Land and Natural Resources Degradation in the Arid and Semi-Arid Lands in Kenya

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Land and natural resources degradation in the Arid and Semi-Arid Lands, Kenya

Technical Report

Client

World Bank

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF ABBREVIATIONS

AOI	Area of Interest
ASAL	Arid and Semi-Arid Lands
AWM	Agriculture Water Management
CBA	Cost-Benefit Analysis
CBO	Community-based organization
CIAT	The International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CPAs	Charcoal Producer Associations
ENPV	Economic Net Present Value
FMNR	Farmer-Managed Natural Regeneration
FNPV	Financial Net Present Value
GDP	Gross Domestic Product
GoK	Government of Kenya
ha	Hectare
IBLI	Index-Based Livestock Insurance
ICRAF	The World Agroforestry Center
ICRISAT	The International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technologies
IFPRI	International Food Policy Research Institute
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
IRR	Internal Rate of Return
ISFM	Integrated Soil Fertility Management
IWDM	Integrated Watershed Development and Management
KCC	Kenya Cooperative Creameries Ltd
KEFRI	Kenya Forestry Research Institute
KLDP	Kenya Livestock Development Program
km2	Square Kilometer
KNAIS	Kenya National Artificial Insemination
LUCC	Land Use-Cover Change
m	Meter
MEA	Millennium Ecosystem assessment
MENR	Ministry of Environment and Natural Resources
MRR	Marginal Rate of Return
NDVI	Normalized Difference Vegetation Index
NEDI	North-Northeastern Development Initiatives
NGO	Non-Governmental Organizations
NPV	Net Present Value
NTFP	Non-Timber Forest Products
PES	Payment for Ecosystem Services
r	Discount Factor
RPLRP	Regional Pastoral Livelihoods Resilience Project

RWHM	Rainwater Harvesting and Management
SLM	Sustainable Land Management
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Units
USA	United States of America
WRI	World Resources Institute

1 INTRODUCTION

Land degradation is severe in Kenya due to deforestation and land use cover change (LUCC) which replaces high value biomes with low-value biomes. Due to deforestation and charcoal-making, Kenya lost 12,400 ha of forest from 1990-2015. Deforestation is especially severe in the Rift Valley (Baker and Miller 2013). The closed canopy forest – which covered approximately 12% of the land area – has been reduced to only 1.7% of its original size (GOK 2010). Excluding charcoal and other subsistence uses, Kenya's forests account for 3.6% to Kenya's GDP and support agriculture, livestock, energy, trade, and other industries – which cumulatively contribute about 39% of the GDP. Forests comprise the country's water towers and catchments where over three quarters of the renewable surface water originates (GoK 2014). Conversion of grasslands and shrublands to cropland has also occurred in many provinces – leading to 16% of cropland expansion from 1990-2015. On static biomes – i.e., biomes which did not experience LUCC, use of land degrading management practices has led to reduced productivity of cropland and grazing lands.

Over 80% of Kenya's total land area is classified as arid and semi-arid land (ASAL) and is considered being at risk of desertification. The ASAL region is home to about 30% of Kenya's human and 50% of its livestock population. 90% of the total meat consumed in the country comes from the ASAL (GoK 2010). The livestock sector in the ASAL employs 10 million people – which is 90% of the adult labor force and accounts for 95% of household income (GoK 2010). Overgrazing in the ASAL region (Mwaura et al 2017) is due mainly to the rapidly increasing livestock population. While grassland areas declined, the number of heads of cattle almost doubled from 14 million in 1990 to 21 million in 2016 (FAOSTAT 2016).

This study analyzes the severity and cost of land degradation in the ASALs focusing on three Areas of Interest (AOIs) – Garissa, Turkana, and Wajir Counties. It identifies suitable restoration options and makes recommendations on how to facilitate their large-scale uptake. Spatial maps are used to present the results – an approach which will help the government and development partners to design and implement investment projects. Chapter 2 provides relevant background information about the institutional, environmental and economic environment of the AOIs. Chapter 3 discusses the cost and drivers of land degradation. Findings of the spatial analysis on the extent of land degradation in the AOIs are presented in Chapter 5. Chapter 6 describes some lessons learnt and past experiences with resource conservation and sustainable land management before Chapter 7 concludes and proposes some policy recommendations.

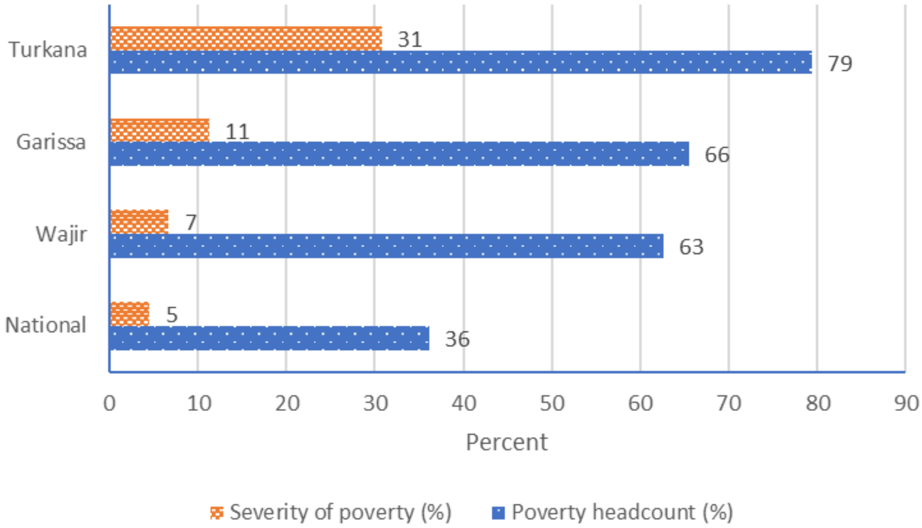
2 GARISSA, TURKANA AND WAJIR

Garissa, Turkana and Wajir are the three largest and among the poorest counties in Kenya. In terms of surface area they account for 28% of Kenya's total surface area of 610,000 km². However, they account for only 4% of the nation's population of 37,724,850 people (NBS 2016[a]). The three counties – located in the eastern and north-western regions (Figure 1) - are among the poorest counties in Kenya (Figure 2). The overarching developmental challenges in the ASAL are infrastructure, water deficit and abject poverty.

With respect to poverty, headcount and severity of poverty all three counties are significantly well above the national average. In Turkana for example, the poverty head-count amounts to almost 80% and the county is the poorest in Kenya. All three counties have sparse population and poor market infrastructure, which hampers development. The main livelihoods in the three counties is livestock production (KNBS 2015b).

Figure 1: Area of Interest: Garissa, Turkana and Wajir

Figure 2: Severity of poverty in the AOI compared to national poverty level



Notes: Poverty headcount = number of people below poverty line as % of total population

Severity of poverty = proportionate poverty gap in the population

Source: KNBS 2015

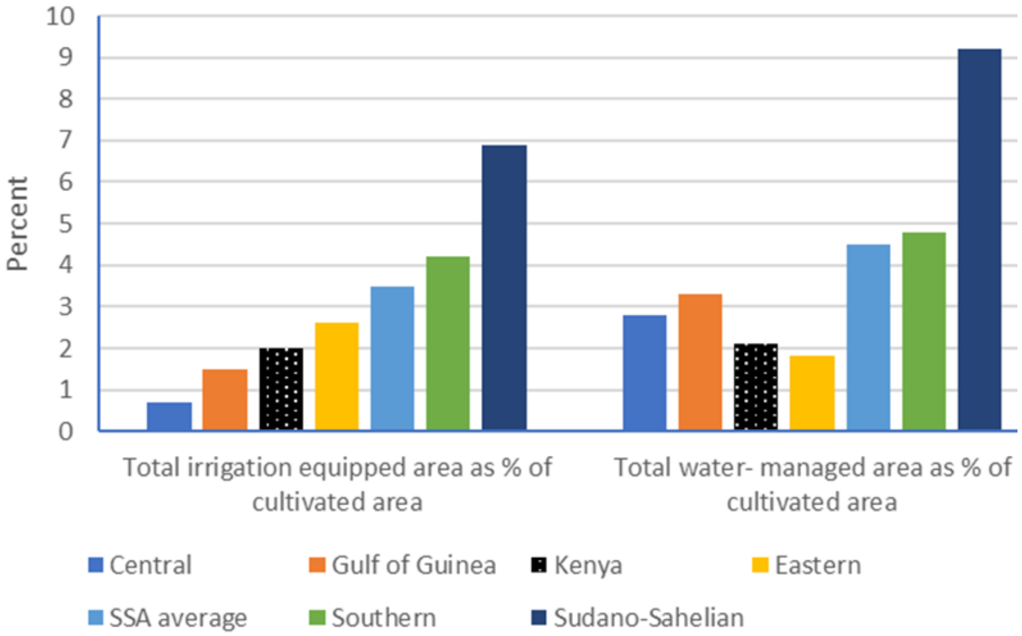
Water development in the ASAL

The population of the AOI faces a severe water shortage, especially for livestock. Droughts which hit Kenya in 2008 to 2011, cost the Kenyan livestock sector US$3.3 billion (ILRI 2015). Loss of livestock due to hydrological shocks could tip households into destitution and desperation. Studies have shown that the significant livestock mortality in the ASAL pastoral communities tips household into a poverty trap (McPeak and Barrett 2001, Lybbert et al. 2004, Barrett et al. 2006).

Discussions with county officials in Turkana and Wajir demonstrated that currently counties do not elaborate strategies for addressing the severe water shortage for livestock. However, they consider it as a priority area for investments. Particularly, rainwater harvesting and management (RWHM) is lacking in Kenya's ASAL. Of interest is the comparison of allocation to water resource development at national and Wajir county level. At national level, the sectors of Environment Protection and Water and Natural Resources account for only 2% of total budget expenditures compared to 16% for Wajir's Ministries of Water Resource Development and Energy, Environment, and Natural Resources (Annex 9.5). The severe water shortage in the ASAL is the major reason behind the big difference between the two budgets.

So far water development has not been considered systematically in programs for restoration of degraded lands in Kenya, even though such combined efforts have shown high payoff. Agriculture Water Management (AWM) - which is management of water used for both irrigated and rainfed crops, livestock production and inland fisheries - is poorly developed in Kenya – even on sub-Saharan Africa's (SSA) scale (Ngigi 2002). Only 2% of cultivated area is equipped for irrigation – compared to 3.5% for SSA (Figure 3). Similarly, only 2% of cultivated area is under AWM – compared to SSA's 4.5%. Irrigation development in the ASAL region is even lower. The Sudano-Sahelian region – with comparable water deficit – has the highest AWM development in SSA.

Figure 3: Irrigation development in Kenya - compared to SSA regions



Key:

Sudano-Sahelian:	Burkina Faso, Cape Verde, Chad, Djibouti, Eritrea, The Gambia, Mali, Mauritania, Niger, Senegal, Somalia, Sudan
Eastern:	Burundi, Ethiopia, Kenya, Tanzania, Uganda, Rwanda
Gulf of Guinea:	Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo
Central:	Angola, Cameroon, CAR, DRC, Rep. of Congo, Equatorial Guinea, Gabon, Sao Tome & Principe
Southern:	Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe

Source: Calculated from Svendsen et al 2009.

Recently, President Uhuru Kenyatta has declared that the government plans to develop two million ha of irrigated land. However, no feasibility study has been conducted so far to verify the area or specify the investments required.

The Vision 2030 – which aims "to transform Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment" – has set a target of developing 1.2m ha irrigated area in the ASALs – a level which suggests developing 32,000 ha of irrigated area per year. If this goal is achieved, it will benefit a large population of people in Turkana – an area with the largest irrigation potential in the AOI (34,180 ha) (Table 1). Wajir has the smallest irrigation potential and consequently fewer potential beneficiaries. However, the crops planned in each AOI counties are cereals, legumes and fruits (banana & mango). Vegetables are not planned for – though their demand is increasing fast with increasing middle income and urban population (Rischke et al. 2015). Plans to invest in irrigated fodder is important but its implementation needs to be considered in terms of strategic commercialization of livestock fed with irrigated fodder.

Table 1: Potential livelihood impacts of irrigation in the AOIs

County	Irrigation Potential (ha)	Crops	Expected Production(Ton)	No of beneficiaries (000)[a]
Garissa	**4560**		**24.8**	
	760	Maize	1.9	14.1
	95	Paddy	0.4	2.6
	380	Sorghum	0.8	5.6
	380	G/ grams	0.4	19.0
	380	Cow peas	1.0	43.2
	570	Fodder	2.4	
	1,235	Banana	9.5	
	760	Mango	8.6	
Turkana	**34,180**		**449**	
	8300	Maize	207.5	1537.0
	3320	Sorghum	6.6	49.2
	3,320	Green grams	8.3	377.3
	830	Bananas	20.8	
	830	Mangoes	41.5	
	4,980	Fodder	74.7	
	4,200	Maize	10.5	77.8
	525	Paddy	2.0	14.6
	2,100	Sorghum	4.2	31.1
	2,100	G/ grams	2.3	105.0
	2,100	Cow peas	5.3	238.6
	525	Bananas	13.1	
	1,050	Mangoes	52.5	
Wajir	**260**		**2.1**	
	100	Maize	0.3	1.9
	40	Sorghum	0.1	0.6
	40	Cow peas	0.1	4.5
	10	Bananas	0.3	
	10	Mangoes	0.5	
	60	Fodder	0.9	

a Total population per county is not reported since beneficiaries of the listed crop could be double-counted.
Source: FAO 2013

Institutional environment

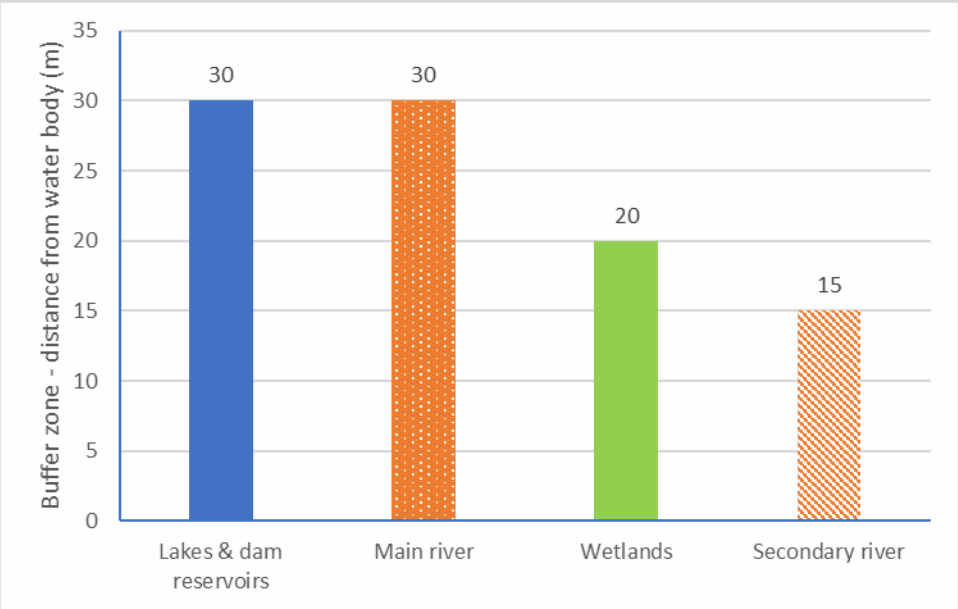
The Government of Kenya and its development partners have increased their efforts to spur ASAL development. The recent oil discovery in Turkana (Johannes et al. 2015) and groundwater discovery in Turkana and Wajir and neighboring counties (Luedeling et al. 2015) has raised interest in developing the three counties. The increased attention is a radical departure from the 50- year neglect of the ASAL.

Decentralization has led to a significant allocation of national resources to the counties and has given the counties a greater mandate to plan their own development reflecting local needs. The 47 counties in Kenya are allocated 15% of the total revenue collected at national level (Kimenyi 2018). County governments are given the mandate to collect additional revenue from within their area of jurisdiction (Khaunya et al. 2015). As part of the government's efforts to speed up development in northern Kenya, the ASAL counties receive a higher allocation of the national level revenues. Accordingly, development partners have joined hands in addressing the ASAL development challenges. For example, the World Bank finances US$253 per capita in North-Northeastern Development Initiatives (NEDI) compared to only US$111 per capita in the rest of the country (World Bank 2016).

