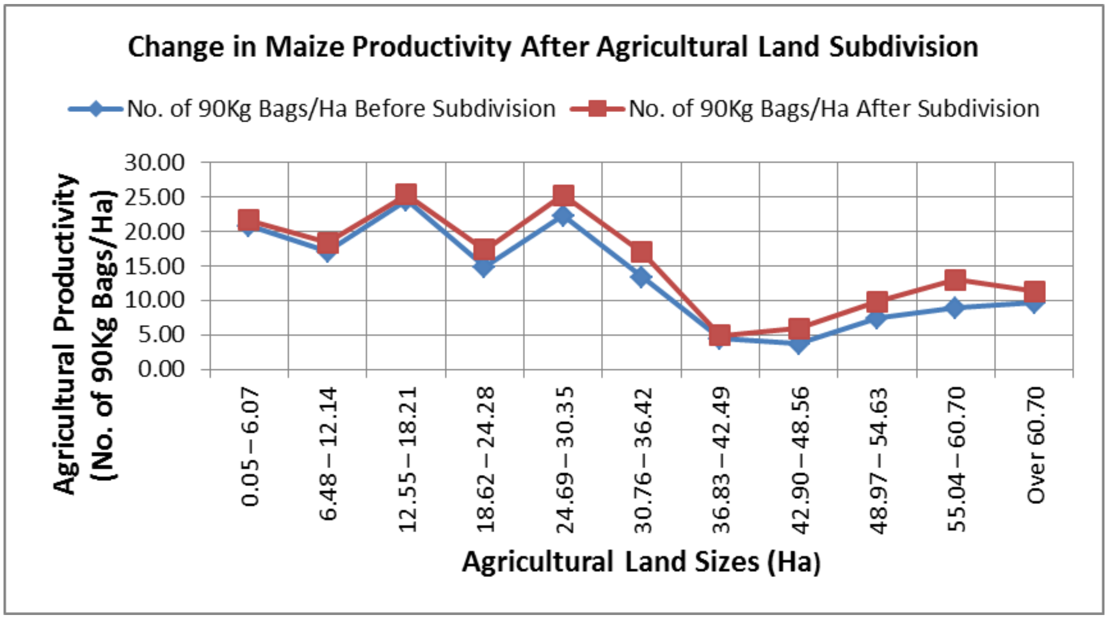

Figure 7.6: Change in Maize Productivity after Agricultural Land Subdivision

Source: Field Survey, 2016/2017

The marginal positive change in maize productivity could be explained by an observation that the crop production acreage usually does not change after subdivision of agricultural land as crop production is normally practiced near the homesteads. The increase in maize productivity therefore could be due to adoption of better farming methods hence soil fertility and socio-economic characteristics of the landowner may be important factors influencing agricultural productivity in the study area.

7.2.2 Correlation analysis (CA)

In general economics, the main factors of production include; land, labour, capital and management/entrepreneurship. The factors that are likely to influence agricultural productivity in the study area are thus considered to be; land (agricultural land size, land fertility, price/value of land & amount of rainfall), labour and management/entrepreneurship (number of adult family members, level of education & age of the landowner) and capital (off-farm income & farm income of the landowner).

Amount of natural rainfall influencing the agricultural production and productivity is a time series data thus is constant for all the output levels, which is cross-sectional data.

Consequently, the amount of rainfall factor has been dropped in the subsequent data analysis. The amount of rainfall received in the study area over the study period is however attached to this report (see appendix 6). There was therefore need to perform correlation analysis between the remaining factors and the agricultural productivity of sheep/goat, cattle and maize to determine the relationship among these variables. Murphy (as cited in Kieti, 2015), however, suggests that descriptive statistics should be performed on data, especially on the dependent variable, before correlation and regression analysis to check whether data obeys normal distribution curve and for completeness of data sets.

Therefore, descriptive statistics was performed on the data to summarize the variables influencing agricultural productivity to enhance understanding and further analysis. The descriptive statistics performed on the above variables are mean, median, standard deviation, skewness and kurtosis. A summary of the descriptive statistics on the variables is presented in table 7.7 below.

Table 7.7: Summary of descriptive statistics on dependent variable (agricultural productivity) and independent variables

Variable	**Mean**	**Median**	**Standard deviation**	**Skewness**	**Kurtosis**
Sheep/Goat productivity	3.654	2.965	1.362	.907	-.065
Cattle productivity	2.113	1.656	.735	1.258	1.227
Maize productivity	12.315	12.355	3.186	-.046	-1.657
Land size	34.255	20.235	42.970	2.761	9.635
Land fertility	1.840	2.000	.371	-1.827	1.350
Price/value of land	11.076	11.120	2.226	.433	-.486
Farm income	7.770	9.000	3.546	-.664	-.950

Off-farm income	5.61	5.000	3.719	.220	-1.345
Level of education	4.250	4.000	1.622	-.524	-.933
No. of adult family members	4.520	5.000	1.841	.234	.031
Age of landowner	2.700	3.000	1.115	.207	-.826

Source: Field Survey, 2016/2017

Data that obeys normal distribution curve should have a small standard deviation, mean and median should be equal or almost equal, skewness value should be <1 or 0 and a kurtosis value of ≤ 3 0r 0. The data sets presented in table 7.7 above appear to satisfy all these conditions, save for the land size variable whose mean (34.255ha) and median (20.235ha) are rather distant and has a big standard deviation of 42.970 and a kurtosis value of 9.635. This variation could be explained by the fact that land ownership in Kenya is usually skewed with a few individuals/families owning large tracts of land while others own small sizes or nothing at all. Land size variable, however, is not a dependent variable in agricultural productivity models but may influence agricultural land size models.

The data for agricultural productivity of sheep/goat, cattle and maize (dependent variables) obeys normal distribution curve. Besides, the independent variables that were considered to be important in influencing their productivity in the study area are also reasonably normally distributed as shown in table 7.7 above. Correlation and multiple regression analysis could thus be performed on the data to determine the relationship between the independent variables and the dependent variable (agricultural productivity).

A Pearson correlation (2-tailed) analysis was first performed on the data to show how each independent variable relates to the dependent variable (sheep/goat productivity, cattle productivity and maize productivity), N = 203, significance level or α = 0.05. Linear correlation between variables is measured in terms of correlation coefficients (r), whereby if; r = 0 – 0.19 indicates very weak correlation, r = 0.2 – 0.39 is weak correlation, r = 0.4 – 0.59 is moderate correlation, r = 0.6 – 0.79 is strong correlation and r = 0.8 – 1 is very strong correlation (Kingoriah, 2004). A negative sign before the correlation coefficient would indicate a negative correlation between two variables. The significance level of the statistics data is indicated by p-value.

At 95% confidence level (α = 0.05 significance level), correlation between two variables whose p-value is less than or equal to α (0.05) would be statistically significantly correlated to each other, and vice versa. Therefore a multiple correlation analysis was necessary to demonstrate how the dependent and independent variables explain each other hence testing hypothesis two of this study. Besides, correlation analysis is necessary to check for multicollinearity or collinearity, a situation where high correlation exists between two or more variables thus affecting relative contribution of each independent variable to the final regression model. A summary of the correlation analysis is presented in table 7.8 below.

Table 7.8: Summary of correlation analysis

Independent variables	**Agricultural productivity (dependent variable)**					
	Sheep/Goat		**Cattle**		**Maize**	
	(r)	**(p)**	**(r)**	**(p)**	**(r)**	**(p)**
Land size	**-.216**	**.002****	**-.195**	**.005****	**-.028**	**.002****
Land fertility	-.038	.596	.040	.574	.008	.909
Value of land	-.066	.349	**.156**	**.027***	-.120	.091
No. of adult family members	**.465**	**.008****	**.591**	**.000***	**.232**	**.001****
Level of education of landowner	.031	.661	.046	.518	.085	.230
Age of landowner	-.075	.288	-.130	.066	.026	.713
Off-farm income	-.030	.673	.055	.435	.030	.669
Farm income	.116	.100	.087	.218	**.231**	**.001****

Source: Field Survey, 2016/2017

** *Means that the correlation is significant [**P ≤ 0.05 or alpha (α)**]*

The results of the correlation coefficients are shown in table 7.8 above which indicates that only agricultural land size and number of adult family members are significantly correlated with the agricultural productivity of sheep/goat, cattle and maize. Agricultural land size has a significant weak negative correlation with sheep/goat productivity (r = - .216, p =

.002), cattle productivity (r = - .195, p = .005) and maize productivity (r = - .028, p = .002). This means that as agricultural land size decreases, the agricultural productivity of sheep/goat, cattle and maize increases but marginally, and vice versa. This observation confirms the inverse or negative relationship of the two variables observed earlier. Correlation analysis has also revealed the magnitude of the relationship to be weak.

The number of adult family members, however, has a moderate positive correlation with sheep/goat productivity (r = .465, p = .008) and cattle productivity (r = .591, p = .000). In addition, there is a weak positive correlation between the number of adult family members and maize productivity (r = .232, p = .001). Therefore, the more the number of adult family members, the more the agricultural productivity of sheep/goat and cattle. The association between these variables is moderate and positive while the relationship between agricultural land size and maize productivity is positive and weak.

The relationship between the value of land and cattle productivity is positive and very weak (r = .156, p = .027) while the correlation between farm income and maize productivity is positive and weak (r = .231, p = .001). These variables are, however, significantly correlated to each other as indicated by their p-values, which are less than the significance level or α of 0.05 at 95% confidence level. The other remaining independent variables are insignificantly correlated to agricultural productivity as shown in table 7.8 above since their p-values are greater than α at 0.05.

Subdivision of agricultural land, which results to decrease in agricultural land size, is thus generally weakly and negatively correlated to agricultural productivity in the study area and does not affect negatively agricultural productivity of sheep/goat, cattle and maize in the study area. This observation could be explained by local land use and management interventions adopted by landowners in the study area as discussed in section 7.3.

7.2.3 Multiple regression analysis (MRA)

The next and final data analysis regarding implication of agricultural subdivision on agricultural productivity involves multiple regression analysis of the independent variables against the dependent variable. Before multiple regression analysis is performed there is need to check for multicollinearity to confirm whether independent variables are statistically significantly correlated to each other. This is necessary to avoid developing misleading agricultural productivity models. A summary of the collinearity testing is presented in table 7.9 and 7.10 below.

Essentially, multicollinearity ensures that only independent variables that are correlated to the dependent variable are included in the final model (Murphy, 1989 in Kieti, 2015). Multicollinearity exists if; correlation coefficient between independent variables is > +/- 0.7, largest Variance Inflation Factor (VIF) is between 5 and 10 and tolerance is < 0.1 or below 0.2 (Murphy, 1989 in Kieti, 2015). The correlation coefficients between variables presented in table 7.10 indicates that there are no multicollinearity problems on the independent variables since no correlation coefficient is above +/- 0.7. This is an indication that the independent variables are not strongly correlated to one another thus they can be used in MRA model to predict the dependent variable.

Besides, the values for multicollinearity tolerance and variance inflation factor between the independent variables suggest that collinearity is not an issue in our data sets since no VIF value is more than 5 and all tolerance values are more than 0.2, as shown in table 7.10 below.

Basically, the independent variables in this study are not considerably correlated to each other thus cannot significantly affect the agricultural productivity models in a negative manner. Besides, the purpose of the MRA in this study is to show the relative contribution to and direction of association between agricultural land size and agricultural productivity of sheep/goat, cattle and maize in the study area. Therefore, all the selected independent variables can be entered into the agricultural productivity models without negatively interfering with accuracy of the models.

Table 7.9 Multicollinearity diagnosis on independent variables using correlation coefficients

Independent Variables	**Correlation coefficient between variables (r)**							
	Land size	Land fertility	Value of land	No. of adult members	Level of education landowner	Age of landowner	Off-farm income	Farm income
Land size	.000	.076	.307*	.049	.287*	.249*	-.032	.221*
Land fertility	.076	.000	.036	-.080	.011	-.109	-.148*	-.002
Value of land	.307*	.036	.000	.059	-.259*	.039	.298*	.040
No. of adult family members	.049	-.080	.059	.000	.073	-.001	.001	.259*
Level of education of landowner	.287*	.011	-.259*	.073	.000	.303*	.377*	.088
Age of landowner	.249*	-.109	.039	-.001	.303*	.000	.377*	.191*
Off-farm income	-.032	-.148*	.298*	.001	.377*	.377*	.000	-.053
Farm income	.221*	-.002	.040	.259*	.088	.191*	-.053	.000

** Indicates that the correlation is significant between the variables ($p \leq 0.05$).*

Source: Field Survey, 2016/2017

Table 7.10 Multicollinearity diagnosis using collinearity tolerance and variance inflation factor (VIF)

Independent Variables	Land Size		Land fertility		Value of land		No. of adult family members		Level of education		Age		Off-farm income		Farm income	
	Collinearity Statistics															
	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
Land size	N/A	N/A	.950	1.053	.861	1.162	.907	1.102	.729	1.372	.835	1.197	.783	1.277	.889	1.125
Land fertility	.778	1.285	N/A	N/A	.791	1.265	.915	1.092	.704	1.421	.821	1.218	.786	1.272	.864	1.158
Value of land	.852	1.173	.956	1.046	N/A	N/A	.916	1.092	.716	1.397	.834	1.199	.818	1.223	.862	1.160
No. of adult family members	.777	1.286	.958	1.044	.793	1.262	N/A	N/A	.711	1.407	.819	1.221	.769	1.300	.927	1.079
Level of education of landowner	.805	1.242	.949	1.053	.798	1.252	.916	1.092	N/A	N/A	.891	1.123	.879	1.138	.865	1.157
Age of landowner	.800	1.250	.960	1.041	.807	1.239	.916	1.092	.772	1.295	N/A	N/A	.774	1.293	.886	1.129
Off farm income	.791	1.264	.970	1.031	.835	1.197	.907	1.102	.804	1.243	.816	1.225	.000	.000	.865	1.156
Farm income	.802	1.247	.951	1.052	.785	1.273	.976	1.025	.706	1.417	.834	1.199	.772	1.296	.000	.000

Source: Field Survey, 2016/2017

The components and expected results in the MRA models are explained at this point to help the reader comprehend and interpret the models developed. An MRA model usually has B coefficients, coefficient of determination (R square or R^2 and adjusted R^2), standard error of the estimate (SEE), F-statistic and T-statistic. B coefficients are unstandardized coefficients which indicate how much and the direction (positive or negative) the dependent variable changes in respect to a unit change in the independent variable. In the general regression equation presented and discussed earlier in the methodology section, the B coefficients are the $b_1 \ldots b_n$. If a particular independent variable such as agricultural land size has a B coefficient of – 0.234, it means that when the size of agricultural land is added by one unit (hectare), the agricultural productivity would decrease by 23.4%. The negative sign signifies a negative relationship between the two variables. A summary regression model has a constant (accounting for factors not considered in the model) and B coefficients.

The coefficient of determination R square or R^2 is the fraction deviation or variation in the dependent variable that can be described by the collective effect of all the independent variables used in the model. In other words, R^2 indicates how much of the discrepancy in the dependent variable is accounted for by the regression model. The values of R^2 thus ranges from 0 – 1 (0% to 100%), when the value of R^2 is equal to zero it denotes that the independent variables do not explain the dependent variable at all and when the value of R^2 is equal to 1, it means that all the variation in the dependent variable is expounded by the model. The value of R^2 therefore measures the accuracy of prediction of the model given the independent variables included in the model. In MRA models presenting significant independent variables to predict a dependent variable a value of about 0.500 (50.0%) or more is usually viewed as realistic in explaining the accuracy of the model.

Adjusted R^2 on the other hand takes into account the number of independent variables used in the regression model and the sample size to adjust the value of R^2 to match the real world situation since the unadjusted value of R^2 tends to over-estimate the accuracy of the model. The value of adjusted R^2 thus provides a more accurate estimate of the model's success.

The standard error of estimate (SEE) indicates the amount of discrepancy between the actual or what was observed in the real world and the projected or predicted value of the dependent variable in the model, which is hypothetical. It tests the accuracy and reliability of the MRA model thus the lower the SEE, the more accurate and reliable the model is.

The value of F-statistic is used to determine the significance of the entire regression model. Ideally, when sample size is more than 10, the value of F-statistic should be more than 5. In general terms, any F-value equal to or more than 5 means that the model is acceptable at 95% confidence level because it is derived from the results of analysis of variance (ANOVA). The T-statistic on the other hand tests whether each independent variable is statistically significant in the model. As a common rule and provided that the sample size is large (at least 50 cases), t-values which are more than 2 (plus or minus) indicate that particular independent variable is significant in predicting the dependent variable at 95% confidence level.

A multiple regression analysis (MRA) was thus performed on the data to determine the association of the independent variables and the agricultural productivity of sheep/goat, cattle and maize. This was necessary to check the relative contribution and direction of relationship (negative or positive correlation) of agricultural land size and the agricultural productivity. The MRA was performed by use of a computer program known as Statistical Package for Social Sciences (SPSS) software, Version 22. Simultaneous/ENTER method was used since it is preferred when there are relatively low number of variables under study as it can analyze both weak and strong independent variables (Brace *et al.*, as cited in Kieti, 2015). The significance level was set at 0.05.

First, the independent variables were regressed against sheep/goat productivity. The main objective of this was to determine the relative contribution of agricultural land size to agricultural productivity hence establish whether this variable influences sheep/goat productivity significantly and in what direction (positive or negative). The results are shown in tables 7.11, 7.12 and 7.13 below.

A) <u>Model 1: Sheep/Goats productivity (Dependent Variable)</u>

Table 7.11: Sheep/Goat productivity MRA results (Model Summary)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df 1	df2	Sig. F Change
1	.705	.497	.476	.985834	.497	23.745	8	192	.000

Source: Field survey, 2016/2017

Table 7.12 Sheep/Goat productivity: Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	184.614	8	23.077	23.745	.000
	Residual	186.599	192	.972		
	Total	371.213	200			

Source: Field survey, 2016/2017

Table 7.13 Sheep/Goat productivity MRA results (Model Coefficients)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.398	.532		-.748	.455
	Land size	-.003	.001	-.272	-4.684	.000
	Land fertility	-.030	.193	-.008	-.154	.878
	Land value	-2.349E-8	.000	-.038	-.665	.507
	No. of adult family members	.493	.040	.666	12.404	.000
	Level of education	.046	.051	.054	.890	.374

	Age of landowner	-.028	.069	-.023	-.403	.687
	Off farm income	-.003	.021	-.008	-.139	.889
	Farm income	.000	.021	.001	.022	.982

Source: Field survey, 2016/2017

The summary of regression model predicting sheep/goat productivity presented in table 7.11 above indicates the value of R square (R^2) as 0.497 signifying that the model accounts for 49.7% of the variance of sheep/goat productivity. It means that the model comprising of the eight variables is 49.7% (almost 50%) accurate in predicting the productivity of sheep/goat, which is considered a good prediction. Besides, the standard error of the estimate is less than 1 at 0.985834 while F-value is more than 5 at 23.745 (at 95% confidence level) as shown in change statistics in table 7.11 and in analysis of variance in table 7.12 above.

The significance/contribution of each factor to the success of the model is indicated by the t-values shown in the model coefficients in table 7.13 above. Indeed, using the t-values the independent variables can be ranked in order of their significance or influence on the success of the model. Generally, the bigger the t-value associated with a particular predictor variable is, the more significant it is in predicting the dependent variable.

At 95% confidence level, any predictor variable with a t-value more than +/- 2 is considered significant thus in our model for sheep/goat productivity the number of adult family members (t = 12.404) and agricultural land size (t = - 4.684) are then only significant factors in predicting the sheep/goat productivity (see table 7.13 above). All the other factors; land fertility (t = -.154), land value (t = -.665), level of education of landowner (t = .890), age of landowner (t = - .403), off-farm income (t = -.139) and farm income (t = .022) are insignificant in predicting sheep/goat productivity. Therefore, number of adult family members (t = 12.404) is the most significant factor in predicting sheep/goat productivity followed by the agricultural land size (t = - 4.684). In addition, the significance level for the two independent variables is 0.000, which is less than our alpha level of 0.05.

While the t-values indicate the significance of each independent variable, the unstandardized B coefficients show the contribution of each factor in predicting the dependent variable. The B coefficient associated with agricultural land size, for example, is - .003 while that of number of adult family members is 0.493. This means that a unit change in size of agricultural land (by one hectare) would lead to 0.3% negative change in sheep/goat productivity while a unit change in number of mature family members (addition of one adult family member) would lead to 49.3% positive change in sheep/goat productivity, and so on. The constant, in the sheep/goat productivity model is -.398, accounts for other factors not included/considered by the model. Using the unstandardized B coefficients in table 7.13 therefore the final model predicting the sheep/goat productivity can be written as follows.

Goats /sheep productivity = - .398 – [.003 Land size] – [.030 Land fertility] – [2.349E - 8 Land value] + [.493 No. of adult family members] + [.046 Level of education of landowner] – [.028 Age of landowner] – [.003 Off-farm income] + [.000 Farm income].

In the sheep/goat productivity model, agricultural land size is negatively associated with the productivity of sheep/goat (B = - .003). This means that a unit change in size of agricultural land (by one hectare) would lead to 0.3% negative change in sheep/goat productivity. In addition, the t-value associated with land size is t = - 4.684. Therefore, it can be concluded that subdivision of agricultural land (agricultural land size) does not affect productivity of sheep/goat in a negative manner in the study area, the two are negatively associated.

Secondly, the independent variables were regressed against cattle productivity. The main objective of this was to determine the relative contribution of agricultural land size to agricultural productivity thus determine whether this variable influences cattle productivity significantly and in what direction (positive or negative). The results are shown in tables 7.14, 7.15 and 7.16 below.

B. Model 2: Cattle productivity (Dependent Variable)

Table 7.14: Cattle productivity MRA results (Model Summary)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
2	.649	.421	.396	.571107	.421	17.422	8	192	.000

Source: Field survey, 2016/2017

Table 7.15 Cattle productivity: Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	45.459	8	5.682	17.422	.000
	Residual	62.623	192	.326		
	Total	108.082	200			

Source: Field survey, 2016/2017

Table 7.16 Cattle productivity MRA results (Model Coefficients)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	(Constant)	-.137	.308		-.446	.656
	Land size	-.001	.000	-.165	-2.656	.009
	Land fertility	.101	.112	.051	.907	.366
	Land value	2.959E-8	.000	.090	1.446	.150
	No. of adult family members	.242	.023	.605	10.492	.000
	Level of education	-.014	.030	-.031	-.479	.633
	Age of landowner	-.048	.040	-.073	-1.189	.236
	Off farm income	-.018	.012	-.092	-1.476	.142
	Farm income	-.004	.012	-.018	-.301	.764

Source: Field survey, 2016/2017

The summary of regression model predicting cattle productivity presented in table 7.14 above indicates the value of R square (R^2) as 0.421 indicating that the model accounts for 42.1% of the variance of cattle productivity. Besides, the standard error of the estimate is less than 1 at 0.571107 while F-value is more than 5 at 17.422 (at 95% confidence level) as shown in change statistics in table 7.15 and in analysis of variance in table 7.15 above.