Although almost all forest area and rangelands in the AOI are community-owned there is no clear mandate for villages to enact and enforce by-laws. Discussion with county officials in Turkana and Wajir showed that the counties have not yet enacted significant legislation for natural resources management because they are in the early stage of establishing their institutions. For example, the Turkana Land Act is still under discussion and has not been finalized.

Given the key role played by rivers in the three counties for supplying water for both people and livestock, regulations have been placed to safeguard riverbanks. The national environmental protection law requires the establishment of a buffer zone around water bodies (GoK 2013). No cultivation or any activities are allowed within 15-30 m from water bodies (Figure 4). County level legislation on the protection of riverbanks exists and is in conformity with the national level statutes. To successfully implement this regulation, the central and county governments promote tree planting along water bodies.

Figure 4: Kenya Government environmental regulations for the protection of water bodies



Source: Authors – based on data processed by KFS (2013)

Management of pastoral conflicts and supporting nomadism is another important institutional challenge which the ASAL counties are facing. All three AOI counties share borders with countries which have decades-long armed conflicts. This has created a supply of small arms, which have changed the nature of the traditional weapons used in conflicts. The pastoral communities in all three counties acquire guns to defend themselves from invaders from across international borders and other domestic cattle rustlers. Garissa and Wajir are neighboring Somalia – a country with no formal government for the past 27 years and with constant tribal fighting. Turkana is neighboring South Sudan, a country which has experienced civil war for more than 40 years and Uganda where Karamoja pastoralists live – both of which use small arms in cattle rustling operations.

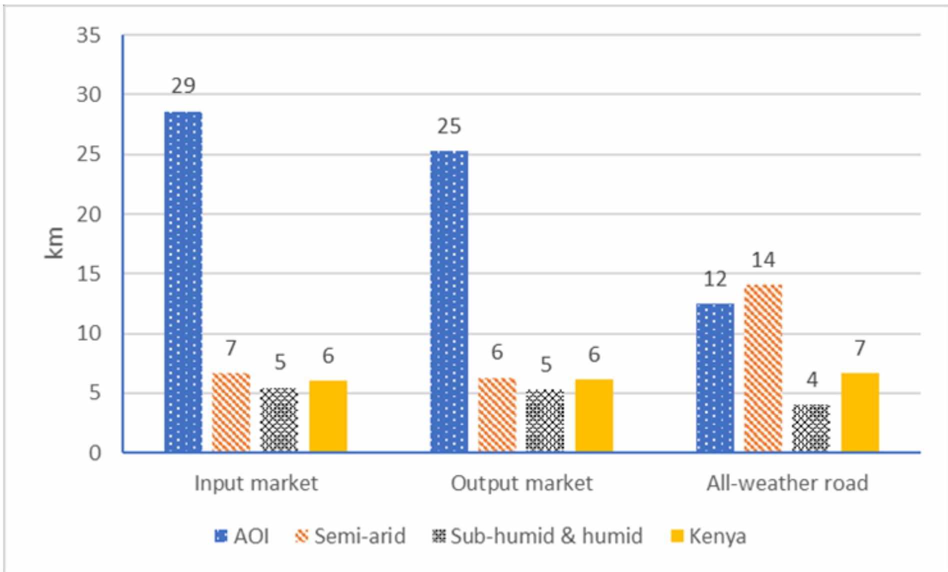
Cattle rustling is showing an upward trend as it becomes commercialized. The rustlers steal livestock and sell them in urban markets – as opposed to the tradition of keeping the stolen livestock as a symbol of wealth and prestige (Khisa 2016). A study done in Samburu and Marsabit showed cattle rustling increased from 5 to 20 incidents per year in the selected communities (Ibid). In addition to commercialization of cattle raids and the fatal weaponry used, climate change has increased frequency of drought and higher livestock mortality, which in turn forces pastoralists to replenish lost livestock by cattle rustling (Meier et al. 2007).

Government efforts to disarm pastoralists have been used as a strategy for addressing cattle rustling. However, such practices disadvantage the pastoralists against cattle rustlers from neighboring countries. Worse still, studies have shown a strong correlation between firearms recovered and frequency of cattle raids (Khisa 2016). The constitution gives greater recognition to customary institutions used in the communal pastoral areas in the ASAL (Odote 2015) and encourages the application of traditional dispute resolution mechanisms in land conflicts (GoK 2010). Cross-cultural traditional conflict resolution approaches worked in the decades-long conflicts between the Sukuma and Maasai of Tanzania. It ended when clan leaders from both groups met and resolved the cattle rustling conflict. The Government of Tanzania facilitated the meetings and conflict resolutions process. However, several studies report that the militarization of cattle rustling has brought an end to traditional conflict resolution avenues (Brock-Utne 2004; Kariuki 2015).

Access to roads, markets and information

Farmers in the AOI counties travel a distance five times longer than the rest of the country to reach an input or output market. Figure 5 also shows that farmers in AOI counties travel twice the distance that farmers in the rest of the country travel to reach the nearest all-weather road. Studies have shown that access to roads, markets and extension services are key drivers of adoption of sustainable land management practices and productivity (e.g. see Barrett 2008; Barrett et al. 2010).

Figure 5: Distance to the nearest rural service in the AOI compared to other areas

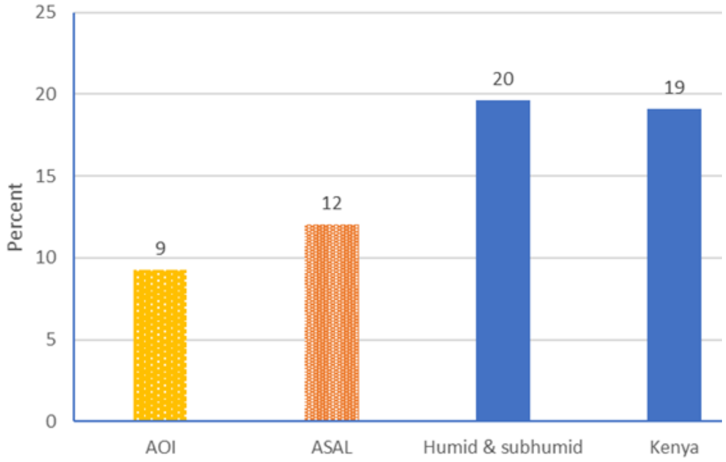


Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Access to advisory services in the AOI is the lowest countrywide (Figure 6). The department of extension froze hiring extension agents for many years. Additionally, many extension agents are retiring – leaving behind a big gap. Currently one Kenyan public extension agent serves around 6000 rural farmers, a level which is higher than the average at regional and sub-regional level, but reflects the limited number of providers. Based on 228 working days[1] per year, it will take one Kenyan extension agent 26 years to visit each of the 6000 farmers under her/his jurisdiction. The number of extension providers are even more limited in the ASAL region. Advisory services offered by formal extension services – which includes extension services offered by government, NGOs, and research institutions (including universities and colleges) – reach only about 20% of households in Kenya and only 9% of farmers in the AOI. This underscores the limited access to advisory services in the AOI.

[1]There are 13 public holidays, 102 weekend days and 20 days of annual vacation. Thus, the total non-working days are 137.

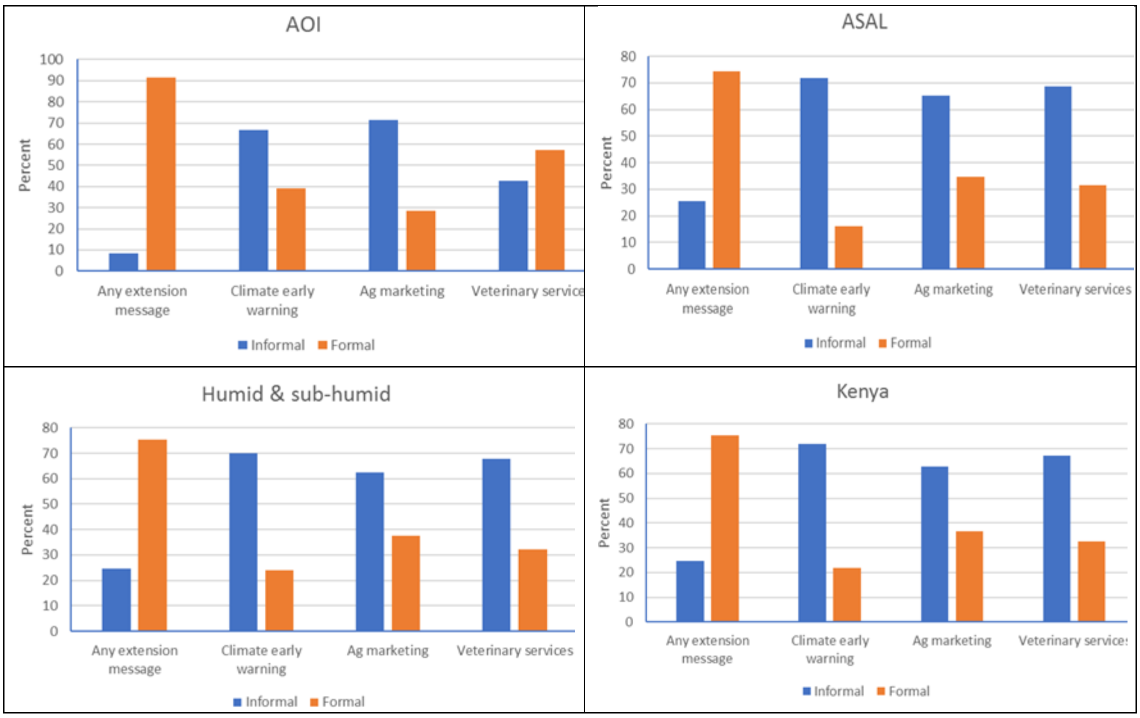
Figure 6: Access to formal agricultural extension services



Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Extension service providers affiliated with the government are the major providers of any form extension services (Table A 2). The content offered by those formal providers is mainly related to production. For advisory services related to climate/drought early warning, agricultural marketing and veterinary services, non-formal advisory service providers are the major providers (Figure 7 and Table A 2). For example, of farmers receiving services related to agricultural marketing only 28% of farmers received services from formal/public services, while 78% from informal/private sources (Figure 7 and Table A 2). In general, the low numbers of the public advisory service provision illustrate the potential role other type of service providers, such as from the private sector, could play.

Figure 7: Content of advisory services in the AOI and ASAL (by source)

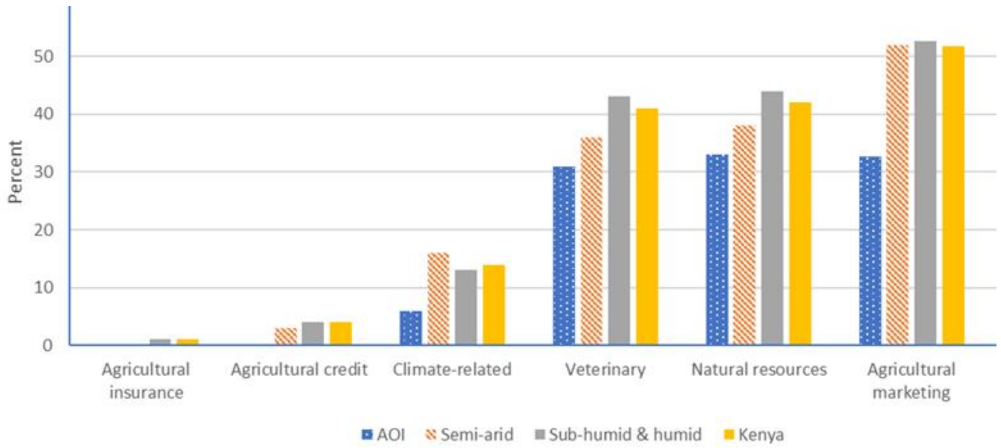


Source: Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Despite their high acceptability among pastoralists, use and promotion of indigenous knowledge by formal extension agents is rare. Pastoral communities have a rich indigenous knowledge of rangeland management. Studies have shown that indigenous pastoral knowledge is effective and sustainable (Reed et al. 2007; Niamir 1998). The pastoralists have a deep knowledge of their ecological environment and their livelihoods have sustainably managed rangelands and water resources for decades. For example, Table A 4 (Annex) shows the calendar for Turkana people. Each month has a word which has a meaning, which translates into rainfall seasons, condition of rangelands, other biomes and other prevailing conditions that pastoralists must cope with. Indigenous knowledge related to sustainable rangeland management includes aspects such as enclosures, nomadic livelihoods, and selective tree harvesting. Annex 9.5 provides details of some of sustainable indigenous knowledge practices.

Interestingly, on the topic of output marketing, farmer-to-farmer advisory services is the third most important source (Table A 2. This underscores the role that farmers could play and fill in the gaps of public providers (Krishnan and Patnam 2013). With respect to climate early warning, media are the most important source with 60% indicating the increasing role modern ICT could play. Veterinary services are largely provided by government extension agents in AOI and by agro-vet dealers and private companies in the rest of the country.

Figure 8: Access to agricultural advisory services in the AOI compared to other areas (by topic)



Source: Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

3 DRIVERS, EXTENT AND COST OF DEGRADATION

3.1 Drivers of land degradation

This section presents original research results on the drivers of degradation of cropland. We use an econometric approach to determine drivers of land degradation. The analytical approach is given in Annex 1. The focus is on drivers of adoption of ISFM. Understanding the drivers of ISFM indirectly implies the drivers of land degradation. For example, we show below that rural services increase adoption of ISFM. This suggests that poor access to rural services is a driver of land degradation.

The discussion on drivers of rangeland management is based on literature review. Unfortunately, the 2013 Agricultural Sector Household Baseline Survey did not collect good data on livestock management. For example, there was no question on grazing land management.

Drivers of cropland degradation

Access to rural services is a major driver of adoption of ISFM. As expected, access to rural services is correlated with adoption of ISFM in Kenya (Table 2). Belonging to farmer groups is also associated to higher propensity of adoption of ISFM, suggesting the need for investing in access to rural services as part of land restoration efforts. Proximity to all-weather roads in Kenya is positively associated with propensity to ISFM adoption. Access to market does not seem to play a significant role, likely due to strong relationship between market access and roads or district headquarters. Access to general agricultural extension and agroforestry advisory services is positively correlated with ISFM adoption in Kenya. The limited access to extension services is due to small number of staff. As discussed above, the department of extension froze hiring extension agents for many years and many extension agents are retiring – leaving behind a big gap.

Human capital increases adoption of ISFM – a knowledge-intensive agricultural practice. Education increases the propensity to adopt ISFM in Kenya (Table 2). This is consistent with empirical evidence from Africa – which has shown that education is associated with higher adoption of agricultural technologies (Alene and Manyong 2007; Appleton and Balihuta 1996) – especially those related to knowledge intensive technologies such as ISFM (Bationo et al. 2007). The AOI counties have among the lowest level of education in Kenya (CRA 2011). It is thus not surprising that ISFM adoption is low in the AOI.

The number of adults – a proxy of family labor supply– is negatively correlated with adoption of ISFM. It is expected that family labor would increase ISFM adoption since the technology is labor intensive – especially if it involves biomass transfer (Nkonya et al. 2015). However, the unexpected result could be linked to poverty factors associated with large families – which could limit ISFM adoption.

Capital endowment has weak impact on adoption of ISFM. Contrary to a priori expectations, land tenure does have a significant impact on adoption of ISFM. This could be due to the limited variability of land tenure type. Land size reflects wealth and financial ability to adopt ISFM. However, cropland size does not have significant association with adoption of ISFM.

Number of livestock is negatively correlated. Other studies have shown that livestock rearing increases biomass production (through manure) and provides animal draught power to biomass transfer (Nkonya et al. 2015) and both enhance adoption of ISFM. The negative correlation with number of livestock could be due to the lower dependency on crop production among predominantly livestock keepers' households – especially in the AOI.

Table 2: Drivers of adoption of ISFM, Kenya

	Probit maximum likelihood coefficients	
	Structural	Reduced
Human capital		
Male-headed household	0.098***	0.108***
Education of household head (cf no education)		
• Primary	0.399***	0.420***
• Post-primary	0.470***	0.498***
Number of adults	-0.005***	-0.004***
Physical capital		
Farm size	0.000	-0.0001
Land tenure (Freehold)		
• Customary	-0.167***	-0.171***
• Leasehold/rented	-0.228**	-0.260**
TLU	-0.018***	-0.017***
Access to rural services		
Distance (km) to market	$3.73e^{-06}$	$4.76e^{-06}$*
Distance (km) to all-weather road	-0.005***	-0.006***
Belong to farmer group	0.202***	
Received general agricultural extension	0.075**	
Received agroforestry extension services	0.225***	
Have access to credit services	0.230***	
Constant	-0.983***	-0.933***

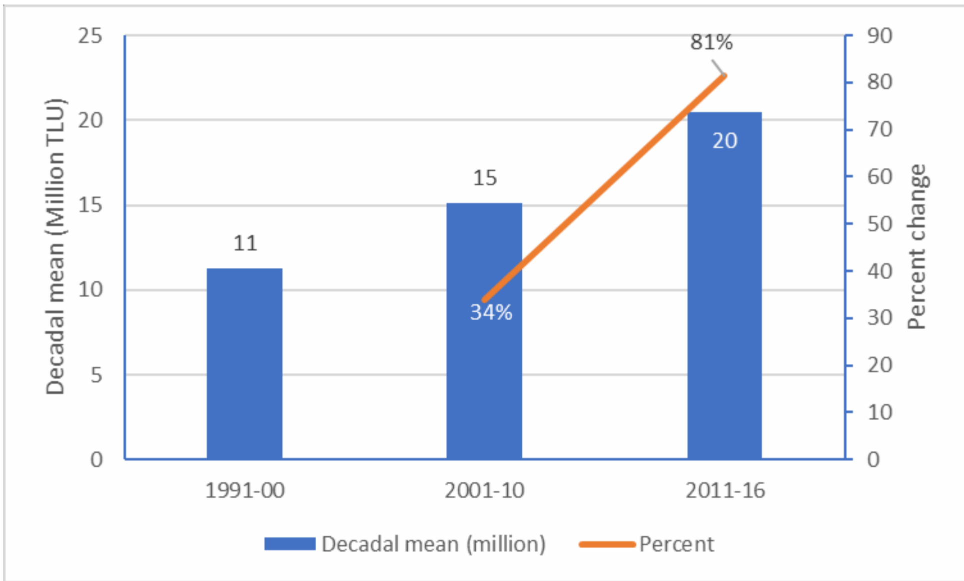
TLU=Tropical Livestock Units: conversion factors to TLU: Cattle = 0.7, Sheep = 0.1, Goats = 0.1, Pigs = 0.2, Chicken = 0.01 & Donkey=0.5

Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Drivers of adoption of land management practices for restoration of grazing lands

The main driver of rangeland degradation in the AOI is overgrazing. Livestock population has been increasing fast in Kenya, seeing an increase of more than 80% over the last 26 years (Figure 9). During the same period, the total area of grazing lands has decreased (FAOSTAT 2016). Wildfire frequency in rangelands in Kenya has increased (Phillips 2012) – largely due to climate change, charcoal burning and pastoral practices (Sankaran et al. 2008). Higher frequency and intensity of wildfire increases rangeland degradation.

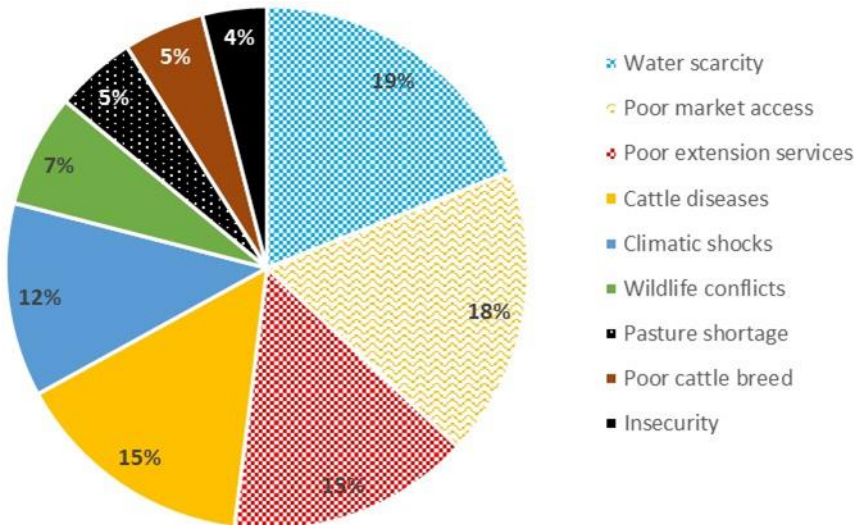
Figure 9: Trend of livestock population (TLU) in Kenya, 1991-2016



Notes: TLU = Tropical livestock unit. Conversion factor to TLU: Camel=1.0; Cattle=0.7, goat or sheep = 0.1. *Source: Computed from FAOSTAT raw data.*

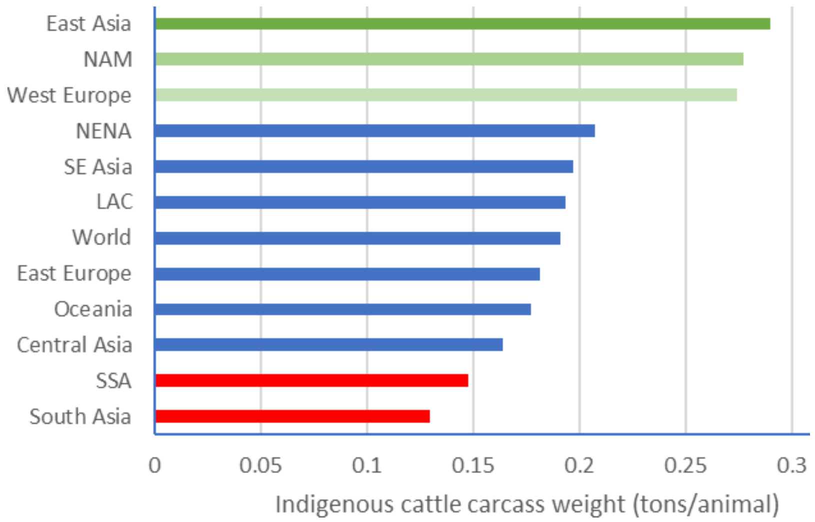
Consistent with ISFM results reported above, access to rural services is among the most important constraints reported by pastoralists (Figure 10). ASAL pastoralists reported access to markets as one of the leading constraints of livestock production (Figure 10). Likewise, access to extension services is the most important constraint reported by pastoralists. Water scarcity and diseases are also reported to be major constraints. This illustrates the need to invest in improving agricultural markets and all-weather roads to incentivize farmers to invest in rangelands and cropland improvement and to increase agricultural water development investment. Such investment could increase rangeland productivity by increasing carcass weight of animals. For example, carcass weight of two heads of indigenous cattle from SSA is equivalent to the weight of only one indigenous cattle from East Asia, North America and Europe (Figure 11). Rangeland improvement will help increase carcass weight – which in turn will help farmers obtain higher prices.

Figure 10 Livestock production constraints in the ASAL



Source: Onono et al. 2013

Figure 11: Comparison of indigenous cattle carcass weight across regions



Notes: NAM=North America, NENA=Near East and North Africa; SE = South East; LAC=Latin America and Caribbean countries; SSA= sub-Saharan Africa.

Source: FAOSTAT raw data online.

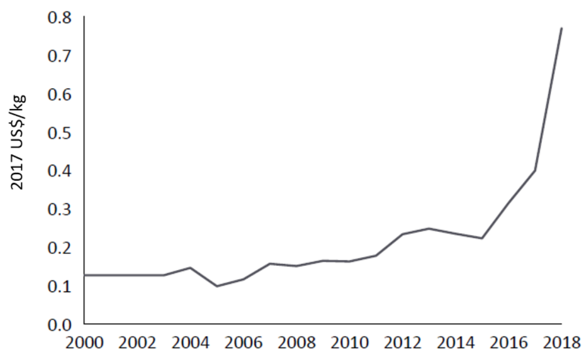
Pilot studies done by ILRI and other partners have shown that implementation of Index-Based Livestock Insurance (IBLI) is effective in de-risking livestock production in the ASAL. IBLI simplified by using satellite imagery to objectively assess vegetation data in near-real time. This information can be used to determine the risks and impacts of drought on livestock. The satellite data are then combined with household-level livestock data to determine payments. Thereby, the basis risk is reduced (ILRI 2015). It is the satellite imagery and household data which determines payment – rather than livestock mortality, which could be hard to determine. Initial assessment shows high acceptability of IBLI (Ibid). Even in the northeastern area, IBLI has been made compliant with the Islamic sharia law by using the “takaful” system in which pastoral community members contribute money into a pool system to guarantee all members of compensation if a shock happens (ILRI 2015).

Drivers of forest degradation

Charcoal making is the major driver of deforestation in the ASAL region. Kenya is one of the largest charcoal consumers in SSA and its consumption is expected to double by year 2030 (Njenga et al 2013). To address the deforestation challenge, Kenya set the Charcoal Regulations of 2009 (also known as the “Charcoal Rules”) – charcoal producers need to have a license to produce charcoal and have to be members of the Charcoal Producer Associations (CPAs) (Wajiru and Omedo 2016). The CPAs responsibilities include identifying sources of wood, ensuring sustainable harvesting and carbonization technologies and selling from centralized points (Ibid). Despite this effort, it is estimated that 60% of Kenya’s charcoal is produced and sold by non-CPA members. The inefficient earth kilns – with a 10-15% rate of carbonization – remains the predominant production process (Ibid).

A study done in Ewaso North forest conservancy – which covers ASAL counties of Isiolo, Samburu and Marsabit – showed that the major driver of increasing charcoal making is the increasing prices of charcoal and urbanization (KFS 2013). For example, price of charcoal in Nairobi increased by six fold from US$0.12/kg in 2000 to 2017 US$0.75/kg in 2018 – a 34% annual increase (**Error! Reference source not found.**). However, the price spiked in the past five years, rising from about US$0.2 to US$0.75. The increased enforcement of the charcoal rules and kerosene, electricity and other cooking energy sources are among the drivers of the charcoal price spike (Daalberg 2018).

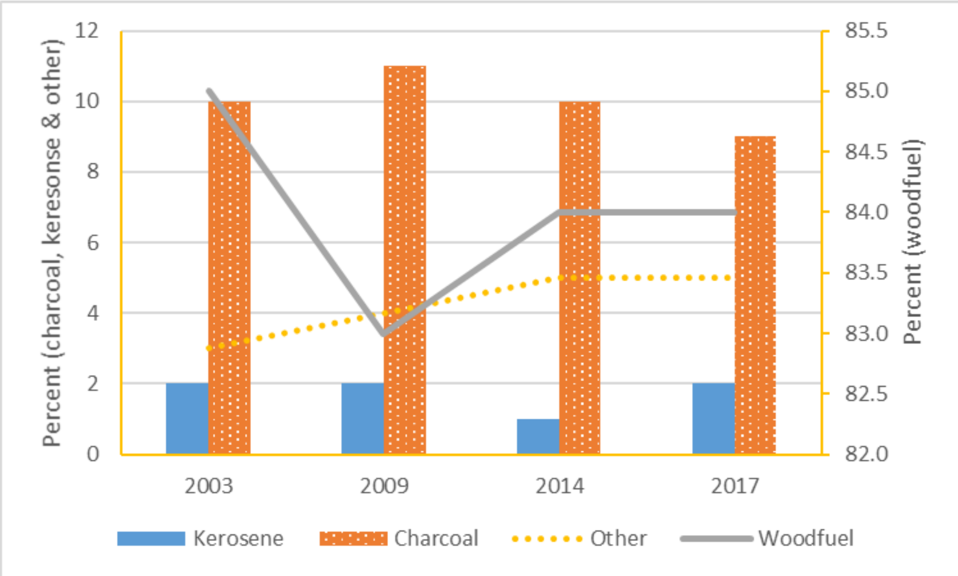
Figure 12: Charcoal price trend in Kenya, 2000-2018



Source: Extracted from Daalberg 2018

Demand for fuelwood in rural areas is also a major driver of deforestation. About 85% rural households use fuelwood and its intensity of use has remained unchanged in the past 15 years (**Error! Reference source not found.**). Thus, increasing human population has increased fuelwood harvesting – contributing to deforestation.

Figure 13: Trend of use of fuelwood and other cooking energy source among Kenyan rural households



Source: Extracted from Daalberg 2018

3.2 Extent of land degradation

We use the Millennium Ecosystem assessment (MEA) definition of land degradation. MEA de- fines land degradation as long-term loss of on-site and off-site terrestrial ecosystem goods and services, which humans derive from them (MEA 2005).

Two types of land degradation are analyzed in this study:

- Land degradation due to land use/cover change (LUCC). Land degradation due to LUCC occurs if a low-value biome replaces a high value biome. A biome is a community of plants and/or animals occupying a distinct area. This includes forests, cropland, shrublands, etc.
- Using land degrading management practices in a biome which did not experience LUCC. For example, overgrazing on rangeland, which remained rangeland, is considered to be degradation.

Different approaches are used to measure degradation of land, forests, and rangelands. We measured rangeland productivity using normalized difference vegetation index (NDVI) data. NDVI is a standardized indicator of vegetation health – healthier plants have high NDVI. For forests, productivity is measured using its density. The denser a forest, the more productive it is. For land we regard the non-adoption of agroforestry and integrated soil fertility management (ISFM) as indicators of degradation on cropland. ISFM is a set of soil fertility management practices that include the use of improved germplasm, judicious amount of mineral fertilizers, and organic inputs adapted to local conditions (Vanlauwe et al 2015). Riverbank degradation is analyzed based on the degree of tree clearing along riverbanks.

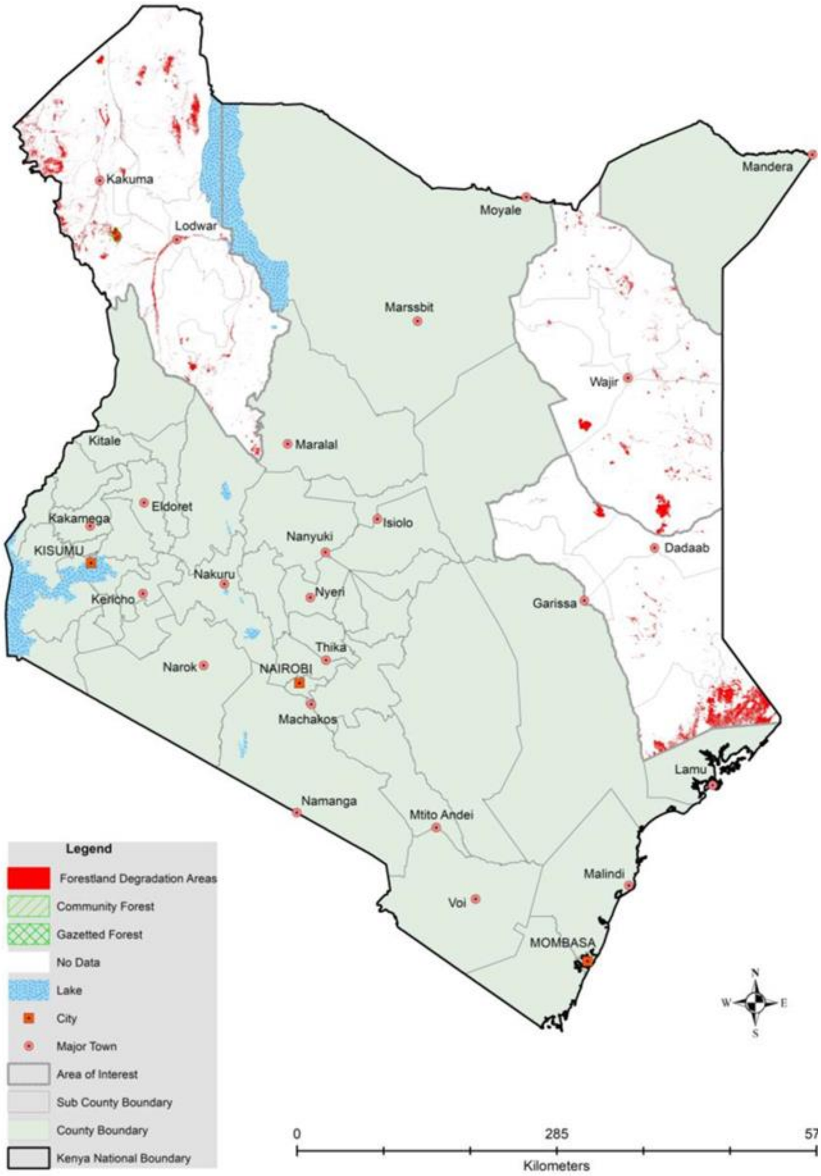
Degradation of forests is very severe in the three counties. About 76% of the forest area in both Garissa and Turkana are degraded (Table 3 and Map 1). In Wajir the situation is even more severe, since 97% of its forest area is degraded. In the three counties there is no forest under national ownership (gazette forest). All forest areas are under community ownership.