The significance of each factor to the success of the model is indicated by the t-values shown in the model coefficients in table 7.16 above. At 95% confidence level, any predictor variable with a t-value more than +/- 2 is considered significant thus in our model for cattle productivity the number of adult family members (t = 10.492) and agricultural land size (t = - 2.656) are then only significant factors in predicting the cattle productivity (see table 7.17 above). All the other factors; land fertility (t = 0.907), land value (t = 1.446), level of education of landowner (t = - .479), age of landowner (t = - 1.189), off-farm income (t = - 1.476) and farm income (t = - .301) are insignificant in predicting sheep/goat productivity. Therefore, number of adult family members (t = 10.492) is the most significant factor in predicting cattle productivity followed by the agricultural land size (t = - 2.656). In addition, the significance levels for the two independent variables are .000 and .009, respectively which are less than our alpha level of 0.05.

The B coefficient associated with agricultural land size is - .001 while that of number of adult family members is .242. The constant of - .137 in the cattle productivity model accounts for other factors not included/considered by the model. Using the unstandardized B coefficients in table 7.16 therefore the final model predicting the cattle productivity can be presented as follows.

Cattle productivity = - .137 – [.001 Land size] + [.101 Land fertility] + [2.959E - 8 Land value] + [.242 No. of adult family members] - [.014 Level of education of farmer] – [.048 Age of landowner] – [.018 Off-farm income] - [.004 Farm income].

In the cattle productivity model, agricultural land size is negatively associated with the productivity of cattle (B = - .001). This means that a unit change in size of agricultural land (by one hectare) would lead to 0.1% negative change in cattle productivity. In addition, the t-value associated with land size is t = - 2.656. Therefore, it can be concluded that subdivision of agricultural land (agricultural land size) does not affect productivity of cattle in a negative manner in the study area since the two are negatively related.

Lastly, the independent variables were regressed against maize productivity. The main purpose of this was to determine the relative contribution of agricultural land size to agricultural productivity thus determine whether this variable influences maize productivity significantly and in what direction (positive or negative). The results are shown in tables 7.17, 7.18 and 7.19 below.

C. Model 3: Maize productivity

Table 7.17: Maize productivity MRA results (Model Summary)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
3	.503	.253	.222	3.692871	.253	8.121	8	192	.000

Source: Field survey, 2016/2017

Table 7.18 Maize productivity: Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	886.009	8	110.751	8.121	.000
	Residual	2618.360	192	13.637		
	Total	3504.369	200			

Source: Field survey, 2016/2017

Table 7.19 Maize productivity MRA results (Model Coefficients)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
3	(Constant)	.699	2.000		.349	.727
	Land size *	1.247	.204	.403	6.118	.000
	Land fertility	.160	.722	.014	.221	.825

	Land value	3.012E-7	.000	.160	2.354	.020
	No. of adult family members	.418	.149	.184	2.810	.005
	Level of education	-.223	.189	-.086	-1.181	.239
	Age of landowner	-.016	.257	-.004	-.064	.949
	Off farm income	-.109	.080	-.097	-1.355	.177
	Farm income	.115	.080	.097	1.429	.155

* *The land size used here is land under maize crop which is usually less than the total land owned by an individual entity (usually a portion of the total land).*

Source: Field survey, 2016/2017

The summary of regression model predicting maize productivity presented in table 7.17 above indicates that the model accounts for 25.3% of the variance of maize productivity as shown by the value of R square (R^2) = .253. Besides, F-value is more than 5 at 8.121 (at 95% confidence level) as shown in change statistics in table 7.17 and in analysis of variance in table 7.18 above. The model thus has good predictive power of the maize productivity. In addition, the purpose of this model is to show the relationship between agricultural land size and maize productivity rather than to identify significant factors influencing maize productivity in the study area.

The significance of each factor to the success of the model is indicated by the t-values shown in the model coefficients in table 7.19 above. At 95% confidence level, any predictor variable with a t-value more than +/- 2 is considered significant thus in our model for maize productivity the agricultural land size (t = 6.118), land value (t = 2.354) and number of adult family members (t = 2.810) are then only significant factors in predicting the maize productivity (see table 7.19 above). All the other factors; land fertility (t = .221), level of education of landowner (t = - 1.181), age of landowner (t = - .064), off-farm income (t = - 1.355) and farm income (t = 1.429) are insignificant in predicting maize productivity. Therefore, crop land size (t = 6.118) is the most significant factor in predicting maize productivity followed by the number of adult family members (t = 2.810) and value of agricultural land (t = 2.354). In addition, the significance levels for the three independent variables are .000, .005 and .020, respectively which are less than our alpha level of 0.05.

A regression analysis of the independent variables against maize productivity using the total land size, however, showed that land size is not significant (t = -.414, significance level > 0.05 at .679). This could be explained by the fact that the land size under crop in dry agricultural lands only accounts for a very small percentage of the total land owned by an individual owner. Besides, the value of R square = .108 while the value of F was < 5 at 2.904).

The B coefficient associated with agricultural land size is 1.247 while that of number of adult family members and land value is 2.354 and 3.012E-7, respectively. A regression analysis of the independent variables using the total agricultural land size, however, produced a B coefficient for land size at - .001. The constant of .699 in the maize productivity model accounts for other factors not included/considered by the model. Using the unstandardized B coefficients in table 7.19 (associated with crop land size) therefore the final model predicting the maize productivity can be presented as follows.

Maize productivity = .699 + [1.247 Land size] + [.160 Land fertility] + [3.012E - 7 Land value] + [.418 No. of adult family members] - [.223 Level of education of farmer] - [.016 Age of landowner] – [.109 Off-farm income] + [.115 Farm income].

In the maize productivity model, agricultural land size is positively associated with the productivity of maize (B = 1.247). This means that a unit change in size of crop land (by one hectare) would lead to 124.7% positive change in maize productivity. In addition, the t-value associated with crop land size is t = 6.118. This association is only applicable only if the land size under crop is considered in the model. If the total agricultural land size is taken into account, however, the association is negative (B = -.001, t = -.414). Therefore, it can be concluded that subdivision of agricultural land (crop land size) does affect productivity of maize in a positive manner in the study area since the two are positively related. Taking the total land size into account, however, leads to an insignificant negative change (- 0.1%) in maize production.

D. Model 4: Policy Guidelines on Agricultural Land Sizes

Elsewhere, previous research carried out in Rwanda, Turkey, Iran and Greece has shown that the size of agricultural land is likely to be influenced by socioeconomic factors such as number of livestock and crop production, availability of labour, land fertility, off-farm income, education of farmers, value of agricultural land and farm income (Bizimana *et al.*, 2004; Gul *et al.*, 2016; Kalantari & Abdollahzadeh, 2008; Sermos, 1995). Consequently, these variables were regressed against the agricultural land sizes in the study area to determine the most important predictors of agricultural land sizes. The stepwise method of SPSS, which automatically eliminates insignificant variables from a model, was used in this analysis. This was necessary to develop a model that can guide in policy interventions to address the main factors influencing agricultural subdivision. The results of the regression analysis produced the following model.

Model 4: Agricultural Land Sizes (Dependent Variable)

Table 7.20: Agricultural Land Sizes$_f$ MRA results (Model Summary)

					Change Statistics				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**R Square Change**	**F Change**	**df1**	**df2**	**Sig. F Change**
1	.655[a]	.430	.427	80.39836	.430	149.837	1	199	.000
2	.748[b]	.559	.555	70.85922	.130	58.186	1	198	.000
3	.768[c]	.589	.583	68.57243	.030	14.426	1	197	.000
4	.798[d]	.637	.630	64.62418	.048	25.807	1	196	.000
5	**.805[e]**	**.648**	**.639**	**63.79812**	**.011**	**6.108**	**1**	**195**	**.014**

a. Predictors: (Constant), Cattle Production
b. Predictors: (Constant), Cattle Production, Maize Production
c. Predictors: (Constant), Cattle Production, Maize Production, No. of adult family members

d. Predictors: (Constant), Cattle Production, Maize Production, No. of adult family members, Goat Sheep Production
e. Predictors: (Constant), Cattle Production, Maize Production, No. of adult family members, Goat/Sheep Production, Land value.
f. Dependent Variable: Land size

Source: Field survey, 2016/2017

In agricultural land sizes regression analysis, Model 5 in table 7.14 above is the most accurate since the values of R, R Square and adjusted R Square are greatest at .805, .648 and .639, respectively. In addition, the standard error of the estimate is least for model 5. It is therefore adopted to predict influence of agricultural land sizes thus the other models (number 1 – 4) are ignored in further discussion.

Table 7.21 Agricultural Land Sizes: Analysis of Variance (ANOVA)

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
5	Regression	1461159.583	5	292231.917	71.798	.000[b]
	Residual	793688.995	195	4070.200		
	Total	2254848.578	200			

a. Dependent Variable: Agricultural Land size
b. Predictors: (Constant), Cattle Production, Maize Production, No. of adult family members, Goat/Sheep Production, Land value.

Source: Field survey, 2016/2017

Table 7.22 Agricultural Land Sizes MRA results (Model Coefficients)

		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig.**
5	(Constant)	77.885	15.082		5.164	.000
	Cattle Production	.602	.100	.364	6.011	.000
	Maize Production	.144	.021	.333	6.754	.000
	No. of adult family members	-13.576	2.757	-.235	-4.923	.000
	Goat Sheep Production	.354	.076	.294	4.694	.000

	Land value	- 5.222E-6	.000	-.109	-2.472	.014

Source: Field survey, 2016/2017

Model 5 has retained five significant factors influencing agricultural land sizes (cattle production, maize production, number of adult family members, goat/sheep production and land value). Land fertility, farm income, level of education of farmers and off-farm income were thus found to be insignificant factors in influencing agricultural land sizes, they were therefore dropped from the model.

The summary of regression model predicting agricultural land size presented in table 7.20 above indicates the value of R square (R^2) as 0.648 signifying that the model accounts for 64.8% of the variance of agricultural land size. It means that the model comprising of the five variables is 64.8% (above 50%) accurate in predicting the size of agricultural land, which is considered a good prediction. Besides, (at 95% confidence level) F-value is more than 5 at 6.108 as shown in change statistics in table 7.20 and at 71.798 in analysis of variance in table 7.21 above. The rather large standard error of the estimate could be explained by the big difference between average/mean land size (30.255ha) and the median land size (20.235ha), large standard deviation of 42.970ha, large kurtosis of 9.635, as shown in table 7.7. As explained earlier, this difference exists due to a big disparity in ownership of land in Kenya where some landowners own large tracts of land and others own very small portions. Based on the values of R square and F-value however the model is fit to offer policy guidelines on subdivision of agricultural land.

The significance/contribution of each factor to the success of the model is indicated by the t-values shown in the model coefficients in table 7.22 above. Indeed, using the t-values the independent variables can be ranked in order of their significance or influence on the success of the model. Generally, the bigger the t-value associated with a particular predictor variable, the more significant it is in predicting the dependent variable.

At 95% confidence level, any predictor variable with a t-value more than +/- 2 is considered significant thus in the model for agricultural land size, arranged in their order of importance, maize production (t = 6.754, p = .000), cattle production (t = 6.011, p =

.000), number of adult family members (t = - 4.923, p = .000), goat/sheep production (t = 4.694, p = .000) and land value (t = - 2.472, p = .014) are significant factors in predicting agricultural land sizes (see table 7.13 above). Therefore, maize production (t = 6.754) is the most significant factor in predicting agricultural land sizes followed by the cattle production (t = 6.011), and so on. In addition, the significance levels for all the five variables is less than the alpha level of 0.05.

While the t-values indicate the significance of each independent variable, the unstandardized B coefficients show the contribution of each factor in predicting the dependent variable. The B coefficient associated with cattle production, for example, is .602. This means that a unit change in number of cattle (by one head) would lead to 60.2% positive change in agricultural land size while a unit change in number of mature family members (addition of one adult family member), whose B coefficient is -13.576, would lead to 1357.6% negative change in agricultural land size, and so on. The constant, in the agricultural land size model is 77.885, accounts for other factors not included/considered by the model. Using the unstandardized B coefficients in table 7.22 therefore the final model predicting agricultural land size can be written as follows;

Agricultural Land Size = 77.885 + [.602 Cattle Production] + [.144 Maize Production] - [13.576 No. of adult family members] + [.354 Goat/Sheep Production] - [5.222E-6 Land value]

In the agricultural land size model, number of adult family members and agricultural land value are negatively associated with the agricultural land size at B = - 13.576 and - 5.222E-6, respectively. This implies that an increase in the number of family members (population growth) would lead to a decrease in agricultural land sizes, probably due to subdivision of agricultural land for inheritance purposes. Similarly, increase in agricultural land values is expected to influence decrease in agricultural land sizes, perhaps due to increased demand for agricultural land by property developers/land speculators. The other variables (cattle production, B = .602, maize production, B = .144 and goat/sheep production, B = .354) are positively correlated to agricultural land size thus a positive unit change in these variables would lead to a positive change in agricultural land sizes, and vice versa.

Therefore, it can be concluded that an increase in agricultural production (maize, cattle, goat/sheep) would lead to an increase in agricultural land sizes. On the contrary, an increase in number of family members and value of agricultural land would lead to a decrease in agricultural land sizes, and vice versa.

7.3 Discussion on Implications of Agricultural Land Subdivision on Productivity

The results of cross tabulation analysis have revealed that agricultural productivity is increasing with decreasing agricultural land sizes, signifying an inverse relationship between the two variables.

The results of Pearson correlation (2-tailed) analysis has revealed that agricultural land size has a significant weak negative correlation with sheep/goat productivity. (r = - .216, p = .002), cattle productivity (r = - .195, p = .005) and maize productivity (r = - .028, p = .002). This means that as agricultural land size decreases, the agricultural productivity of sheep/goat, cattle and maize increases but marginally, and vice versa. This observation confirms the inverse or negative relationship of the two variables observed earlier. Correlation analysis has also revealed the magnitude of the relationship to be weak.

Subdivision of agricultural land, which results to decrease in agricultural land sizes, is thus generally weak and negatively correlated to agricultural productivity in the study area and does not affect negatively agricultural productivity of sheep/goat, cattle and maize in the study area.

The results of multiple regression analysis on agricultural productivity has produced the following models;

1. **Goats /sheep productivity = - .398 – [.003 Land size] – [.030 Land fertility] – [2.349E - 8 Land value] + [.493 No. of adult family members] + [.046 Level of education of landowner] – [.028 Age of landowner] – [.003 Off-farm income] + [.000 Farm income].**

2. **Cattle productivity = - .137 – [.001 Land size] + [.101 Land fertility] + [2.959E - 8 Land value] + [.242 No. of adult family members] - [.014 Level of education of farmer] – [.048 Age of landowner] – [.018 Off-farm income] - [.004 Farm income].**

3. **Maize productivity = .699 + [1.247 Land size] + [.160 Land fertility] + [3.012E - 7 Land value] + [.418 No. of adult family members] - [.223 Level of education of farmer] - [.016 Age of landowner] – [.109 Off-farm income] + [.115 Farm income].**

Regression results thus indicate that the relative contribution and association between agricultural land size and sheep/goat and cattle productivity is B = - .003, p = 0.000 and B = - .001, p = .009, respectively. The t-values corresponding to these variables are – 4.684 and – 2.656, respectively. The B coefficients associated with maize productivity, and taking only crop land size into account, was found to be 1.247, p = .000. When the total agricultural land size was considered in the MRA model, however, the B coefficient was found to be - .001, p = .679, t = -.414, signifying a negative and weak correlation between the two variables.

The above correlation and beta coefficients prove that there is a weak and negative relationship between agricultural land size and agricultural productivity of sheep/goat, cattle and maize in the study area.

The above inverse/negative relationship between agricultural land size and agricultural productivity could be explained by land use measures adopted by the landowners in the study area to avoid tragedy of the spatial anticommons. Table 7.23 below presents a summary of the interventions being utilized by the agricultural landowners in the study area.

Table 7.23: Summary of local land use practices in the study area

Local intervention		Responses (N = 203)	Percentage (%)
Intensive agricultural land use:-	Zero grazing	25	12%
	Irrigation/greenhouses	76	37%
	High value crops	76	37%
Crop farming		154	76
Semi-nomadism		159	78%
Off-farm economic activities		128	63%
Informal regulation of agricultural land subdivisions		167	78%

Source: Field Survey, 2016/2017

(a) Intensive agricultural land use

The findings show that the agricultural landowners with small land sizes (between 0.0505 to 12.140ha) are practicing intensive agriculture. About 12% of the small landowners are practicing zero grazing, 37% are growing crops under irrigation or greenhouses while 37% are growing high value crops mainly vegetables like tomatoes, onions, cabbage and kales. These intensive agricultural practices are likely to influence high agricultural productivity. Since the agricultural land size is decreasing over the years and the world is urbanizing, intensive agricultural land use practices could be the way to go in the long run.

(b) Crop farming

The study has found out that crop production is more practiced by the landowners with small agricultural land sizes (76%) while extensive livestock production is mostly practiced by farmers with large agricultural land sizes (24%). The average agricultural land holding acreage per household is 34ha, which has been found to be less than adequate to support the current average sized herd of 60 cattle and 101 goats/sheep in the area. Thus, embracing crop farming could be a step in the right direction. It should be encouraged and intensified going forward.

(c) Semi-nomadism

The study has established that most of the farmers/pastoralists with large livestock herds yet their agricultural land is relatively small (78%) are practicing semi-nomadism whereby they move their livestock to areas with pasture and water especially during the dry seasons. It appears that this practice has enabled some farmers to avoid reduced agricultural productivity as their agricultural land size reduces thus escaping tragedy of the spatial anticommons.

Nomadism, in whatever form, may not be a sustainable agricultural practice given the Kenyan land laws that protect private land rights by excluding non-rights holders. Nomadism in the dry agricultural lands is a combination of cultural and economic practice which has led to social conflicts arising from land use conflicts in some parts of Kenya. Reports indicate that Kenyan pastoralists have previously invaded private land, conservancies and urban areas in search of pasture for their livestock, sometimes leading to loss of human lives and livestock. Several media reports in Kenya for example, including Matara (2017), reported that armed herders with over 100,000 cattle, sheep and goats had invaded private land in Laikipia and Isiolo Counties, killing some private landowners, wild animals and destroying property.

Kenyan government has tried to uphold and protect private land rights. In enforcement and protection of private property rights, for example, police shot and killed more than 500 cattle in Laikipia County in a bid to force pastoralists out of private land (Munyeki, 2017). Nomadism, therefore, seem to be incompatible with private land rights and urbanization.

While these illegal private land invasions could be fuelled by claims of historical land injustices and drought, they could also point to the negative effects of subdivision and privatization/enclosure of communal land. In view of this, therefore, nomadism may not be a sustainable agricultural land use in the future.

(d) None and off-farm economic activities

Majority of the respondents (63%) were found to be engaging in off-farm activities whereby 45% were doing small businesses, 12% were formally employed and 5% were informally employed. Only 33% of the respondents were practicing agriculture (crop production at 22% and livestock production at 22%). These off-farm activities have the potential to diversify income sources for the rural communities thus reducing overreliance on agriculture. Given the trends of the agricultural land subdivisions and urbanization in Kenya, these off-farm economic activities should be encouraged in the long run.

(e) Informal regulation of agricultural land subdivisions

The respondents (82%) revealed that the community has formed local committees to manage subdivisions of the agricultural land in the study area. The mandate of the local committees is to discourage the local agricultural landowners to desist subdividing and fencing off their land to enable free movement of livestock.

According to Heller (1998), communities can escape tragedy of the spatial anticommons if they can develop informal local mechanisms to manage anticommon properties even without the formal land management policy intervention. Due to the fact that communities are often not close-knit, however, informal land management strategies eventually fail in the long run (Heller, 1998). In this study, about 12% of the non-farmer landowners were found to have bought land in the study area. It is expected that as agricultural land subdivision and sales continues, this percentage will be increasing over the years hence community cooperation may be reduced, especially where the new private landowners are not practicing similar or agricultural activities. This is an indication that the existing informal land management strategies may not be relied upon to manage agricultural land subdivisions in the long run.

7.4 Second Hypothesis Testing

The second hypothesis for this study was as follows.

Null Hypothesis (H_O) 2: There is no positive correlation between agricultural land size and agricultural productivity in Kajiado County.

Alternative Hypothesis (H_A) 2: There is a positive correlation between agricultural land size and agricultural productivity in Kajiado County.

A correlation analysis between agricultural land size and agricultural productivity of sheep/goats, cattle and maize using Pearson correlation (2-tailed) resulted to negative and weak significant correlation coefficients of; r = - .216, p = 0.002; r = - .195, p = 0.005 and r = -.028, p = 0.002, respectively. The weak inverse association has further been confirmed by the multiple regression coefficients whereby the relationship between sheep/goat and cattle productivity has been determined to be B = - .003, p = 0.000 and B = - .001, p = .009, respectively. The B coefficients associated with maize productivity, and taking only crop land size into account, was found to be 1.247, p = .000. When the total agricultural land size was considered in the MRA model, however, the B coefficient was found to be - .001, p = .679, signifying a negative and weak correlation between the two variables.

The above correlation and beta coefficients prove that there is a weak and negative relationship between agricultural land size and agricultural productivity of sheep/goat, cattle and maize in the study area. Thus, the data collected and analyzed has confirmed that there is no positive correlation between agricultural land size and agricultural productivity in Kajiado County thus supporting the null hypothesis (Ho) 2 and rejecting the alternative hypothesis (HA) 2.

The above finding on the inverse implication of agricultural land subdivision (land size) on the agricultural productivity is similar to several previous studies carried out in New Zealand which have shown that subdivision of agricultural land may lead to a positive change in agricultural productivity. In New Zealand, previous studies have shown that intensification of agricultural production and alternative high value agricultural land uses such as horticulture have led to increased agricultural productivity in arable land (Lawn *et* *al.*, Peacocke, Mears, Meister & Knighton, as cited in Lee, 1999; Kelleher, *et al.*, 1998; Mearns, 1999). It appears the same results are replicable even in dry agricultural lands (see table 8.1).

Similarly, many previous studies in India have also found an inverse relationship between the size of agricultural land and agricultural productivity, whereby as the size of farms decrease, the agricultural productivity increases (Sen, Mazumdar, Khusro, Hanumantha, Saini, Bardhan, Berry, as cited in Chand *et al.*, 2011; Sial *et al.*, 2012). The previous studies have however been carried out in arable agricultural land and not in dry agricultural land, which was the focus of this study. The results however appear to be similar.