Table 3: Extent of forest and rangeland degradation

Subcounty	Biome area		Extent of biome as percent of total sub-county area		Area degraded as per-cent of total biome area	
	Forest	Rangelands	Forest	Range-lands	Forest	Range-lands
	Extent (1000 ha)		Percent			
Garissa County	305.7	3991.4	**5.4**	**93.3**	**76.2**	**94.9**
- Balambala	0.8	419.8	0.2	99.1	100	96.3
- Daadab	0.8	667.5	0.1	98.2	40.8	86.7
- Fafi	15.8	1518.3	1	97.8	66.4	71.4
- Garissa-urban	0.7	65.6	1	98.5	100	98
- Ijara	276.4	689.2	28.2	70.2	50	100
- Ladgera	11.2	631	1.7	96.3	100	100
Turkana County	278.5	6180.3	**3.6**	**89.8**	**75.8**	**73.1**
- Loima	39.3	815.8	4.4	91.3	85.1	58.9
- Turkana Central	10.8	487.7	1.9	85.8	55.9	94.2
- Turkana East	28.1	970.4	2.5	86.4	71.4	84.4
- Turkana North	73.1	1831.2	3.7	93.2	99.9	69.6
- Turkana South	14.7	661.4	2	90.2	42.6	51.1
- Turkana West	112.5	1413.8	7.3	92.1	100	80.4
Wajir County	104.6	5487.1	**1.5**	**96.8**	**82.1**	**82.3**
- Eldas	1	392.6	0.2	95.8	27.6	90.2
- Tarbaj	15.6	927.4	1.6	97.9	99.7	88.3
- Wajir East	6.5	390.9	1.6	97.4	99.7	64.8
- Wajir North	12.8	836.5	1.5	97.5	99.8	82.5
- Wajir South	56.6	2070.5	2.6	95.7	87.9	66.8
- Wajir West	12.1	869.2	1.3	96.4	77.9	100

Source: Authors – based on data processed by KFS (2013)

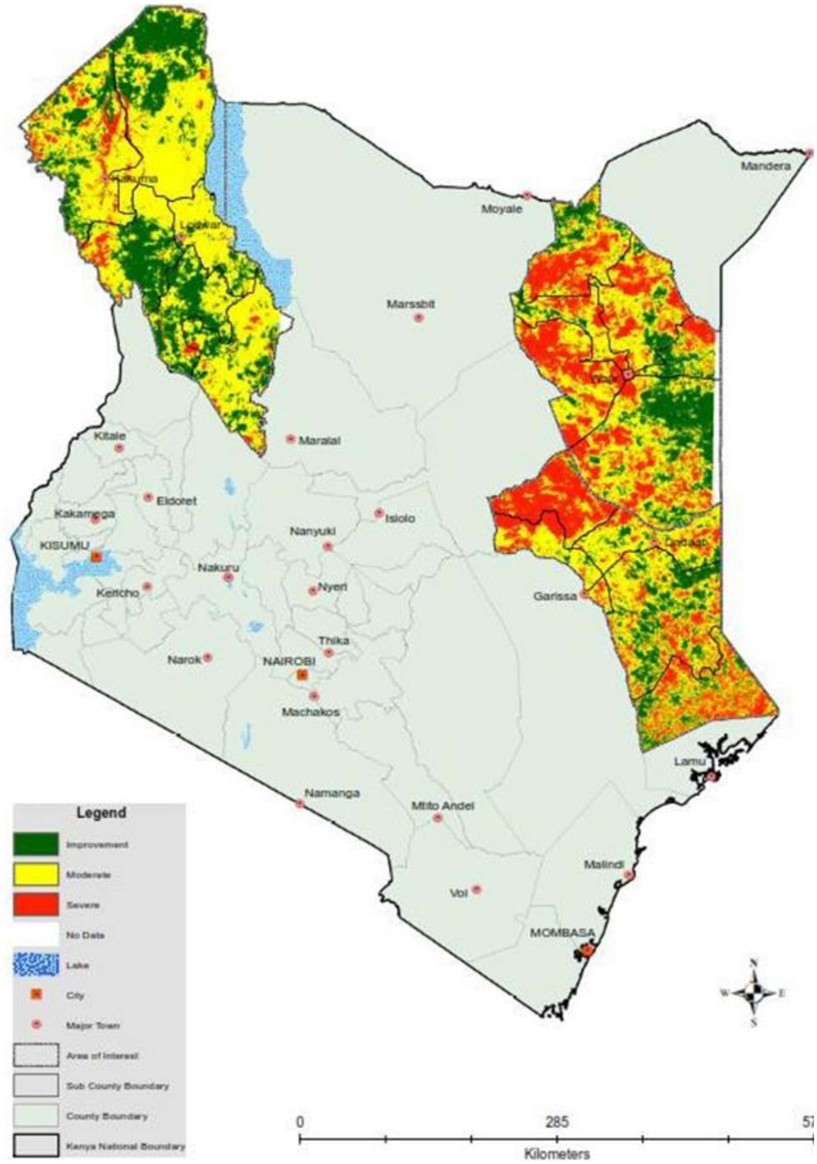
Map 1: Forest degradation in the AOI



Source: Authors – based on data processed by KFS (2013)

Rangeland degradation is also severe in all three counties (see Table 3). Degraded rangeland area as a share of total rangeland is 95% in Garissa, 82% in Wajir and 73% in Turkana. Map 2 shows that almost the entire land area in each county is degraded rangelands. A number of sub-counties report 100% degradation of rangelands.

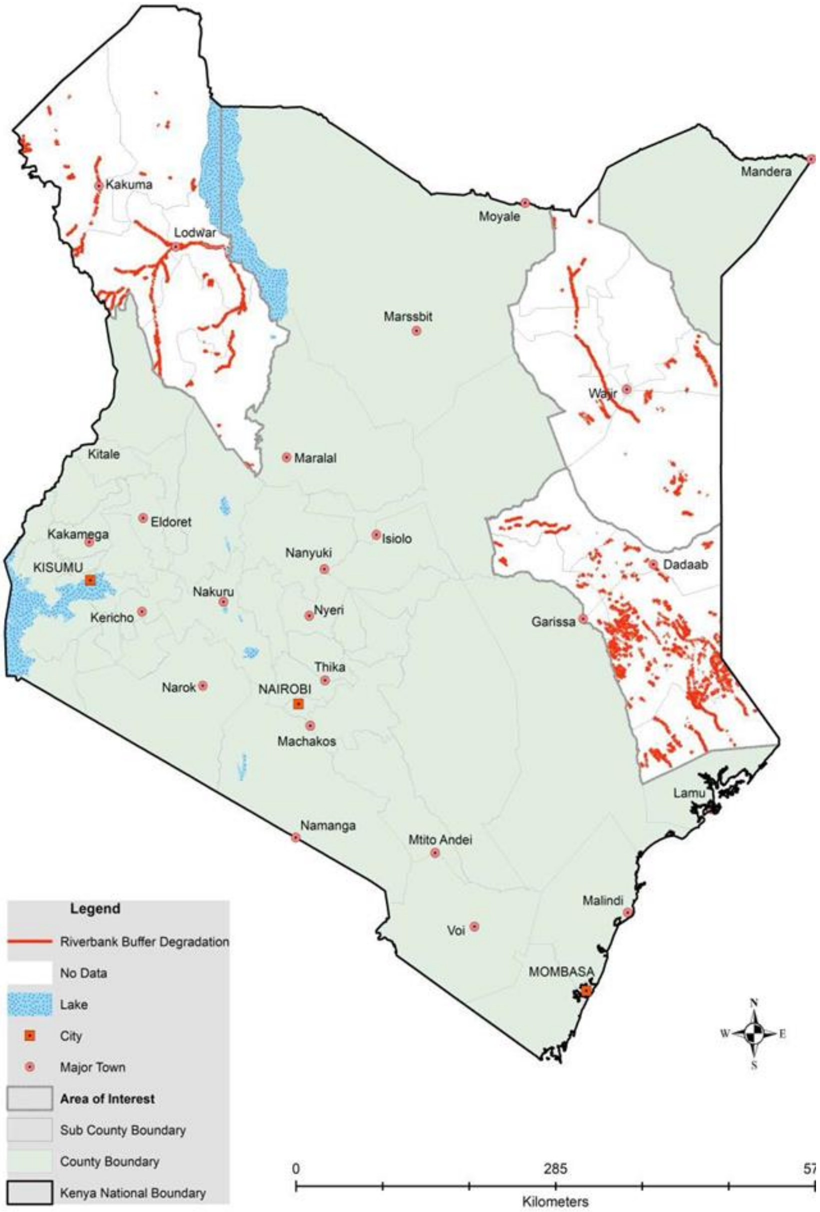
Map 2: Level of rangeland degradation in the AOI



Source: Authors – based on data processed by KFS (2013)

Although limited in number, rivers play an important role for ASAL livelihoods. The extent (land area) of riverbanks is small given that the AOIs are in the drylands. Map 3 shows the severity of land degradation along all rivers. Riverbank degradation is most severe in the southern part of Garissa County.

Map 3: Riverbank degradation in the AOI



Source: Authors – based on data processed by KFS (2013)

Land degradation on cropland is severe. Table 4 shows no adoption of ISFM in Turkana and Wajir and only 4% adoption in Garissa. Adoption of agroforestry is also zero in Wajir and only 1% and 5% in Turkana and Garissa respectively. Comparison of adoption of ISFM and agroforestry in the AOI and the rest of Kenya shows that adoption of both integrated soil fertility management practices is the lowest in the AOI compared to other regions of the country (Table 4, Map 4 and Figure 8). At national level, Kenya has one of the highest adoption rates in sub-Saharan Africa (SSA) but the high adoption rate is concentrated in the sub-humid and humid zones (Table 4). Even adoption of the use of manure – whose production is highest in the AOIs is low.

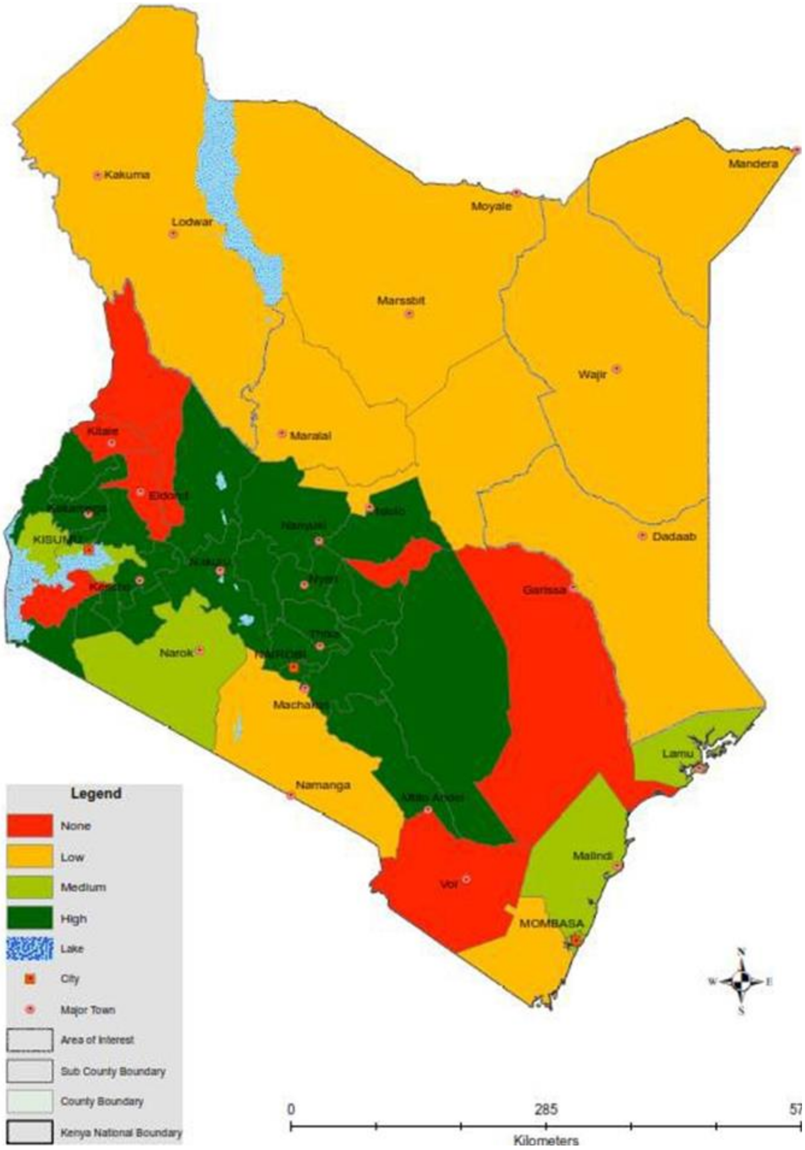
Table 4: Adoption of ISFM, agroforestry, manure and inorganic practices (by county, percentage of households)

County	ISFM	Agroforestry	Manure	Inorganic fertilizer
Samburu	0.0	0.0	5.7	0.0
Wajir	0.0	0.0	0.0	0.0
Mandera	1.0	1.0	6.6	1.0
Turkana	0.0	1.4	0.7	0.7
Marsabit	0.9	1.9	1.9	0.0
Kwale	1.5	2.5	37.7	2.0
Isiolo	1.7	3.4	4.2	4.2
Garissa	4.3	5.4	9.2	4.3
Kajiado	2.2	5.8	21.9	1.8
Tana river	2.9	12.4	2.9	1.9
Kilifi	2.5	12.6	15.5	1.6
Kisumu	5.8	16.3	18.4	5.2
Lamu	4.9	16.7	6.9	6.9
Mombasa	10.6	21.2	23.5	6.8
Narok	6.0	24.0	13.5	12.4
Siaya	23.6	27.1	39.5	41.1
Elgeyo-marakwet	8.3	29.8	10.7	52.9
Kitui	18.4	29.9	48.6	4.4
Nairobi	37.0	35.4	58.3	31.7
Nandi	8.7	37.3	10.4	77.2
Kisii	16.1	37.9	18.2	56.1
Laikipia	22.4	39.8	29.2	16.1
Machakos	45.8	40.2	71.9	37.0
Homabay	11.1	40.3	17.2	17.5
Taitataveta	11.6	42.0	19.6	16.1
Transnzoia	1.5	43.1	1.9	8.2
Migori	18.5	44.4	23.4	68.5
Kiambu	61.9	46.5	67.4	69.6
Bungoma	20.1	48.8	21.8	60.8
Kericho	15.4	50.2	17.9	48.8
Nyandarua	41.0	52.0	42.7	67.8
Nakuru	15.7	52.7	17.6	54.1
Nyamira	14.8	53.2	15.3	85.2
Tharaka	31.4	53.6	50.7	29.3
Uasingishu	7.9	58.2	9.7	32.7
Kakamega	34.0	58.3	38.3	54.1
Bomet	10.9	58.7	12.7	67.4
Nyeri	66.8	59.9	70.6	74.7
Kirinyaga	54.1	62.0	57.4	66.1
Embu	57.7	62.0	63.5	66.3

County	ISFM	Agroforestry	Manure	Inorganic fertilizer
Meru	47.4	62.7	54.2	58.9
Makueni	49.1	63.5	62.5	21.5
Muranga	66.8	63.6	71.8	67.3
Vihiga	63.6	64.1	64.1	83.1
Busia	25.5	70.3	31.4	38.1
Baringo	0.0	72.5	0.0	1.3
Westpokot	0.0	93.9	0.0	0.0
National (Kenya)	**25.3**	**41.8**	**33.1**	**39.1**
SSA[a]	**6.2**	**24**	**24.6**	**19.1**