The findings of this study regarding the impact of agricultural land subdivision on the agricultural productivity nevertheless contradicts other studies that have found a positive correlation between farm size and agricultural productivity in India (Bhalla & Roy, Chadha, Ghose, as cited in Chand *et al.*, 2011).

The findings of this study thus confirm that there is no universal relationship between agricultural land size and agricultural productivity as Rudra (as cited in Chand et al., 2011) postulated. Besides, the statement holds true in both arable and dry agricultural lands. The findings also confirm that anticommons properties are not necessarily tragic in the short run. In the long run however anticommons properties are likely to become tragic hence the need to put in place formal land administration and management policy interventions before tragedy strikes.

7.5 Chapter Summary

Trends and drivers of agricultural land subdivisions (agricultural land sizes) are likely to influence productivity of the agricultural land. Indeed, the greatest Kenyan and global concern regarding subdivision of agricultural land is about the potential negative impact of subdivisions on the agricultural productivity (GoK, 2010b; 2009; Heller, 1998; Lee, 1999). This chapter has, however, established that the relationship between agricultural land sizes and agricultural productivity in the study area is weak and negative. Agricultural productivity for sheep/goat, cattle and maize decreases with increasing agricultural land sizes, contrary to the general assumption and expectation.

Currently, the private agricultural land parcels (spatial anticommons), therefore, are not tragic in the study area. According to Heller (1998) this scenario may happen in the short or even medium run. It is important to note, however, that even though anticommons properties may not be tragic in the short term, eventually they will be due to existence of transaction costs thus proper land administration and management interventions should be put in place to avoid tragedy in the future. Besides, some of the mechanisms being used by the community to avoid tragedy could be unsustainable in the long run as population and urbanization expand.

The next chapter provides a summary of the main study findings and conclusions. Land administration and management policy interventions and areas of further study are also presented.

CHAPTER EIGHT

SUMMARY OF MAIN FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

The purpose of this study was to create more knowledge on the phenomenon of subdivisions of agricultural land by investigating the trends, drivers and implication of this phenomenon on productivity, the main local and global concern. The hypotheses of this study were two; null hypothesis for hypothesis 1 was that population growth rate is not the most significant driver of agricultural land subdivisions in Kajiado County while its alternative hypothesis was that population growth rate is the most significant driver of agricultural land subdivision in Kajiado County. The null hypothesis for hypothesis 2 was that there is no strong positive correlation between agricultural land size and productivity in Kajiado County while its alternative hypothesis stated that there is a strong positive correlation between agricultural land size and productivity in Kajiado County.

The previous chapters have presented various data and information in accordance to the study's aim/purpose, with the preceding chapters six and seven presenting data analysis and results on the two main objectives of this study: trends and drivers of agricultural land subdivisions and implications of subdivision of agricultural land on productivity, respectively.

This chapter presents a summary of the key findings, conclusions and land administration and management policy interventions necessary to manage the phenomenon of subdivision of agricultural land. The policy interventions are based on the key trends, drivers and implications of agricultural land subdivision on productivity in the study area. Areas of further study are also presented at the end of this chapter.

8.2 Summary of Main Findings

8.2.1 Trends and drivers of agricultural land subdivision

a) Trends of agricultural land subdivision

The trends indicate that the rate of agricultural land subdivision in the study area is at 568ha per annum, over the study 10-year period. The pattern of agricultural land subdivision trends appears to increase over the years peaking in 2013, before establishment of Kajiado County government, and then declining immediately in 2014 and 2015. This trend is further confirmed by the trends of number of applications and consents issued for land subdivisions which increased from 2010 to 2012 then declined from 2013 up to date. The decline could be explained by the extra-legal measures (development moratoria) that the County government of Kajiado put in place immediately after its establishment in 2013 to ban subdivisions of agricultural land, among other land transactions in the County.

The current average agricultural land size per household in the study area is 34.255ha, down from 55.44ha in 2004 and 60.70ha in 2003. The minimum land size per household has also decreased from 1.6ha in 2003 to 0.81ha in 2004 and 0.051ha in 2016. This finding confirms that the average agricultural land size per landowner in the study area is decreasing over the years. Similarly, the average crop land size in the study area has declined from 0.85ha in 2004 to 0.476ha in 2016.

b) Drivers of agricultural land subdivision

The significant drivers of agricultural land subdivision have been identified to be agricultural land inheritance practices ($\overline{X}$ = 3.8, Z = 42.32), individualization of titles ($\overline{X}$ = 3.7, Z = 32.06), price/value of the agricultural land ($\overline{X}$ = 3.2, Z = 30.89), demand for urban housing ($\overline{X}$ = 3.2, Z = 26.54) and future expectations on the value of agricultural land ($\overline{X}$ = 3.2, Z = 25.89). Other important drivers include customary land tenure systems ($\overline{X}$ = 3.2, Z = 22.56), poverty/per capita income ($\overline{X}$ = 3.1, Z = 22.09), price of urban land ($\overline{X}$ = 3.1, Z = 21.67), rural population growth rate ($\overline{X}$ = 3.1, Z = 20.78) and urban population growth rate ($\overline{X}$ = 2.9, Z = 16.52).

Data analysis has thus revealed that the most significant driver of agricultural land subdivision in the study area is land inheritance practices (a socio-cultural factor) with a mean score of $\overline{X}$ = 3.8 and calculated z value of 42.32. Rural population growth rate was ranked ninth with a mean score of $\overline{X}$ = 3.1 and calculated z value of 20.78 while urban population growth rate was ranked tenth with a mean score of $\overline{X}$ = 2.9 and calculated z value of 16.52. Therefore, population growth rate is not the most significant driver of agricultural land subdivisions in Kajiado County. Consequently, the null hypothesis 1 has been supported by the data collected and analyzed while the alternative hypothesis 1 is not supported by the data hence has been rejected.

8.2.2 Implications of agricultural land subdivision on productivity

The results of cross tabulation analysis revealed that agricultural productivity is increasing with decreasing agricultural land sizes, signifying an inverse relationship between the two variables. The agricultural productivity trends show that as the agricultural land sizes increase from 0.05 – 6.07ha plots to over 60.70ha parcels, average agricultural productivity decreases. The average agricultural productivity for goats/sheep, cattle and maize for 0.05 – 6.07ha agricultural plots is 10.03/ha, 7.31/ha and 21.65/ha respectively compared to 1.95/ha, 1.38/ha and 11.34/ha for over 60.70ha agricultural parcels, respectively.

The results of Pearson correlation (2-tailed) analysis has revealed that agricultural land size has a significant weak negative correlation with sheep/goat productivity (r = - .216, p = .002), cattle productivity (r = - .195, p = .005) and maize productivity (r = - .028, p = .002). This means that as agricultural land size decreases, the agricultural productivity of sheep/goat, cattle and maize increases but marginally, and vice versa. This observation confirms the inverse or negative relationship of the two variables observed earlier. Correlation analysis has also revealed the magnitude of the relationship to be weak.

The results of multiple regression analysis on agricultural productivity has produced models shown below. The coefficients of determination (R2) for model predicting goat/sheep, cattle and maize productivity are .497, .421 and .253, respectively. In all the models, at 95% confidence level, agricultural land size is a significant variable at .009, .000 and .000, respectively. The purpose of the models is to show the relative contribution and relationship between agricultural land subdivision (as measured in land sizes) and agricultural productivity (measured in goat/sheep, cattle and maize productivity).

1. **Goats /sheep productivity = - .398 – [.003 Land size] – [.030 Land fertility] – [2.349E - 8 Land value] + [.493 No. of adult family members] + [.046 Level of education of landowner] – [.028 Age of landowner] – [.003 Off-farm income] + [.000 Farm income].**

2. **Cattle productivity = - .137 – [.001 Land size] + [.101 Land fertility] + [2.959E - 8 Land value] + [.242 No. of adult family members] - [.014 Level of education of farmer] – [.048 Age of landowner] – [.018 Off-farm income] - [.004 Farm income].**

3. **Maize productivity = .699 + [1.247 Land size] + [.160 Land fertility] + [3.012E - 7 Land value] + [.418 No. of adult family members] - [.223 Level of education of farmer] - [.016 Age of landowner] – [.109 Off-farm income] + [.115 Farm income].**

Regression results thus indicate that the relative contribution and association between agricultural land size and sheep/goat and cattle productivity is B = - .003, p = 0.000 and B = - .001, p = .009, respectively. The t-values corresponding to these variables are – 4.684 and – 2.656, respectively. The B coefficients associated with maize productivity, and taking only crop land size into account, was found to be 1.247, p = .000. When the total agricultural land size was considered in the MRA model, however, the B coefficient was found to be - .001, p = .679, t = -.414, signifying a negative and weak correlation between the two variables.

The above correlation and beta coefficients prove that there is a weak and negative relationship between agricultural land size and agricultural productivity of sheep/goat, cattle and maize in the study area. Thus, the data collected and analyzed has confirmed that there is no positive correlation between agricultural land size and agricultural productivity in Kajiado County thus supporting the null hypothesis 2 and rejecting the alternative hypothesis 2.

The results of multiple regression analysis on agricultural land sizes has produced the model shown below. The coefficient of determination (R2) for model predicting agricultural land size is .639. At 95% confidence level, all the variables are significant at < 0.05.

Agricultural Land Size = 77.885 + [.602 Cattle Production] + [.144 Maize Production] - [13.576 No. of adult family members] + [.354 Goat/Sheep Production] - [5.222E-6 Land value]

Therefore, an increase in agricultural production (maize, cattle, goat/sheep) would lead to an increase in agricultural land sizes. On the contrary, an increase in number of family members and value of agricultural land would lead to a decrease in agricultural land sizes, and vice versa. These factors thus are important in determining economical agricultural land sizes in Kenya.

8.3 Conclusions

The pattern of agricultural land subdivision trends appears to increase over the years but decline after immediately establishment of Kajiado County government in 2013. The trends of number of applications for agricultural land subdivisions and consents issued have supported this observation. This shows the influence of policies formulated by county governments in administration and management of agricultural land in their areas of jurisdiction. The findings indicate that subdivisions of agricultural land (as measured in agricultural land sizes) are likely to be perpetuated by the old and less educated landowners with less income and more family members/dependants. Socio-economic characteristics of agricultural landowners are therefore important in influencing rate of subdivision of agricultural land.

Using the mean scores and z-test, the significant drivers influencing subdivision of agricultural land in the study area have been determined to be; agricultural land inheritance practices, individualization of titles, value of agricultural land, demand for urban housing and future expectation on the value of agricultural land. Other important factors include customary land tenure systems, income of the agricultural landowners, price/value of urban land, rural population growth rate and urban population growth rate.

The study concludes that contrary to the popular assumption, population growth rate is not the most significant driver of subdivision of agricultural land in the study area. Neoliberalism theory therefore appears to explain the phenomenon of agricultural land subdivision in the study area.

By use of cross tabulation, correlation and regression analysis, it has been shown that there is no strong positive relationship between agricultural land sizes and agricultural productivity in the study area. The study, therefore, concludes that there is a weak and negative correlation between agricultural land size and productivity.

Therefore, there is no negative impact of subdivision of agricultural land on productivity at the moment. The inverse relationship between agricultural land size and agricultural productivity however may mislead the agricultural landowners to believe that subdivision of agricultural land is harmless. Indeed, anticommons property may not be tragic in the short or even medium term but they will eventually be in the long term. There is thus need to put in place effective policy interventions before tragedy strikes.