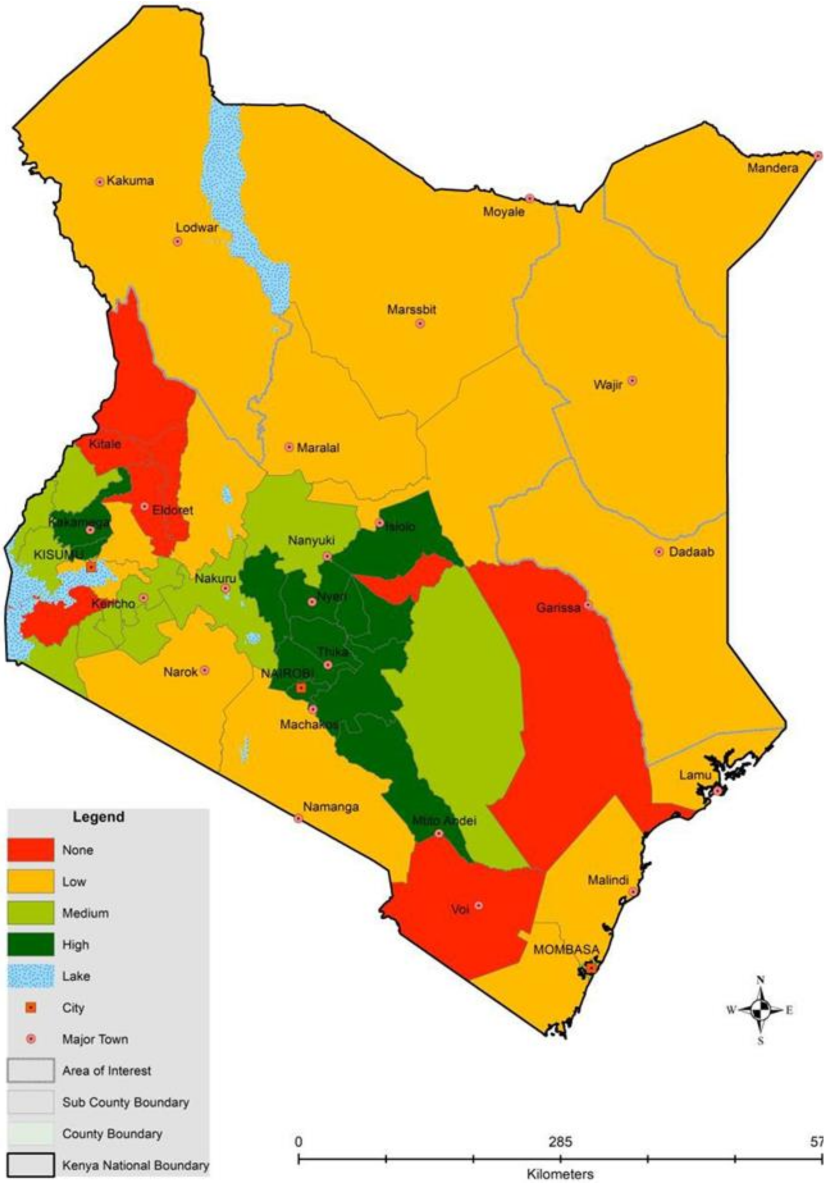
Sources: SSA adoption – Nkonya et al. (2016), Adoption rates in Kenya - Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Map 4: Adoption rate of agroforestry in Kenya by county



Source: calculated from Kenya Agricultural Sector Household Baseline Survey, 2013

Map 5: Cropland degradation as reflected by adoption of ISFM in AOI and other areas



Source Kenya Agricultural Sector Household Baseline Survey, 2013

3.3 Cost of land degradation

Using the MEA (2005) of land degradation as long-term loss of ecosystems, Mulinge et al. (2016) estimated the cost of land degradation in Kenya due to LUCC to be about US$1.3 billion per year (Table 5). The per capita cost of land degradation due to LUCC was highest in Coast and Northeastern provinces. The northeastern province includes Garissa and Wajir while Rift Valley Province – with the third highest per capita cost of land degradation – includes Turkana. The cost of land degradation due to using land degrading management practices on static cropland and grazing lands was found to be US$116.7 million and US$77.914 million in 2007 respectively. The total cost of land degradation – including LUCC and land degrading management practices – was US$1.525 billion or 5.6% of Kenyan GDP in 2007.

Table 5: Annual cost of land degradation due to land use/cover change, 2000-09

Province	Percent of Kenya land area	Annual cost of land degradation, 2007 US$ million	Annual per capita cost of land degradation, 2007 US$ million
Central	2.0	80.9	144
Coast	14.2	290.2	680
Eastern	25.0	214.2	296
Nairobi	0.1	2.3	8
North-Eastern (Includes Garissa & Wajir)	22.7	187.8	640
Nyanza	2.2	72.1	104
Rift Valley (includes Turkana)	32.5	452.1	352
Western	1.3	31.0	56
Total	**100**	**1330.6**	**272**
Cost of land degradation as percent of GDP		**4.9**	**32.4**

Source: Mulinge et al. 2016

4 RESTORATION OPTIONS

A national-level study commissioned by the Ministry of Environment and Natural Resources (MENR) established the national restoration options for degraded lands. The National Assessment of Forest and Landscape Restoration Opportunities in Kenya (MENR 2016) discusses several restoration options based on biophysical and socio-economic criteria. Table 6 summarizes the restoration options applicable to the AOI and associated justification and main challenges of implementing them. They are then discussed in more detail in the sections below.

Table 6: Restoration options, justification and main challenges for degraded biomes

Biome	Restoration options	Justification	Main Challenges
Rangelands	Rotational grazing & farmer managed natural regeneration (FMNR)	Indigenous knowledge and effective	Formal land tenure and fencing block livestock movements along stock routes
		Low-cost practice	Degradation, climate change, & increasing livestock population overwhelm existing pasture resources

	Vegetation reseeding	Seeding leguminous plants significantly increases nutritive value of rangelands	Collection of seeds is labor intensive Limited distribution of formal and informal suppliers of seed and planting material (figure 14).
Forests	Reforestation and afforestation of community forests	Timber and non-timber forest products highly beneficial to communities Growing value of timber and NTFP	Weak tenure security of community forests Rampant deforestation due to high demand for charcoal and fuelwood Low survival rates due to moisture deficiency
Riverbanks	Planting trees along buffer zone. Trees to be planted to cover 30m from main river and 15m from secondary river.	Water is a priority resource in drylands for both people and livestock	Weak tenure security of community forests. There is no riparian planning which will ensure ownership and payment for ecosystem services for rewarding those who invest in planting and managing trees.
Cropland	ISFM, FMNR and agroforestry	Low-cost and high returns	ISFM is labor intensive; production of manure or other biomass is a challenge. However, this challenge could be addressed by using FMNR and agroforestry.

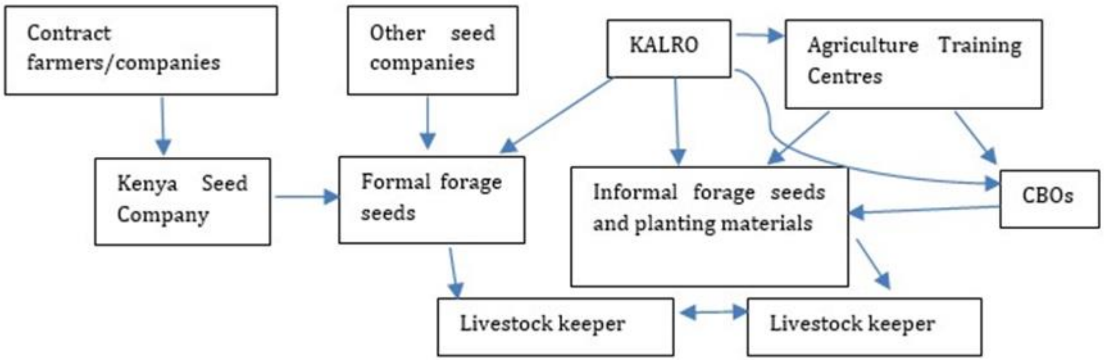
Source: The second column is extracted from MENR (2016); the rest of the columns are from the authors

4.1 Rangeland restoration

Rotational grazing is the most commonly used restoration option by pastoralists in SSA. It is a low-cost practice and has been shown to significantly improve forage productivity (Conant et al. 2002). Rotational grazing leads to increased milk production and weight gain of livestock. Another restoration option for rangelands in ASAL counties is vegetation reseeding using leguminous plants. (Mwendia et al. 2016). While rotational grazing is well-established and based on indigenous knowledge, vegetation reseeding is new and requires collection of seeds – an aspect which is labour-intensive. Rangeland degradation is occurring because rate of adoption of rotational grazing is limited (Kahiga 2015). Seed availability from formal and informal markets (Figure 14) is also limited – and this poses a challenge to widespread adoption of the practice. Seeds and planting materials for forages in the ASAL go through a complex process before they reach livestock keepers as illustrated in Figure 10. Market failure is also a major problem given that the demand for forage seed/planting material is low due to the low adoption rate of pasture improvement in the ASAL.

Forage harvesting – such as cut-and-carry is not a common livestock feeding system among the pastoral communities. However, animal fattening practices are done using other methods - by grazing selected animals on fodder banks – which is common among pastoralists. Fodder banks are enclosures – which are not grazed during the rainy season to allow grass to grow for fattening selected livestock like pregnant or lactating cows, or animals for sale. The fodder banks are also used in the dry season for all animals when there is shortage of forage in the surrounding rangelands (Angassa and Oba 2008).

Figure 14: Formal and informal sources of seeds and planting material for forages in the ASALs of Kenya



Source: Mwendia et al. 2016

Rotational grazing is a profitable practice. Table 7 shows the results of a financial analysis of rotational grazing. Pastoralists will reach the breakeven point after 4 years (Table 7 and Figure 15), since they have to invest in building barriers using local materials and use more labor to control animal movement. For every US$ they invest, they get an average of US$2.5 in return. The results imply there is strong financial incentive for adoption of rotational grazing compared to the continuous grazing, which is practiced by majority of the pastoralists (Kahiga 2015).

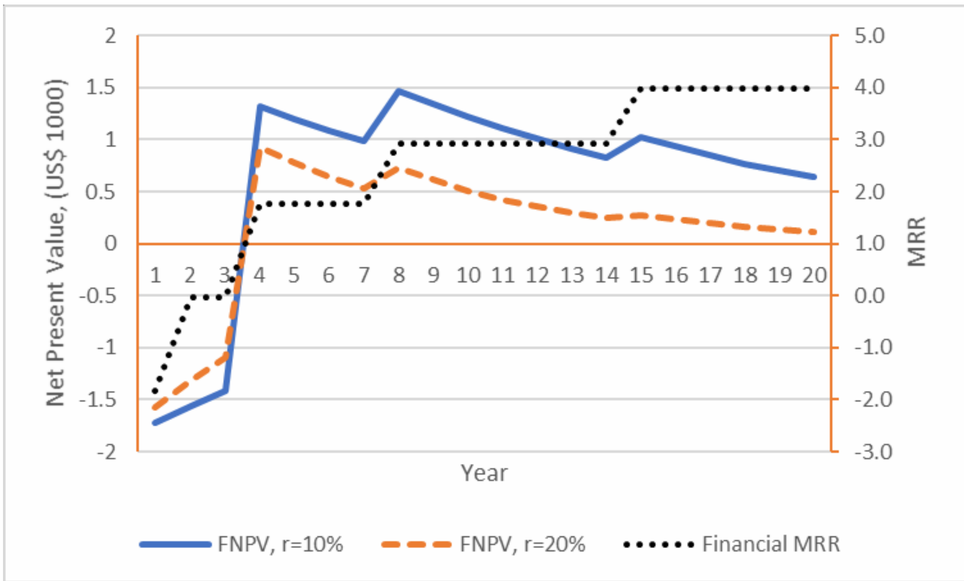
Table 7: Financial Net Present Value of rotational grazing for a 20 year planning horizon

	r=10%	r=20%
FNPV (US$000)	12.68	3.19
IRR	19%	9%
Breakeven point (year)	4	4
Average MRR	2.5	2.5

Notes: r = discount factor, MRR = marginal rate of return

Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Figure 15: Financial Net Present Value of rational grazing

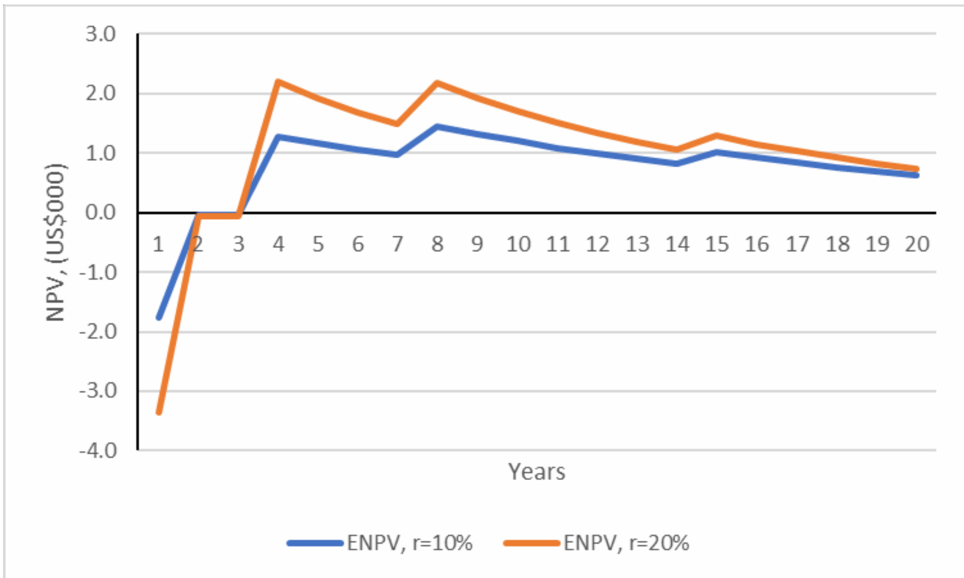


Notes: Off-take rate = 16% for farmers using rotational grazing & 10% for the BAU; Livestock feeding on rotation grazing gain weight and attract a 30% higher price than those grazing on continuous

Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Economic NPV for rotational grazing also shows break-even on the fourth year but with higher returns because ecological benefits of carbon sequestration are considered. This further illustrates that there are strong economic and financial incentives for practicing rotational grazing compared to continuous grazing.

Figure 16: Economic NPV of rotational grazing



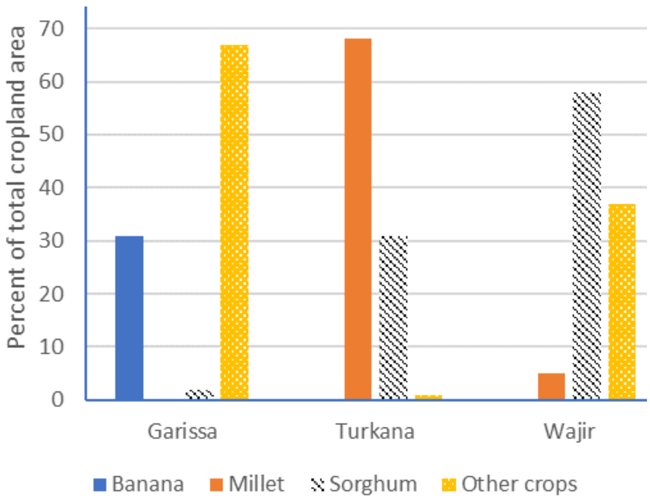
Notes: ENPV includes the carbon sequestration due to rotational grazing. One hectare stores of rangelands under rotational grazing stores 1.5tons C/ha/year (Tennigkeit, T. and Wilkes, A. 2008).

4.2 Cropland restoration

The major crops grown in the AOI are sorghum and millet – both of which traditionally receive very low rate of inorganic fertilizer. The cropland management practice which is likely to be adopted widely in the ASAL is agroforestry since it is based on indigenous knowledge and its non-timber forest products (NTFP) serve other useful purposes. As seen in the discussion above, agroforestry adoption rate in the AOI is low. As it will be seen in the discussion below, extension services play a key role in promoting adoption of SLM practices. ISFM is another key restoration option. Judicious application of inorganic fertilizer – micro-dosing - has been shown to significantly increase grain yield. The major problem is the low adoption of improved millet and sorghum varieties in the ASAL. Implementing ISFM using agroforestry as a source of organic input is the most amenable practice.

The economic and financial analysis is based on three crops, which are major crops grown in each of the three counties. Figure 17 shows that banana is grown mainly in Garissa and accounts for 30% of cropland area. Other crops account together for about 70% of the cropland area of the county (Table A 1). Millet is the major crop in Turkana while sorghum is the leading crop in Wajir.

Figure 17: Major crops grown in each of three AOI counties



Sources: Garissa, Turkana and Wajir County statistical abstracts, 2014

ISFM has been shown to have many economic and environmental benefits. Nkonya and Koo (2017) show that compared to other technologies, ISFM is the most profitable practice since it has the lowest yield variability and is more sustainable. One of the challenges of ISFM is its high labor intensity if organic inputs are supplied from external sources – such as hauling manure from kraals (*bomas*) to crop plots. Hence, both production of external inputs and high labor intensity are daunting challenges. The practical option for addressing such challenge is agroforestry, which, once trees are planted, labor to maintain the trees is minimal and no biomass transfer labor is required. Our economic and financial analysis combines ISFM and agroforestry, where the latter constitutes the organic soil fertility management element.

Using agroforestry and judicious amount of inorganic fertilizer, farmers begin receiving profits in the second year (Table 8) when the fast-growing *Faidherbia albida* leguminous plant is used (Garrity et al. 2010). Banana, grown only in Garissa, is the most profitable crop while the profits for millet and sorghum are low due to their low prices. They are staple food crops in all three counties and their production ensure food security. The results suggest high returns as the average marginal rate of return is 2. The results also suggest that there are financial and economic incentives to adopt ISFM – in which agroforestry is combined with inorganic fertilizer. The BAU option is no application of organic and inorganic fertilizer, against which NPV for the SLM practice is computed.

Table 8: Economic and Financial NPV for restoration of degraded cropland

	Millet	Sorghum	Banana
	NPV, (US$000), 20-year total		
ENPV, r=10%	11.8	11.9	24.2
ENPV, r=20%	5.6	5.7	11.7
FNPV, r=10%	7.1	7.3	21.6
FNPV, r=20%	2.8	2.9	10.2
Break-even year	2	2	4
IRR	12.1	12.1	18.5
MRR	2.3	2.3	4.0

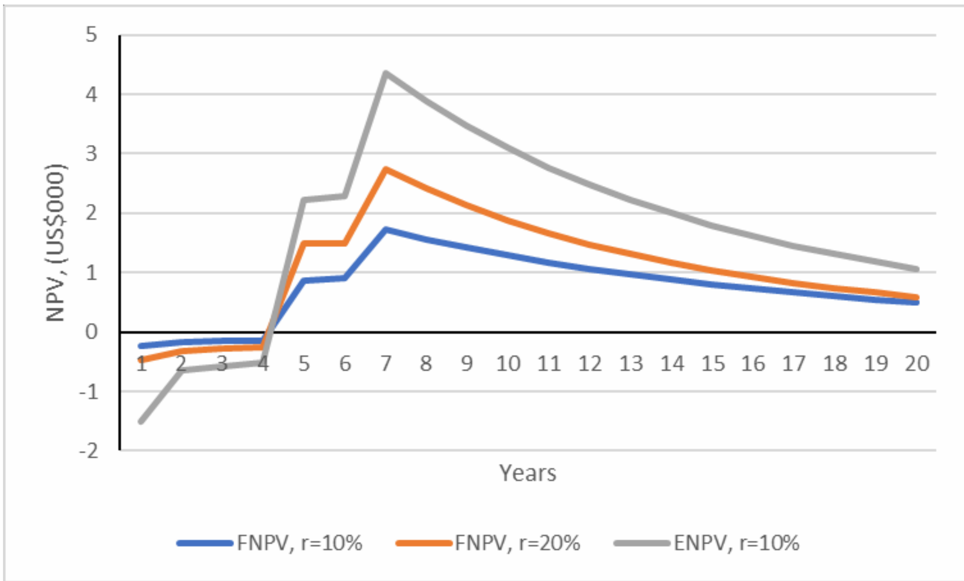
Notes: r = discount factor, MRR = marginal rate of return

4.3 Reforestation and afforestation

Tree-planting is a long-term investment which requires secure tree tenure for land users. Data on forest tenure indicates that almost all forests in the AOIs are owned by communities. This underscores the key role which participatory forest management will need to play in implementing forest restoration interventions.

Planting acacia trees to restore degraded forests is financially profitable. Farmers break even only in the fifth year – which poses adoption challenge for poor farmers who heavily discount future consumption. The results of the financial analysis show that there is strong incentive for planting trees provided the farmers can internalize the benefits. This is likely the largest challenge which could be addressed by ensuring that the farmers reap the long-term benefits of investing in planting trees. A successful example which could be emulated is the Nigerien Rural Code, which gave tree tenure to those who plant or protect trees.

Figure 18: Financial and economic analysis of reforestation and riverbank restoration



5 SPATIAL ANALYSIS

5.1 Methodology

MENR used option-specific criteria to identify opportunity areas for restoration. Additional criteria were added during the consultation meeting as part of this study. Table 9 summarizes the criteria and justification of restoration of forests, rangelands, croplands and riverbanks.

Table 9: Criteria for identification of restoration area by biome

	Criteria	Justification	Source
Rangelands	i. Environmental – precipitation, soils, topography, hydrology and floristic dynamics. ii. Fauna – wildlife and livestock numbers, distribution, population dynamics and habitat utilization. iii. Economical/political - land-use/cover type, projected land	Livestock sector in the ASAL home to about 30% of Kenya's human population; supports 50% of Kenya's livestock population and supplies 90% of the total meat consumed in the country.	- Consultation with stakeholders - MENR (2016)
Forests	i. Potential for natural regeneration of native trees – e.g. Acacia. ii. Protection of land with slope exceeding ≥35%; riverbank, lake and dam buffer zones.	- Bioenergy (woodfuel) accounts over 95% of cooking energy - Trees used for livestock browsing; building material, beekeeping, etc	- Consultation with stakeholders - MENR (2016)

Riverbanks	i. As above ii. Environmental law requires tree buffer zone of 30m for main river and 15m for secondary	- Water sources a most limiting natural resource in ASAL - Potable water and livestock watering	- Consultation with stakeholders - MENR
Croplands	i. Current cropland only ii. Exclude cropland areas with slope iii. more than 35% iv. Exclude protected areas	- Coarse grain cereal (millet and sorghum – are staple food crops – which ensure food security and livelihood di- versification - Potential for banana production and other horticultural	- Consultation with stakeholders - MENR (2016)

In this report, biome restoration potential means that there is the opportunity to significantly increase the productivity of the biome. Restoration potential does not necessarily mean a biome was degraded previously – but rather that productivity could be increased. Restoration could also mean expansion of a certain biome. This means restoration potential could exceed a degraded area of the same biome reported above.

5.2 Reforestation and afforestation

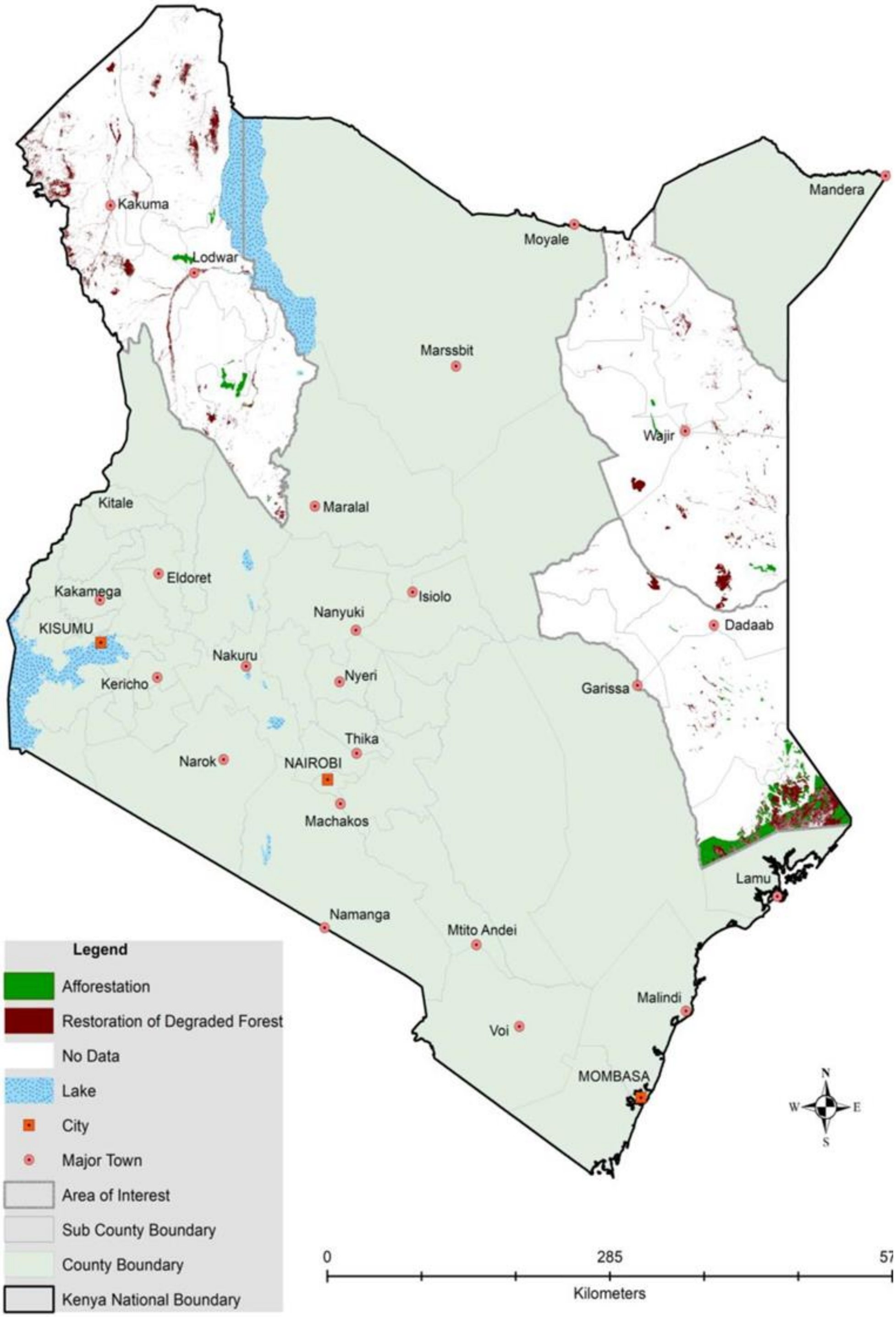
The total area with high potential for restoration is 136% of the current forest cover. Table 10 reports the restoration potential for forest and riverbanks in the sub-counties of the AOI. Map 6 shows where the reforest and afforestation areas are located. Among the three AOI counties, Garissa has the largest forest area (of currently 429,000 ha), which is 5.4% of its total surface areas. Ijara subcounty accounts for 92% of total county forest area. Turkana – the largest county by area in Kenya – has about 307,000 ha forest cover, which is 4% of Kenya's surface area. Wajir has the smallest area under forest cover, but the area with high potential for forest restoration at 150%. In all three counties, the area with high potential for restoration is greater than the current forest area. This suggests that there are other non-forest areas with high potential for afforestation and reforestation. Riverbank restoration is largely concentrated in Garissa (Table 10 and Map 6).

Table 10: Restoration potential of forest and riverbanks

Subcounty	Forest	Riverbank	Forest
	Extent (000ha)		Percent of current total biome area
Garissa County	**429.2**	**7.7**	**136**
- Balambala	0.8	0.3	100
- Daadab	2.1	0.5	246
- Fafi	19.9	4.4	126
- Garissa Township	0.7	0.1	99
- Ijara	394.6	1.7	143
- Ladgera	11.2	0.7	100
Turkana County	**306.9**	**3.8**	**132.7**
- Loima	49.3	1	125
- Turkana Central	19.2	0.7	179
- Turkana East	38.9	0.6	139
- Turkana North	71.6	0.1	98
- Turkana South	23.9	0.7	163
- Turkana West	104	0.7	92
Wajir county	**117.8**	**1.9**	**150**
- Eldas	3.7	0.2	361
- Tarbaj	15.6	0	100
- Wajir East	6.5	0.4	100
- Wajir North	12.2	0.4	95
- Wajir South	64.3	0.6	114
- Wajir West	15.6	0.4	128

Source: Authors – based on data processed by KFS (2013)

Map 6: Forest and riverbank restoration potential in the AOI



Source: Authors – based on data processed by KFS (2013)

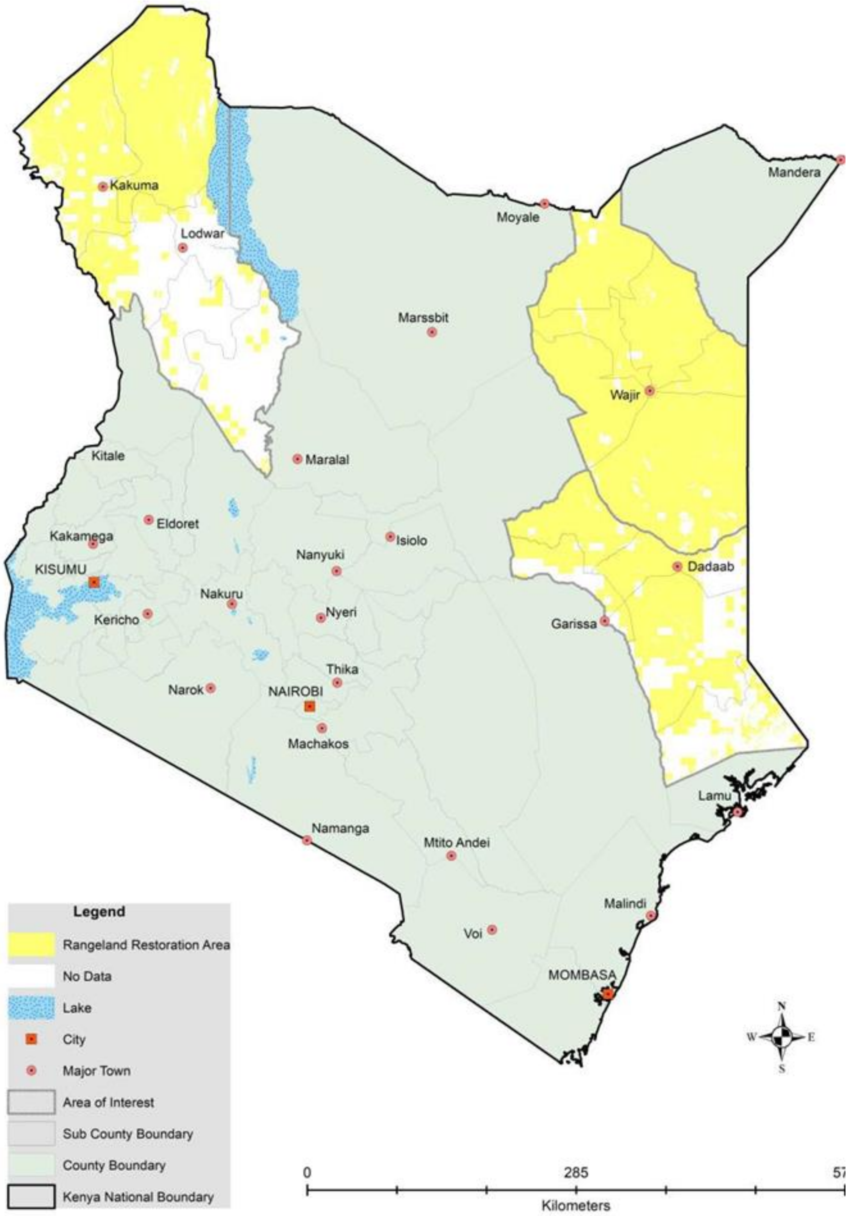
5.3 Rangeland restoration

An area equivalent to 99% and 65% of the rangelands in Wajir and Garissa, respectively, has high potential for restoration (Table 11). In Garissa, the central and north-western parts show particular potential (Map 7). The area with potential for rangeland restoration in Turkana is only 45% of current rangeland area. Map 7 shows this area concentrated in the northern and central part of the county. In Garissa and Turkana, areas which were under grazing lands are either not degraded or do not have potential for restoration using the rotational grazing or reseeding practices.