8.4 Policy Recommendations

(a) Measures to control agricultural land inheritance practices

Agricultural land inheritance practices was cited as the most important driver of subdivision of agricultural land. Currently, the impact of subdivision of agricultural land on productivity however is weak and negative. In order to reduce the impact of agricultural land inheritance practices, this study recommends the following measures;

(i) The County Government of Kajiado should encourage agricultural landowners in the County to adopt intensive and modern land use practices such as zero grazing, mixed cropping, use of more variable inputs, high value crops and irrigation. These agricultural practices were noted to influence agricultural production and productivity in a positive manner. In addition, agricultural production has been determined to be positively correlated to land size in the study area.

(ii) The county and national government should improve access to formal education of the rural population in Kenya since the study found that educated farmers are less likely to engage in agricultural land subdivision practices and are more likely to practice intensive agricultural land uses thus increasing productivity.

(iii) The County Government of Kajiado should educate and sensitize agricultural landowners in the County on the potential effects of subdivision of agricultural land into small/uneconomic sizes (tragedy of spatial anticommons) hence discourage landowners from unproductive and unsustainable transformation of agricultural land. Education of landowners has been noted to be a significant socioeconomic variable in influencing subdivision of agricultural land.

(iv) The national and county governments should put in place appropriate and clear policy, legal and institutional frameworks to prescribe allowable minimum economical/optimal agricultural land sizes in various agro climatic zones in Kenya. The minimum agricultural land sizes should be based on a scientific study.

(b) Measures to address individualization of titles

(i) Individualization of titles was cited as the second most significant driver of agricultural land subdivisions. Since it is difficult and unnecessary to reverse agricultural land privatization trends, in any case it is assumed to be a cure of the tragedy of the commons and it fosters economic development, individual titles should have restrictions on the minimum allowable sizes depending on the location and use of the land. Where agricultural land is used for extensive livestock production system, for example, large tracts should be encouraged unless and until the owner wants to change the user. The legal framework for physical planning and registration of land in Kenya such as the Land Registration Act and the Physical Planning Act should thus make it mandatory that allowable minimum agricultural land sizes are adhered to before registration of new titles.

(ii) Where agricultural land has been subdivided to the minimum allowable size, fractional ownership (legal subdivision), as is the case in Rwanda, should be encouraged as opposed to physical subdivision to avoid possible negative impact on productivity.

(iii) The county and national government should encourage farmers with small land sizes to consolidate their parcels for efficient and economical agricultural production. The resultant large parcels could then be owned in fractional basis. The affected households should then be settled in one area to free up their small parcels for economical joint production.

(c) Measures to address value of agricultural land

(i) Government and private sector should support agricultural enterprises, including livestock production to make agricultural activities economically viable and competitive to reduce the influence of attractive agricultural land prices, the third most significant driver of agricultural land subdivisions. This policy measure would in turn raise the income of the landowners and help them invest in agricultural production. The study has shown that income of agricultural landowners and value of agricultural land are important factors influencing subdivisions/agricultural land sizes.

(ii) Appropriate property taxation policies should also be used to discourage speculation on agricultural land. This intervention would discourage idle agricultural land thus avoiding land fragmentation. The allowable minimum economical agricultural land sizes in various agro climatic zones would also go a long way in this endeavor.

(d) Model on policy guidelines on agricultural land subdivision

This study has shown that optimal/minimum agricultural land sizes are likely to be influenced by many factors thus would require a multidisciplinary approach to determine appropriate economical sizes in a particular locality. Therefore, it would be difficult to determine optimal/economic land sizes or one-size-fits-all minimum sizes based on land economics perspective. Some of the significant factors however are summarised in the model below and could help policy makers to put in place appropriate measures to tackle the problem of subdivision of agricultural land. Increasing agricultural production is likely to influence agricultural land sizes positively (reduce subdivision of agricultural land).

Agricultural Land Size = 77.885 + [.602 Cattle Production] + [.144 Maize Production] - [13.576 No. of adult family members] + [.354 Goat/Sheep Production] - [5.222E-6 Land value]

The county and national governments should therefore consider size of agricultural production, size of households and value of agricultural land in determining optimal/economical agricultural land sizes for various agro climatic zones in Kenya.

(e) Other measures

Demand for urban housing was ranked the fourth most significant driver of subdivision of agricultural land. The following policy interventions should be adopted to tackle this driver;

(i) Government should encourage and support urban renewal/revitalization strategies and urban land banking as means of providing urban housing within the urban areas. This policy will reduce the influence of demand for urban housing and price of urban land on the agricultural land subdivisions.

(ii) Government may provide affordable urban housing and/or subsidize the cost of housing in the urban areas by creating enabling environment for private sector involvement in low cost housing. Agricultural land earmarked for urban expansion should only be developed once basic services are provided.

(iii) Public facilities requirement ordinances may also go a long way in providing urban housing. Critical agricultural land resource should however be protected at all times from uneconomical subdivisions and/or conversion into other users.

8.5 Areas of Further Study

The study has not covered some important aspects regarding subdivision of agricultural land and its implications on productivity especially due to limitation of resources such as funds and time. Besides, these aspects require a multidisciplinary approach. The following further areas of study are therefore recommended.

(a) A scientific study on the minimum/economical agricultural land sizes for various agro-climatic zones per administrative wards in Kenya.

(b) A scientific study on the maximum agricultural land carrying capacity of livestock for various agro-climatic zones per administrative wards in Kenya.

(c) A scientific study/experiment to determine maximum agricultural land productivity (using maximum inputs and technology) for various agro-climatic zones per administrative wards in Kenya.

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APPENDICES

Appendix 1: Questionnaire to agricultural landowners

PREAMBLE

This questionnaire is in aid of a research thesis being conducted by Erastus K. Museleku, a PhD candidate (in Land Economics) in the Department of Real Estate and Construction Management, School of the Built Environment, University of Nairobi. The research is examining trends, drivers and implication of agricultural land subdivisions into small sizes on agricultural productivity using a **Case of Kitengela Division, Kajiado County.**

The information sought here is for academic purposes and will be treated with utmost confidentiality.

SECTION I: SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

No.	**Questions**	**Responses/Codes/Filters (Please tick appropriately)**	**Remarks**
Q1.	Name of agricultural landowner (**Optional)**		
Q2.	Name of Village		
Q3.	Name of sub-location		
Q4.	Age in years	1. 20 – 30 years 2. 31 - 40 years 3. 41 – 50 years 4. 51 – 60 years 5. Over 60 years	
Q5.	Gender	1. Male 2. Female	
Q6.	Highest level of education completed	1. University degree/postgraduate 2. Diploma 3. Certificate 4. Secondary 5. Primary 6. None 7. Others (Specify)	

Q7.	Number of your family members who are above 18 years of age.		
Q8.	Occupation	1. Subsistence Farmer 2. Pastoralist 3. Employed (Formal) 4. Employed (Informal) 5. Unemployed 6. Business 7. Home Maker 8. Others (Specify)	
Q9.	How long have you lived here?	1. Less than 1 year 2. 1 to 5 years 3. 6 to 10 years 4. 11 to 15 years 5. 16 to 20 years 6. 21 to 25 years 7. 26 to 30 years 8. Over 31 years	
Q10.	Which County did you live in before you came to settle here?	1. Nairobi 2. Kiambu 3. Machakos 4. Kajiado 5. Others (specify)	
SECTION II: EXTENT OF AGRICULTURAL LAND TRANSFORMATION			
Q11.	What is the size of your agricultural land currently (**in Ha or acres**)		
Q12.	What is the approximate size of your agricultural land under crop production (**in Ha/acres**)?		

<table>
<tr><td colspan="6">SECTION III: DRIVERS OF RURAL LAND TRANSFORMATION</td></tr>
<tr><td>Q13.</td><td>How would you describe your agricultural land in terms of fertility?</td><td colspan="3">1. Highly fertile
2. Average fertility
3. Infertile
4. Others (specify)</td><td></td></tr>
<tr><td>Q14.</td><td>What is the topography of your agricultural land?</td><td colspan="3">1. Level
2. Sloppy
3. Undulating/rising & falling
4. Others (specify)</td><td></td></tr>
<tr><td>Q15.</td><td>How far in kilometers are the following services from your agricultural land?</td><td colspan="3">1. Water point
2. Murram roads
3. Tarmacked roads
4. Electricity</td><td></td></tr>
<tr><td>Q16.</td><td>What is your average income per year?</td><td colspan="3">1. Kshs. 0 – 50,000/-
2. Kshs. 51,000 – 100,000/-
3. Kshs. 101,000 – 150,000/-
4. Kshs. 151,000 – 200,000/-
5. Kshs. 201,000 – 250,000/-
6. Kshs. 251,000 – 300,000/-
7. Kshs. 301,000 – 350,000/-
8. Kshs. 351,000 – 400,000/-
9. Kshs. 401,000 – 450,000/-
10. Kshs. 451,000 – 500,000/-
11. Over Kshs. 500,000/-</td><td></td></tr>
<tr><td>Q17.</td><td>On average, what is the value of one acre of your agricultural land in this area?</td><td colspan="3"></td><td></td></tr>
<tr><td>Q18.</td><td>How would you rate the demand for agricultural land in this village for development of urban housing?</td><td colspan="3">1. High demand
2. Average demand
3. Low demand</td><td></td></tr>
<tr><td rowspan="3">Q19.</td><td rowspan="3">On average, how many bags of maize and/or number of livestock do you normally produce per year?</td><td>Maize (No. of 90kg bags)</td><td>Cattle (No. of heads)</td><td colspan="2">Goats/sheep (No. of heads)</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="4">Other production (specify)</td></tr>
<tr><td>Q20.</td><td>How would you rate the demand for agricultural products (e.g. beef, milk) in this area?</td><td colspan="4">1. High demand
2. Average demand
3. Low demand</td></tr>
</table>

Q21.	How would you rate the availability of agricultural finance/capital/credit to farmers in this area?	1. Highly available 2. Moderately available 3. Not available 4. Others (specify)	
Q22.	What are your expectations on the value of your land in the future?	1. Higher value 2. Same value/No change in value 3. Lower value 4. Other expectations(specify)	
Q23.	Do you participate in agricultural/rural land subdivision processes?	1. Yes 2. No	
Q24.	If your answer to **Q23** above is No, please explain your answer?		
Q25.	How did you acquire your agricultural land in this area?	1. Subdivision of group ranches 2. Inheritance/gift from relatives 3. Purchase 4. Gift from government/friends 5. Others (specify)	
Q26.	Do you agree that people have accepted to sell their agricultural land in this Village?	1. Yes 2. No	
Q27.	Is your agricultural land registered/Does your land have a title deed?	1. Yes 2. No	
Q28.	If your agricultural land is registered, under whose name is it registered?	1. Husband 2. Wife 3. Male Children 4. Female children 5. Community 6. Other people (specify)	
Q29.	What is your average income per year from the agricultural activities?	1. Kshs. 0 – 20,000/- 2. Kshs. 21,000 – 40,000/- 3. Kshs. 41,000 – 60,000/- 4. Kshs. 61,000 – 80,000/- 5. Kshs. 81,000 – 100,000/- 6. Kshs. 101,000 – 120,000/- 7. Kshs. 121,000 – 140,000/- 8. Kshs. 141,000 – 160,000/- 9. Kshs. 161,000 – 180,000/- 10. Kshs. 181,000 – 200,000/- 11. Over Kshs. 200,000/-	
Q30.	What is your average	1. Kshs. 0 – 20,000/-	

<table>
<tr><td></td><td>income from non and off-farm activities (e.g. rental income, income from business, employment etc.) per year?</td><td colspan="3">2. Kshs. 21,000 – 40,000/-
3. Kshs. 41,000 – 60,000/-
4. Kshs. 61,000 – 80,000/-
5. Kshs. 81,000 – 100,000/-
6. Kshs. 101,000 – 120,000/-
7. Kshs. 121,000 – 140,000/-
8. Kshs. 141,000 – 160,000/-
9. Kshs. 161,000 – 180,000/-
10. Kshs. 181,000 – 200,000/-
11. Over Kshs. 200,000/-</td><td></td></tr>
<tr><td>Q31.</td><td>Have you ever subdivided your agricultural land in this area?</td><td colspan="3">1. Yes
2. No</td><td></td></tr>
<tr><td>Q32.</td><td>If your answer to Q31 above is yes, please provide the following information</td><td colspan="3">1. Year(s) land was subdivided……………………

2. Size of the land subdivided……….…………….

3. Size of land subdivided and sold off……………</td><td></td></tr>
<tr><td rowspan="3">Q33.</td><td rowspan="3">If your answer to Q31 above is yes, on average, how many bags of maize and/or number of livestock did you normally produce per year before subdivision of your agricultural land?</td><td>Maize (No. of 90kg bags)</td><td>Cattle (No. of heads)</td><td>Goats/sheep (No. of heads)</td><td rowspan="3"></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Other production (specify)</td><td></td><td></td></tr>
<tr><td>Q34.</td><td>Which of the following drivers/factors influenced your decision to subdivide your agricultural land?

(You may tick several drivers/factors).</td><td colspan="3">1. Quality/fertility of rural land
2. Topography
3. Proximity of rural land to services
4. Rainfall
5. Temperature
6. Poverty/Per capita income
7. Price of the rural land
8. Price of urban land
9. Demand for urban housing</td><td></td></tr>
</table>

		10. Low income from agricultural activities 11. Low demand for agricultural products (meat, milk etc.) 12. Non and off farm income 13. Cost of agricultural finance/interest rates 14. Availability of agricultural finance/credit/capital 15. Supply of rural land 16. Future expectations on value of rural land 17. Urban population growth rate 18. Local/rural population growth rate 19. Lack of public participation in land development decision making 20. Lack of local land institutional technical capacity 21. Land inheritance practices 22. Commodification of land (acceptance to sell land and homes) 23. Customary land tenure systems (men owning land on behalf of the family) 24. Individualization of titles 25. Lack of rural land use policies and laws 26. Others (specify)…………………………………………	

		Driver/Factor	**(1)**	**(2)**	**(3)**	**(4)**
Q35.	Among the following drivers/factors, select and rank the ones which are likely to influence agricultural landowners in this area to subdivide agricultural land into small sizes. Rank the drivers/factors in a scale of 1, 2, 3 and 4 (tick where applicable). **KEY:** **1= NOT IMPORTANT;** **2= LESS IMPORTANT;** **3= IMPORTANT;** **4= VERY IMPORTANT.**	1. Quality/fertility of rural land				
		2. Topography				
		3. Proximity of rural land to services e.g. water, electricity and roads.				
		4. Rainfall				
		5. Temperature				
		6. Poverty/Per capita income				
		7. Price of the rural land				
		8. Price of urban land				
		9. Demand for urban housing				
		10. Low income from agricultural activities				
		11. Low demand for agricultural products				
		12. Non and off farm income				
		13. Cost of agricultural finance/interest rates				

		14. Availability of agricultural finance/credit/capital				
		15. Supply of rural land				
		16. Future expectations on value of rural land				
		17. Urban population growth rate				
		18. Local/rural population growth rate				
		19. Lack of public participation in rural land development decision making				
		20. Lack of local land institutional technical capacity				
		21. Land inheritance practices				
		22. Commodification of rural land (acceptance to sell land and homes)				
		23. Customary land tenure systems (men owning land on behalf of the family)				
		24. Individualization of titles				
		25. Lack of rural land use policies and laws				
		26. Others (specify)…………………………				
Q36.	If you have other comments in regard to the issue of agricultural land subdivisions into small sizes in this area, please state in the space provided.					

Thank you for your participation.

Erastus K. Museleku

MA (Valuation & Property Management); BA (Land Economics); RV; REA; MISK

Appendix 2: Estimated/proposed Minimum and Maximum Land Holding Acreages per Household in Kenya

COUNTY NAME	AREA (Ha)	No. of Households	Max. Land Size (ACZ I-III)	Min. Land Size (ACZ I-III)	Max. Land Size (ACZ IV)	Min. Land Size (ACZ IV)	Max. Land Size (ACZ V)	Min. Land Size (ACZ V)	Max. Land Size (ACZ VI-VII)	Min. Land Size (ACZ VI-VII)	Max. Land Size /Household
Nairobi	70,804.9	985,016	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mombasa	28,564.4	268,700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vihiga	56,301.9	123,347	0.46	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Kisii	132,112	245,029	0.54	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.54
Nyamira	90,095.7	131,039	0.69	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Kakamega	302,258	355,679	0.85	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Bungoma	303,179	270,824	1.12	0.76	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Trans Nzoia	249,557	170,117	1.47	0.93	0.00	0.00	0.00	0.00	0.00	0.00	1.47
Uasin-Gishu	340,769	202,291	1.68	1.04	0.00	0.00	0.00	0.00	0.00	0.00	1.68
Nandi	284,623	154,073	1.85	1.12	0.00	0.00	0.00	0.00	0.00	0.00	1.85
Bomet	270,369	142,361	1.90	1.15	0.00	0.00	0.00	0.00	0.00	0.00	1.9
Busia	182,356	154,225	1.11	0.75	0.07	0.45	0.00	0.00	0.00	0.00	1.18
Murang'a	252,651	255,696	0.88	0.64	0.11	0.47	0.00	0.00	0.00	0.00	0.99

Nyandarua	327,035	143,871	2.02	1.21	0.25	0.54	0.00	0.00	0.00	0.00	2.27
Siaya	354,217	199,034	1.35	0.87	0.43	0.63	0.00	0.00	0.00	0.00	1.78
Kirinyaga	147,531	154,220	0.79	0.59	0.15	0.49	0.01	0.53	0.00	0.00	0.96
Kericho	226,790	160,134	1.37	0.88	0.00	0.00	0.04	0.54	0.00	0.00	1.42
Nyeri	333,625	201,703	1.24	0.82	0.36	0.60	0.05	0.55	0.00	0.00	1.65
Kiambu	254,474	469,244	0.40	0.4	0.09	0.46	0.05	0.55	0.00	0.00	0.54
Nakuru	748,923	409,836	1.17	0.78	0.29	0.56	0.37	0.71	0.00	0.00	1.83
Migori	316,459	180,211	1.23	0.81	0.14	0.49	0.39	0.72	0.00	0.00	1.76
Kisumu	267,695	226,719	0.71	0.55	0.00	0.00	0.47	0.76	0.00	0.00	1.18
Elgeyo-Marakwet	301,807	77,555	2.69	1.54	0.66	0.75	0.54	0.79	0.00	0.00	3.89
Homa Bay	375,968	206,255	0.87	0.63	0.29	0.56	0.66	0.85	0.00	0.00	1.82
Meru	699,041	319,616	1.14	0.77	0.26	0.55	0.79	0.92	0.00	0.00	2.19
Embu	282,316	131,683	0.71	0.55	0.62	0.73	0.81	0.93	0.00	0.00	2.14
Tharaka-Nithi	258,009	88,803	0.99	0.69	0.99	0.91	0.93	0.99	0.00	0.00	2.91
Machakos	604,407	264,500	0.09	0.24	0.34	0.59	1.85	1.45	0.00	0.00	2.29
Narok	1,794,210	169,220	4.88	2.64	3.60	2.22	2.12	1.58	0.00	0.00	10.6
Makueni	817,238	186,478	0.22	0.31	0.88	0.86	3.29	2.17	0.00	0.00	4.38
Kilifi	1,252,390	199,764	0.31	0.35	1.44	1.14	4.26	2.65	0.00	0.00	6.27
West Pokot	933,815	93,777	2.39	1.39	3.29	2.06	4.38	2.71	0.00	0.00	9.96

Kwale	826,381	122,047	1.15	0.77	0.88	0.86	4.81	2.93	0.00	0.00	6.77
Baringo	1,091,200	110,649	1.97	1.18	1.48	1.16	4.83	2.94	0.00	0.00	9.86
Laikipia	954,391	103,114	0.74	0.57	1.20	1.02	7.4	4.22	0.00	0.00	9.26
Kajiado	**2,189,800**	**173,464**	**0.13**	**0.26**	**0.76**	**0.80**	**11.74**	**6.39**	**0.00**	**0.00**	**12.62**
Taita Taveta	1,711,820	71,090	0.24	0.32	0.48	0.66	19.26	10.15	4.09	3.625	24.08
Lamu	618,509	22,184	0.00	0.00	6.41	3.62	21.47	11.26	0.00	0.00	27.88
Tana River	3,915,380	47,414	0.00	0.00	2.48	1.66	27.25	14.15	52.85	28.005	82.58
Samburu	2,102,390	47,354	8.88	4.64	4.00	2.42	31.52	16.28	0.00	0.00	44.4
Kitui	3,043,660	205,491	0.15	0.27	0.59	0.71	13.33	7.19	0.74	1.95	14.81
Mandera	2,598,280	125,497	0.00	0.00	0.00	0.00	1.24	1.14	19.46	11.31	20.70
Garissa	4,359,120	98,590	0.00	0.00	0.00	0.00	18.13	9.59	26.09	14.625	44.21
Turkana	7,035,790	123,191	0.00	0.00	0.00	0.00	19.42	10.23	37.69	20.425	57.11
Isiolo	2,538,190	31,326	0.00	0.00	0.00	0.00	23.5	12.27	57.53	30.345	81.03
Wajir	5,664,910	88,574	0.00	0.00	0.00	0.00	1.28	1.16	62.68	32.92	63.96
Marsabit	7603,070	56,941	0.00	0.00	0.00	0.00	17.36	10.30	116.17	59.665	133.53