Table 11: Rangeland restoration potential at sub-county in the AOI

Subcounty	Extent (000ha)	Percent of total biome area
Garissa county	**2617.6**	**65**
- Balambala	247.7	5
- Daadab	440.3	6
- Fafi	991.9	6
- Garissa Township	39.2	6
- Ijara	296.7	4
- Ladgera	601.8	9
Turkana county	**3645.3**	**45**
- Loima	370.2	4
- Turkana Central	78.9	1
- Turkana East	123.7	1
- Turkana North	1786.2	9
- Turkana South	89.4	1
- Turkana West	1196.9	8
Wajir county	**5406.5**	**99**
- Eldas	389.5	9
- Tarbaj	917.4	9
- Wajir East	390.8	1
- Wajir North	803.9	9
- Wajir South	2035.7	9
- Wajir West	869.2	1

Map 7: Rangeland restoration potential



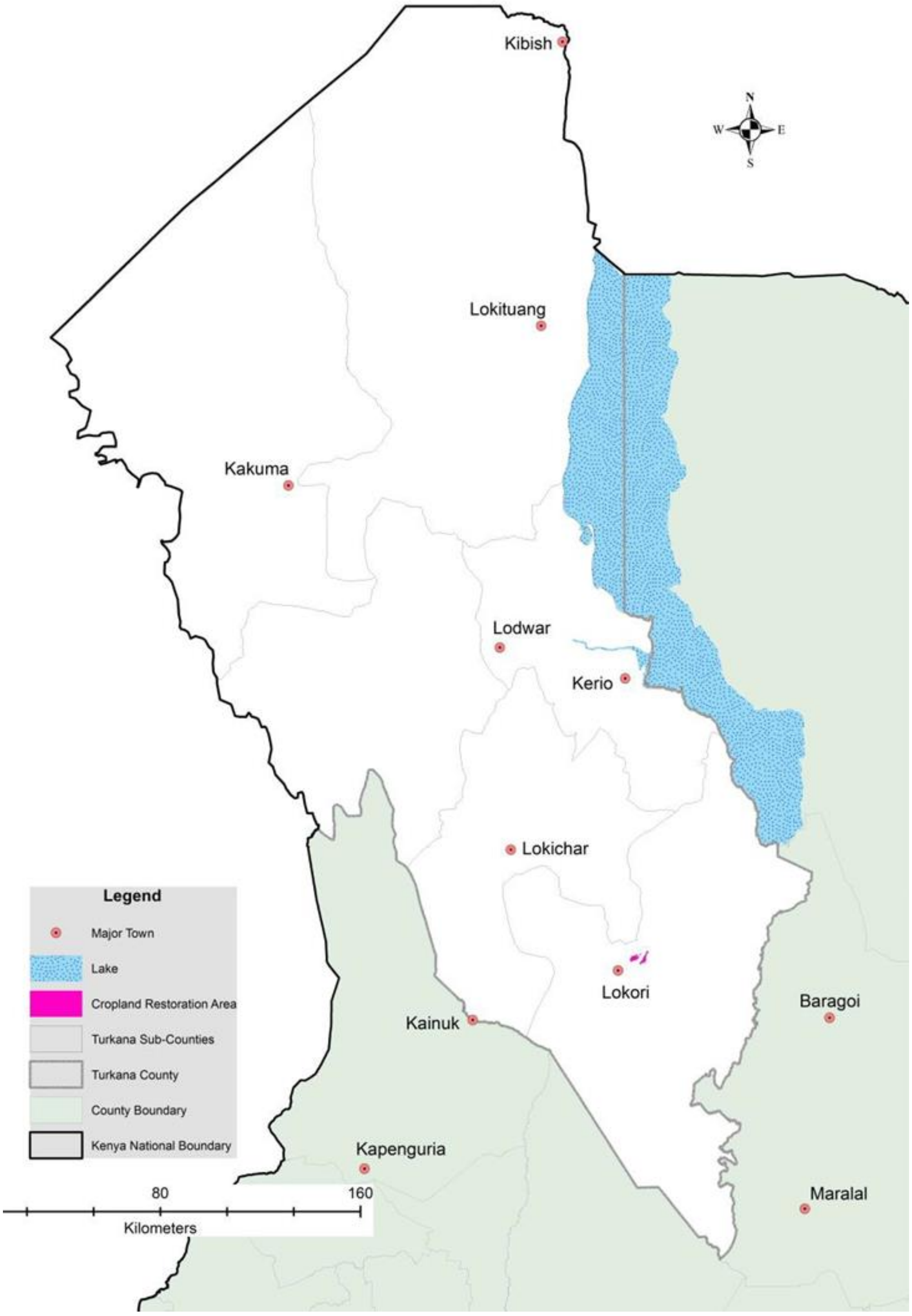
5.4 Cropland restoration

Crop production in the AOI is limited. Table 12 shows that Garissa has the largest cropland area, which is 5% of the county's surface area. However, banana occupies 65% of total cropland area and is detected as forest in the satellite imagery used. The extent of millet and sorghum area was too small to illustrate the area on a map. The area in Turkana under crop is only about 3% of total surface area (Map 8). Wajir has even a smaller cropland area – covering less than one percent of its surface area (which cannot be made visible on a map). As Table 4 shows, adoption rate of ISFM and agroforestry is in the AOI low – suggesting almost the entire cropland area is degraded and requires restoration.

Table 12: Cropland restoration potential in the AOI

	Garissa	Turkana	Wajir
Surface area (000 ha)	4359.4	6818.5	5681.9
Cropland area (000 ha)	219.7	186.8	12.3
Cropland area as percent of surface area	5.0	2.7	0.2
Adoption rate of agroforestry	0.0	0.0	4.3
Restoration potential (000 ha)	219.7	186.8	11.7

Map 8: Cropland restoration potential in Turkana County



6 LESSONS LEARNED AND PAST EXPERIENCE

This chapter examines policies and strategies related to land restoration implemented in the past. The cases offer useful lessons for future interventions.

Kenya dairy sector

Kenya has the highest per capita dairy production in SSA and its level is more than twice the SSA regional average (Ngigi et al. 2010; FAOSTAT 2008; Otte and Chilonda 2002). Early efforts of dairy development started from 1954 to 1962 – which was part of the import-substituting industrialization launched by the colonial government – with largescale dairy producers being the major beneficiaries. After independence in 1963, the government of Kenya implemented agricultural marketing policies and facilitated access to secure land rights to smallholder farmers in the fertile highlands. However, the government imposed significant government control – aimed at helping small dairy farmers. This posture was relaxed to create conducive environment for private dairy sector development (Ngigi et al. 2010). Additionally, the government invested in provision of artificial insemination, dips and other veterinary services. For example, the government established Kenya National Artificial Insemination (KNAIS) to support dairy farmers – a strategy which significantly increased adoption rate of improved dairy cows. The government also invested in research and advisory services to provide affordable production technologies. Dairy extension services provided advisory services on intensive dairy feeding systems including production of grass-legume forage animal feed supplement and crop-livestock synergistic interaction (Murethi et al. 1995).

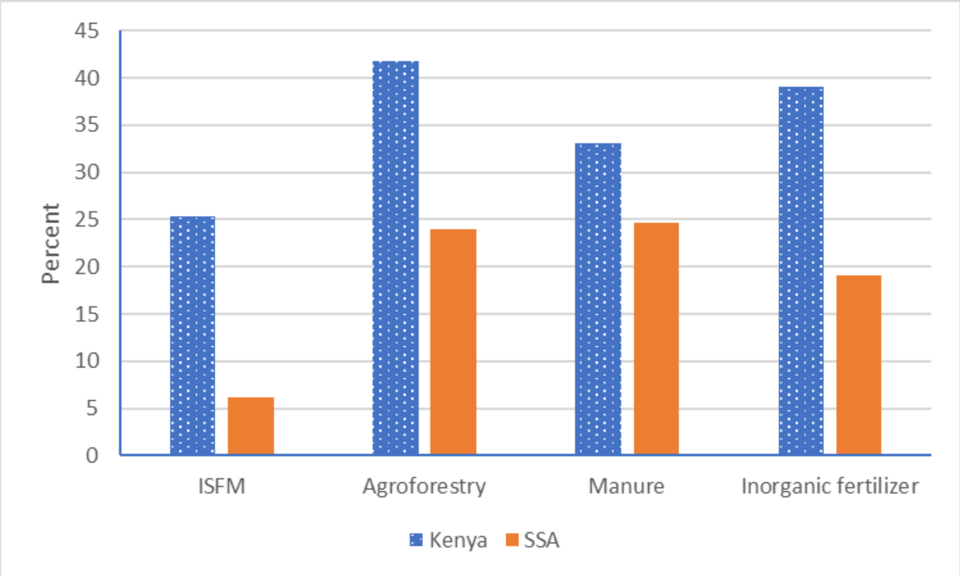
On marketing, Kenya Cooperative Creameries Ltd (KCC) – which was formed in 1931 – serves as the powerful cooperative for dairy farmers marketing services. KCC has built an elaborate milk value chain. To reduce spoilage of the highly perishable milk, KCC built chilling centers and processing centers in major milk-producing districts. The processing plants produce and package milk in different forms – fresh, condensed, ultra-heat-treat long shelf life, butter, ghee, cheese and fermented fresh milk. One of the iconic government regulation strategies to help integrate smallholder dairy farmers in the value chain, was to accept milk from all producers who meet minimum quality standards (Ngigi et al. 2010). However, marketing reforms in 1992 abolished KCC's monopoly and paved the way for private companies and cooperatives to participate in the milk value chain (Ibid). The competition further improved the milk value chain performance as 45 private dairies and 150 cooperative milk processing plants were formed. It is estimated that there are 1.8 million smallholder dairy farmers – who produce 56% of the 5.2 million liters annually since 2012 (FtF 2018). The private sector milk businesses and cooperatives have expanded to support the small to large dairy farmers. There are more than 200 milk cooling and bulking plants – which serve the key role of reducing spoilage (FtF 2018). There are 92 dairy processors – who are vertically linked with dairy producers – buying milk with legally binding terms and conditions (Ibid). The two largest processors are Brookside and New KCC – which account for approximately of 75% of the raw milk market (Ibid).

Important lessons can be drawn from the Kenya dairy success story. The land tenure security, which was initiated soon after independence in 1963 and the elaborate milk value chain development – centered on the competitive sector – have been the major drivers of a successful dairy sector in Kenya.

Soil fertility management practices in western Kenya

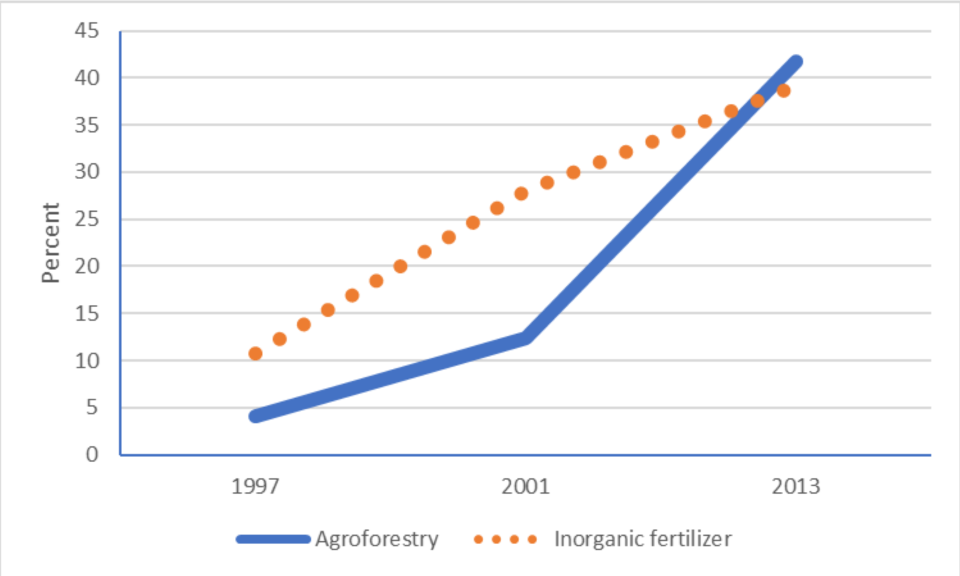
Excluding South Africa, Kenya has one of the highest adoption rate of soil fertility management practices in SSA (Figure 19). The adoption rate of agroforestry has increased dramatically in the past 20 years and by 2013, it has surpassed the adoption rate of inorganic fertilizer (Figure 20).

Figure 19: Comparison of adoption rate of soil fertility management practices in Kenya



Source: Extracted from Table 2

Figure 20: Trend of agroforestry and fertilizer adoption rate in Kenya, 1997-2013



Source: Computed from Place et al. 2013.

The high adoption rate of soil fertility management practices has largely been driven by improved market access, pluralistic agricultural extension services – involving more than 12, 000 active NGO advisory services (Anderson 2017); and national and international research organizations (Haggblade et al. 2010). Active research and extension efforts by ICRAF on agroforestry, CIMMYT, CIAT and ICRISAT – in collaboration with national agricultural institutions – significantly contributed to development and dissemination of soil fertility management practices in Kenya. Additionally, the soil fertility management practices developed, significantly increased yield and were acceptable among the smallholder communities (Haggblade et al. 2010). As shown before, improved soil fertility management practices lead to much higher yield and profit than traditional land degrading management practices. And as illustrated by the famous study "more people, less erosion" in Machakos (Tiffen et al. 1994), access to markets has significantly contributed to higher uptake of improved soil fertility management practices in Kenya (Boyd and Slaymaker 2000).

Farmer-managed natural regeneration (FMNR)

FMNR approaches have been shown to be cost-effective and their adoption rate is high – if appropriate advisory services are provided to encourage communities to practice them. Studies in Kenya have shown that FMNR has been very successful in the ASAL region. FMNR is appropriate for the resource-poor pastoralists since it is cheap, rapid, farmer led and implemented, and uses local skills and resources (World Vision 2018). Studies done in Niger under comparable pastoral farming systems showed that FMNR increased pastoral household income by US$6/ha (Garrity et al. 2010). Another appealing feature of FMNR is that it is an indigenous knowledge and farmer to farmer advisory service that has been one of the leading channels of FMNR diffusion (Taylor 2011; MURIUKI 2017).

As demonstrated in Niger (Moussa et al. 2016), tree tenure is also crucial for widespread adoption of tree planting and protection. It is important to use indigenous trees to minimize the low survival rates of exotic trees. It is equally important to avoid introduction of invasive species, which could alter the ecological systems of the ASAL. For example, *Prosopis juliflora* tree (locally known as 'Etirae' in Turkana) – native to South America – was introduced in the ASAL in Kenya in the 1970-80s to help with rehabilitation efforts. *Prosopis* has a very aggressive growth habit - making it very difficult to eradicate after establishment. Currently, *Prosopis* covers over 1.5 million ha in 15 counties in Kenya – including all AOI – and continues to expand exponentially (Choge et al. 2010). It has reduced pasture production on grazing lands and rangelands and has cause loss of biodiversity among others.

Group ranch development and destocking campaigns

As an effort to commercialize pastoral production and consequently high reduced stocking rates among pastoral communities, the government of Kenya initiated group ranching to provide tenure security and to incentivize Maasai pastoralists to invest in rangeland improvement (Mwangi 2001; Rutten 1992). The Land Groups Act was passed in 1968 to provide legal framework for ranch operation. Through the Kenya Livestock Development Program (KLDP), dips, stock handling facilities, fire breaks and water resources were developed in areas deemed central to the group ranches. Pastoralists were also given loans and extension services (Ibid). The government sought to enhance land tenure security by converting the traditional communal grazing land ownership to smaller ranching groups, each of which were given a land title. Stocking rates were also restricted by allocating grazing quotas to ensure carrying capacity of rangelands is not exceeded (Ibid).

A study done by White and Meadows (1981) found that Group ranch development had minimal impact on livestock commercialization and destocking. Stocking rate increased – leading to more severe degradation (Mwangi 2001). One of the reasons for failure of group ranching was the limited understanding of the deep-seated tradition of keeping large herd of cattle for a host of non-economic objectives. Among the non-economic objectives of keeping large herds are: as a status symbol of wealth, clout in community, paying dowry, and other traditions. The economic reasons are also diverse. Livestock serve as insurance against shocks – under which livestock is liquidated to pay for emergence needs. Livestock serve as a "live" bank. For example, Kamuanga et al. (2008) estimates that livestock accounts for more than 50% of capital held by rural households in SSA. Maasai pastoralists regard selling livestock as selling wealth to buy poverty (Rutten 1992). The lesson from this failed effort is the importance of seriously considering indigenous knowledge when planning interventions.

Fertilizer subsidies to promote adoption of SLM in the ASAL

Crop subsidies in Kenya are mainly targeted to maize farmers. Kilimo Plus subsidies started in 2007 and targeted poor maize farmers by providing them with 100kg of fertilizer and 10 kg of improved maize seed (Mason et al. 2015). By 2012, Kilimo Plus had reached 63,737 farmers or about 2% of the 3.52 million rural households in Kenya but given that the target was maize farmers, only few farmers in the ASAL were beneficiaries. However, the maize price support, which increased maize price to an artificial level and encouraged farmers in the ASAL to grow maize, could have increased production risks and compromised security (Kamau et al. 2012; World Bank 2015). A study by Makau et al. (2016) also showed that fertilizer subsidy in Kenya crowds out commercial development of fertilizer marketing. Fertilizer subsidies reduced farmers' propensity to buy fertilizer from open market by 30%. One kilogram of subsidized fertilizer displaces 0.2kg of commercial fertilizer. Other methods of incentivizing adoption of land restoration techniques are required.