Source: Syagga and Kimuyu, 2016

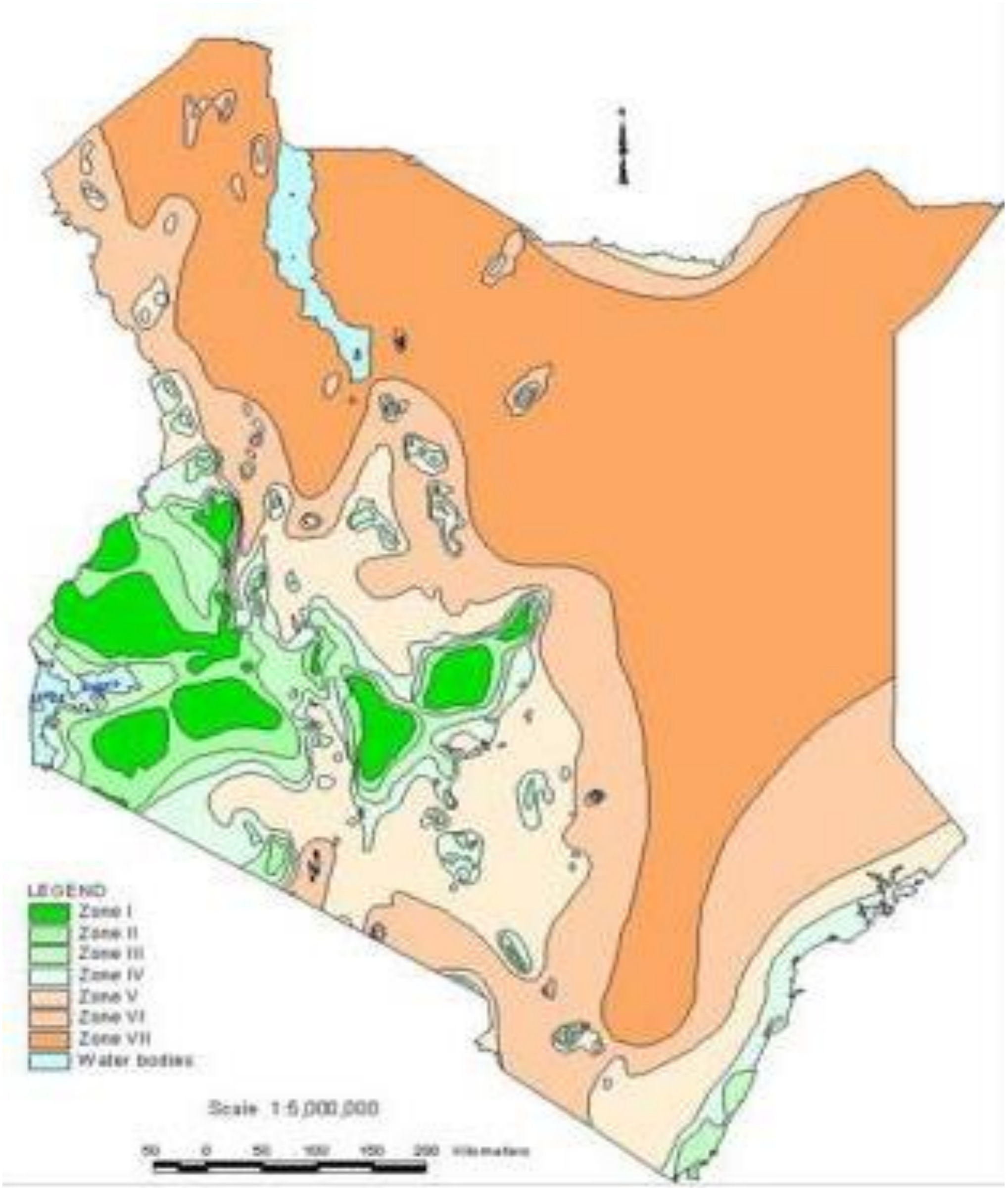
Appendix 3: Relative Percentage of Agro-Climatic Zones Coverage per County in Kenya

COUNTY	ACZ I-III (%)	ACZ IV (%)	ACZ V (%)	ACZ VI_VII (%)
Nairobi	0	0	0	0
Mombasa	0	0	0	0
Vihiga	100	0	0	0
Kisii	100	0	0	0
Nyamira	100	0	0	0
Kakamega	100	0	0	0
Bungoma	100	0	0	0
Trans Nzoia	100	0	0	0
Uasin-Gishu	100	0	0	0
Nandi	100	0	0	0
Bomet	100	0	0	0
Busia	94	6	0	0
Murang'a	89	11	0	0
Nyandarua	89	11	0	0
Siaya	76	24	0	0
Kirinyaga	83	16	1	0
Kericho	97	0	3	0
Nyeri	75	22	3	0
Kiambu	73	17	10	0
Nakuru	64	16	20	0
Migori	70	8	22	0
Kisumu	60	0	40	0
Elgeyo-Marakwet	69	17	14	0

Homa Bay	48	16	36	0
Meru	52	12	36	0
Embu	33	29	38	0
Tharaka-Nithi	34	34	32	0
Machakos	4	15	81	0
Narok	46	34	20	0
Makueni	5	20	75	0
Kilifi	5	23	68	0
West Pokot	24	33	44	0
Kwale	17	13	71	0
Baringo	20	15	49	0
Laikipia	8	13	80	0
Kajiado	**1**	**6**	**93**	**0**
TaitaTaveta	1	2	80	17
Lamu	0	23	77	0
Tana River	0	3	33	64
Samburu	20	9	71	0
Kitui	1	4	90	5
Mandera	0	0	6	94
Garissa	0	0	41	59
Turkana	0	0	34	66
Isiolo	0	0	29	71
Wajir	0	0	2	98
Marsabit	0	0	13	87

Source: GoK, 2015

Appendix 4: The Agro-Climatic Zones Map of Kenya



Source: FAO, 1996

Appendix 5: Kenya's Agro-Climatic Zones and Maize Productivity

Agro-Climatic Zone (ACZ)	Classification	Moisture Zone (%)	Annual Rainfall (mm)	Maize production 90kg bags/ha	Maize production Kg/ha
I	Humid	>80	1100 – 2 700	20.5	1593
II	Sub-Humid	65 – 80	1000 – 1 600	18.5	
III	Semi-Humid	50 – 65	800 – 1 400	14.1	
IV	Semi-Humid to Semi-Arid	40 – 50	600 – 1 100	8.4	756
V	**Semi-Arid**	**25 – 40**	**450 – 900**	**6.7**	**603**
VI	**Arid**	**15 – 25**	**300 – 550**	**2.2**	**198**
VII	**Very Arid**	**<15**	**150 – 350**		

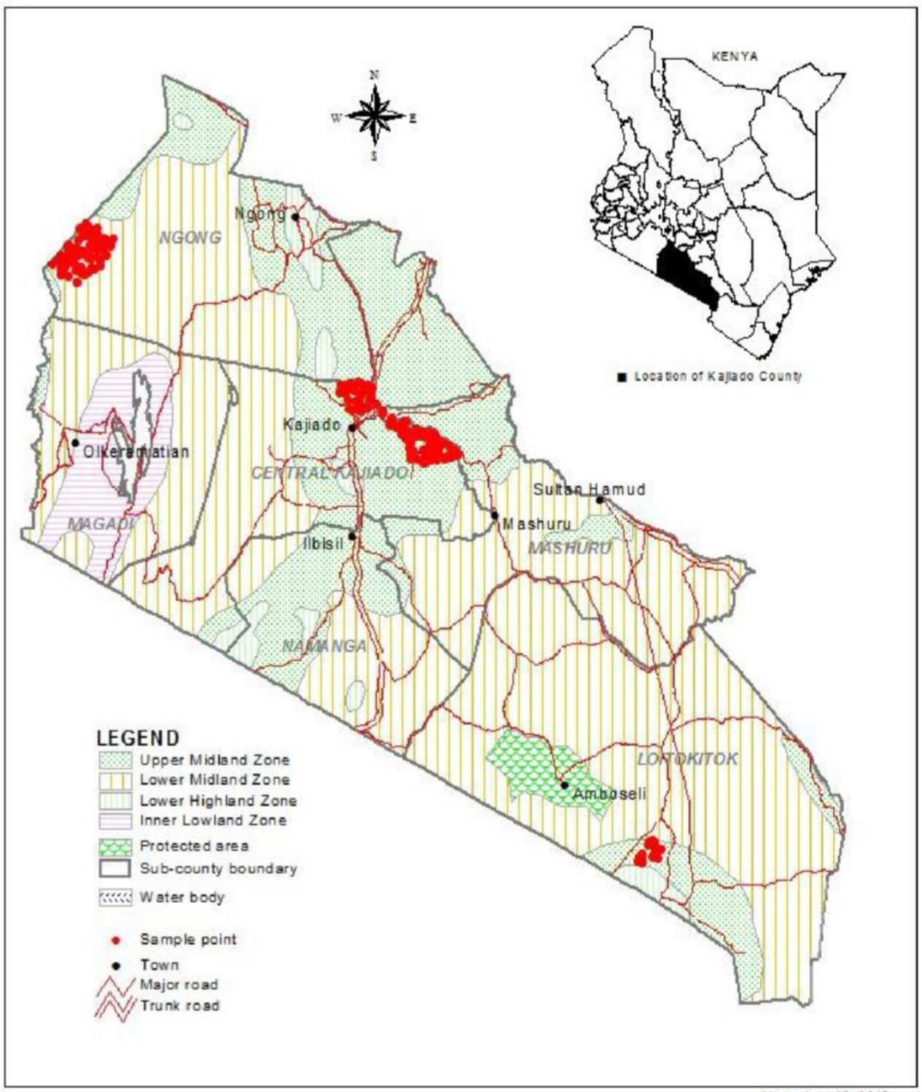
Source: FAO, 2006

Appendix 6: Amount of Rainfall Received in the Study Area

AMOUNT OF RAINFALL OVER THE YEARS													Total amount of rainfall per year
Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
2000	13.4	0.0	18.5	74.8	18.7	26.9	1.0	1.4	8.0	11.6	113.4	37.4	**325.1**
2001	275.4	10.7	122.1	67.8	38.6	13.7	19.9	14.3	3.7	33.6	197.7	15.9	**813.4**
2002	57.6	15.1	99.1	151.9	158.9	1.6	0.2	3.9	54.5	48.7	115.1	331.2	**1037.8**
2003	16.9	9.5	22.1	154.6	234.8	6.8	1.6	47.8	17.8	52.3	119.8	24.3	**708.3**
2004	95.3	76.2	93.3	137.6	57.9	10.7	0.0	0.6	26.5	65.3	123.5	81.4	**768.3**
2005	36.7	1.4	46.3	130.2	89.5	3.6		3.4	9.1	6.6	65.5	1.2	**393.5**
2006	6.3	38.0	124.5	222.9	98.6	0.2	0.0	27.8	5.5	19.2	232.6	204.2	**979.8**
2007	83.4	18.2	35.8	195.7	52.8	27.2	28.0	12.0	19.6	23.7	95.0	36.4	**627.8**
2008	40.5	2.8	134.6	81	4.7	0.5	27.2	3.2	32.2	100	82.6	0.1	**509.4**
2009	52.4	1.9	27.1	84.5	140.0	33.7	5	0.6	2.3	60.4	45.5	112.5	**565.9**
2010	54.0	71.2	133.1	37.2	73.0	23.1	1.3	6.6	8.0	34.9	77.9	55.7	**576.0**
2011	1.8	53.6	91.1	17.8	45.0	29.6	2.9	42.2	27.8	47.4	249.6	29.1	**637.9**
2012	0.0	3.4	4.2	281.7	195.6	32.2	13.4	4.1	36.8	60.9	58.6	194.5	**885.4**
2013	34.7	1.4	133.7	237.4	11.7	39.3	8.0	33.3	36.3	4.6	88.7	190.1	**819.2**
2014	5.0	73.5	92.3	36.4	21.9	43.6	6.1	59.0	2.2	60.2	72.5	49.2	**521.9**
2015	2.8	38.7	17.5	170.5	120.5	116.7	8.7	2.2	6.4	47.1	229.7	176.8	**937.6**
2016	119.7	40.0	34.2	137.4	116.1	22.3	0.0	8.3	0.9	35.1	163.9	18.3	**696.2**

Source: Kenya Meteorological Department, 2017

Appendix 7: Map of Kenya showing location of Kajiado County



Source: Government of Kenya, 2014b

Appendix 8: Google Image of the Study Area - 2006

Appendix 9: Google Image of the Study Area - 2015


9845000 m
9840000 m
9835000 m
9830000 m
9825000 m
245000 m
250000 m
270000 m
275000 m
0.0 km
1.0 km
2.0 km
3.0 km
4.0 km


9845000 m
9840000 m
9835000 m
9830000 m
9825000 m
245000 m
250000 m
255000 m
260000 m
270000 m
275000 m
Image © 2017 DigitalGlobe
Image © 2017 CNES / Airbus
0.0 km
1.0 km
2.0 km
3.0 km
4.0 km