7 POLICY RECOMMENDATIONS

This chapter summarizes the discussion in the previous chapters and concludes by proposing policy recommendations. The spatial analysis shows severe land degradation on rangelands, forests, riverbanks and cropland. The economic analysis clearly shows high returns to adoption of land management practices which restore degraded rangelands, forests, river banks and croplands. However, the low adoption of land restoration practices illustrates that the financial incentives are only part of other requirements for adoption of land restoration practices. Farmers mostly lack knowledge of the proposed measures and are very reluctant to make new investments in the current high risk environment. The policy recommendations below discuss the incentives required to increase adoption of land restoration practices and gaps in the current policies and institutions. The table below structures government interventions and associated gaps that this study identifies as well as lists policy recommendations to address those gaps.

Table 13: Gaps in current government interventions and policy recommendations

Major Government Policy/Strategy		Policy Recommendations
Policy/Strategy	**Gaps**	
Subsidies targeting poor farmers	• Traditional ranching not receiving significant public investment – e.g. promotion of ex- port • Crops grown in ASAL do not receive as significant an investment as maize does	Create/increase incentives for restoration of degraded lands
Decentralization	• Administrative units below county do not have mandate to enact and enforce natural re- source management regulations. • Customary institutions are not fully utilized.	Create institutional environment and rural services conducive for investments in land improvement
• Vision 2030, develop world-class infrastructure • Ministry of Northern Kenya and Development of other Arid Areas – Enhance rural services	• Investment in livestock services still limited • Road density in ASAL is lowest • Extension services weakest in ASAL • Water development for live- stock limited • Weak support of farmer groups	Enhance rural services

Major Government Policy/Strategy		Policy Recommendations
Policy/Strategy	Gaps	
• National Drought Management Authority (NDMA) • Kenya National Agricultural Insurance Policy Taskforce • Reduce cattle rustling by disarmament	• No masterplan for Integrated Watershed Development and Management (IWDM) for livestock • Disarmament strongly correlated to higher frequency of cattle rustling	De-risking livelihoods (major risks include drought & cattle rustling)

Create incentives for investment in land restoration

Incentives for restoration of degraded lands need to increase. Current subsidy programs have not been successful in increasing the adoption of rangeland, forest and cropland restoration practices. It is imperative to re-examine the subsidy approach and to even reorient it towards payment for ecosystem services (PES). The PES could be an effective incentive to adopt tree planting – especially on public land like riverbanks, communal grazing area and on private land.

Create an institutional environment that is conducive for investments in river basins

Due to the dynamic nature of river water and given that its course passes across more than one county, implementation of riverbank restoration will require a riparian approach. Planting trees and other strategies for protecting riverbanks has direct benefits to all who use river water resources. Additionally, beneficiaries and stakeholders along the river basins have different types of water uses. This suggests the need for all stakeholders to be involved in the planning process and if possible pay for the ecosystem services for those who invest in riverbank protection. This calls for appropriate national and county level legislation and support to ensure such plans and subsequent investments are acceptable and strongly supported by legislative instruments to safeguard them against potential conflicts, free-riding and other vices. Integrated water resource management (IWRM) in which catchment or riparian approach is used (GWP 2000; Mtisi and Nicol 2013) is recommended. IWRM is based on coordinated approach to water development and management (including land and related resources) with the objective of equitably and simultaneously maximizing economic and social welfare without compromising ecosystems (GWP 2000).

Enhance rural services

Priority should be given to enhance the effectiveness and reach of the extension service. This will require increasing the number, diversity and capacity of extension agents to provide advisory services on CSA, ISFM, pasture management and other SLM practices. A specific challenge in the ASAL/AOI is also the relatively low population density and the mobility of the pastoralists. Hence, there needs to be sufficient resource allocation for ensuring mobility of extension agents. Further, extension agents need to be adequately incentivized to work in the remote areas of the AOI/ASAL.

Content and quality of advisory services offered to farmers needs to improve. Surveys illustrate the weak capacity of extension agents to provide advisory services on CSA, ISFM, rotational grazing, water harvesting and other practices. For example, only 32% of extension agents promoted organic soil fertility management practices. For pasture management, the results show a lack of emphasis on livestock management practices. Given the water deficit challenge in the ASAL, it is important to promote agricultural water management (AWM) practices. AWM will significantly reduce crop and livestock production risks in the ASAL and enhance food and nutrition security. For extension agents who are already in services, short-term training is required to increase their capacity to provide up-to-date knowledge for restoration of rangelands, CSA, RWHM and other SLM practices. Agricultural college curriculum also needs to include these practices in their training to equip future advisory service providers. Griftu Pastoralist Training College – which has recently been converted into a full-fledged livestock training institute and research centre – is an excellent example of the recent effort to support pastoral production systems in the ASAL. The World Bank provided US$2 million for training extension agents for pastoralists.

Indigenous knowledge should be exploited. There is need for conducting studies to document the indigenous knowledge of rangeland management and use them to provide advisory services. Given climate change and other emerging external factors which challenge use of some indigenous knowledge practices, there is need to discuss how some of the indigenous practices can be adapted and used complementary to innovative technologies and practices. One example is insurance which is discussed in the next section.

In addition to increasing the number of public extension agents, efforts need to be undertaken to increase the diversity of service providers. Other SSA countries have shown promising results in increasing service provision by private agents and NGOs. This could be done by increasing the capacity building of agricultural input traders to provide technical advisory services. Survey results show that private agricultural input traders reach more farmers than the formal providers.

While this diversification of service providers is encouraging, it has to be ensured that private agents also receive adequate training. In addition, strong regulatory mechanisms are required to ensure that private companies do not give biased advisory services with the aim of promoting their products which could be inferior or not required by farmers. A close follow-up done by extension agents and other technical government officials will help to regulate private agricultural input traders.

Another approach to deal with the sparse population and mobility of pastoralists is the increased use of modern ICT to spread relevant information. An example is a SNV program for improving pastoralist production and marketing through farmer groups. The program included a mobile application which disseminates price information and other useful information to pastoralists in Isiolo County in northeastern Kenya. As a result, income of participants increased by about 35% (SNV 2012).

De-risk livelihoods

There is need to reexamine the current approach of disarming pastoralists as it does not seem to work. The same approach used to resolve Maasai-Sukuma conflicts in Tanzania could be used to end the cattle rustling in the ASAL. However, the transboundary nature of cattle rustling and conflicts creates a much more complex environment. The Intergovernmental Authority on Development (IGAD) countries program needs to increase efforts to address this challenge. The World Bank has invested about US$70 million in its Regional Pastoral Livelihoods Resilience Project (RPLRP) – which covers all AOI counties in Kenya. One of the components of the RPLRP is resolving cattle rustling and other conflicts. This implies the need to use more protracted efforts to end these conflicts.

Market-driven livestock insurance should be promoted. There is a need for facilitating development of the Index-Based Insurance (IBLI) to ensure its high acceptability and fully commercialize it. In partnership with the World Bank, ILRI is working with the Kenya National Agricultural Insurance Policy Taskforce to fully commercialize IBLI on a largescale. The well-established pastoral communities and their customary institutions could be exploited to increase acceptability of IBLI. On the supply side, there is need to use aggregators and guarantors could further enhance the IBLI market. Such an approach has been used successful by the Grameen Bank (Yunus 1999).

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9 ANNEX

Annex 1: Analytical methods for analyzing drivers of adoption of land management practices for restoration of degraded lands

Drivers of adoption of ISFM and other soil fertility management practices

We use a probit model to estimate adoption of ISFM:

$Y^* = \Phi{-}1(Y) = X\beta_1 + \varepsilon$,

Where Y* is a latent variable representing adoption of ISFM, given by

$$Y = \begin{cases} 0\ if\ Y^* \leq 0 \\ 1\ if\ Y^* \geq 1' \end{cases}$$

Φ is a normally distributed cumulative static with Z-distribution, i.e. $\Phi(Z)\epsilon(0{,}1)$,

X is a vector of drivers of adoption of ISFM practices; and β_i is a vector of associated coefficients i, i=1, 2. $X\beta$ ~N(0,1); ε is an error term with normal distribution, i.e., ε~N(0,1).

Given that some right-hand side variables are potentially endogenous to adoption decision, we check robustness of our results by estimating both structural and reduced model equations. Choice of X vector variables is driven by literature[2] and data availability.

The empirical model estimated is:

$ISFM_i = \beta_0 + \beta_1 HC + \beta_2 PC + \beta_3 SC + \beta_4 RS + e_i$

Where:

ISFM=1 if household i has adopted ISFM.

HC = human capital – includes household endowment of skills, knowledge and experience that drive productivity (e.g. education, age (an indicator of experience), sex of household head or plot owner); PC expresses physical capital including ownership of livestock, productive assets, type of building material, and so forth; SC encompasses social capital, mainly including membership to farmer associations or other productive groups; RS stands for rural services including proximity to all-weather road and markets.

Annex 2: Cost benefit analysis methodological approach

We conducted the cost-benefit analysis (CBA) following the World Bank (2012) approach. The economic CBA analyzes the costs and benefits of an investment after netting out policy distortions. The most common distortions include tariffs, export taxes and subsidies, excise and sales taxes, production subsidies, and quantitative restrictions. Economic analysis also takes into ac- count social benefits and costs of projects. Shadow prices of goods and services are used for goods and services which are not marketed. The economic prices used are the export parity prices – which is the free-on-board (FOB) price of a good or service at a point of export

[2] Please see Nkonya et al. (2008) and Di Falco (2014) for a review.

when the associated taxes, subsidies, and domestic transport costs are netted out (World Bank 2012). However, if the country is a net importer, the appropriate economic price import-parity price – which is the CIF price of imports and the associated domestic transport cost (Ibid).

The financial analysis is simpler as it uses market prices of goods and services and associated financial flows entity. It does not attach shadow prices to in-kind goods and services such as family labor, manure produced by livestock owned by farmers, etc. Our analysis focuses on restoration practices in rangelands, forests and croplands. The products and associated economic and financial prices are reported in Table A 1. As part of efforts to determine economic prices, we analyzed the import and exports of livestock, banana, millet and sorghum. We also analyzed the subsidies and taxes. Figure A 1 and Figure A 2 show that Kenya does not export or import a significant volume of livestock or the three crops. It is for this reason that a similar study done by the World Bank (2017) in the ASAL region of Kenya assumed all four commodities are autarkic - i.e., traded locally, and only financial prices are used for the economic analysis. As shown in Table A 1 however, we net out the taxes to get the economic prices. There are no subsidies for all four commodities. As discussed earlier, fertilizer subsidies targeted maize, thus we do not include maize in our analysis since the area under maize is still very limited in all three AOI counties. The distortion considered in this case are the county level taxes reported in Table A 1.

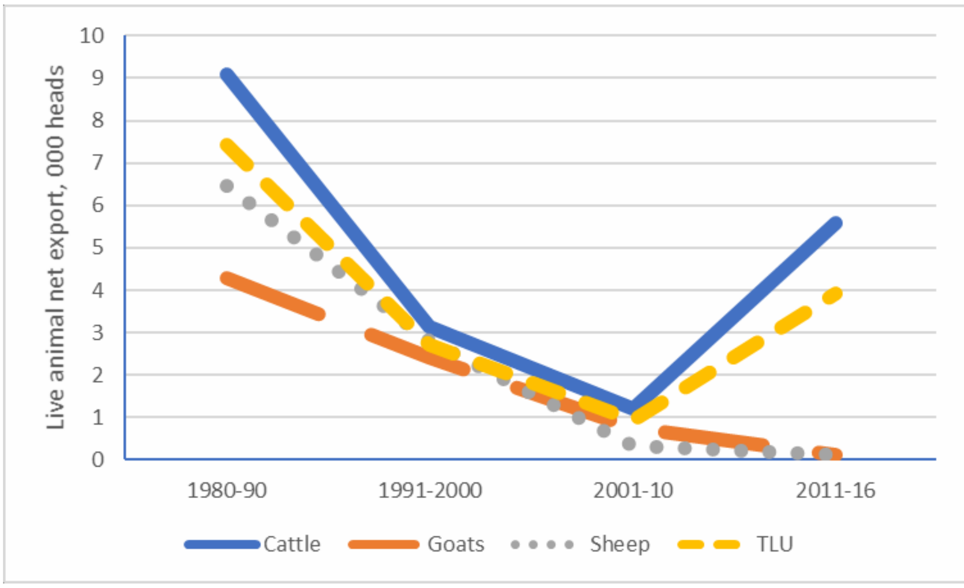
Table A 1: Financial and Economic prices of goods and services used in the CBA

Biome	Products	Market distortions	Unit price	Prices (US$)	
				Economic	Financial
Rangeland	Live animal				
	• Cattle	US$2/head sold	US$/head	202	200
	• Shoats (Goat & sheep)	US$0.75	US$/head	75.75	75
	• Milk	10% of value sold	US$/liter	1.1	1
Major crop in each county (with % of total cropland in brackets)					
- Garissa	Banana (30%)	5% of value sold	US$/ton	80.75	85
- Turkana	Millet (67.5%)	5% of value sold	US$/ton	157.7	166
- Wajir	Sorghum (57.8%)	5% of value sold	US$/ton	157.7	166
Forest					
	Value of forest per ha		US$/ha		2352.06
			US$/ton of CO_2- equiv	7.00	
Daily rural wage rate (US$)				3.5	

Rural wage rates – county officials and key informants

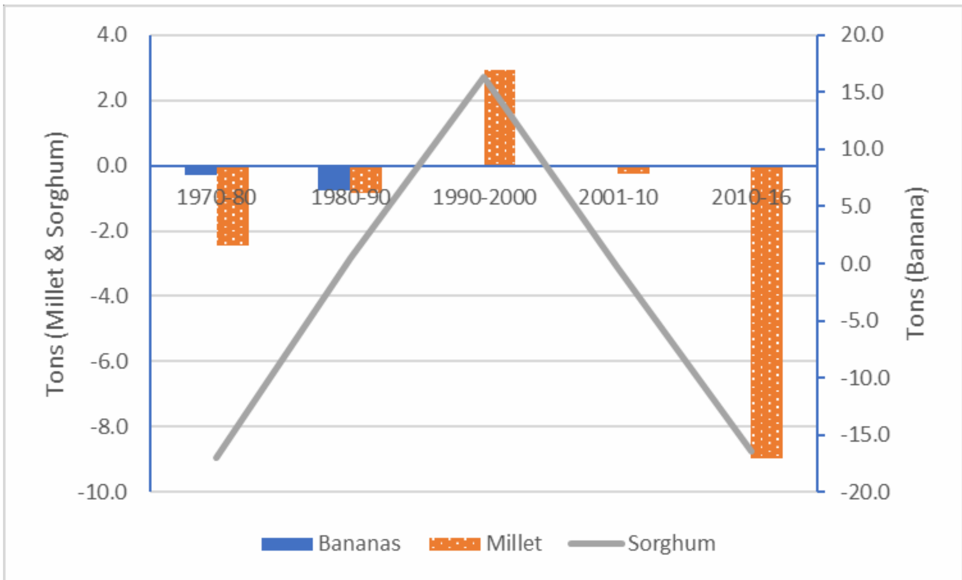
Sources: Commodity prices & taxes– county government data & interviews with county officials.

Figure A 1: Live animal export trend



Source: Calculated from FAOSTAT raw data, http://www.fao.org/faostat/en/#data

Figure A 2: Net export crops (1970-2016) grown in AOI counties



Annex 3: Opportunities and challenges of provision of extension services in Kenya

Table A 2: Providers of different extension services in AOI and other areas

	AOI	Semi-arid	Sub-humid & humid	Kenya
Advisory service provider	Percent of service recipients			
Any agricultural extension service				
• Agro-vet dealer	0.0	5.2	9.4	8.1
• Research Institute	0.0	6.0	3.6	4.1
• Government extension	91.5	68.5	71.8	71.3
• Commodity cooperative	0.0	5.4	2.2	3.0
• SACCOS	0.0	0.6	0.7	0.7
• Private company	0.0	5.4	6.8	6.3
• NGO	8.5	6.0	3.7	4.4
• Farmer-to-farmer	0.0	1.3	0.6	0.8
• Others	0.0	1.6	1.1	1.3
Climate early warning provider				
• Agro-vet dealer	0.0	1.2	1.9	1.6
• Research Institute	13.0	3.1	2.6	3.0
• Government extension	13.0	12.5	19.0	16.9
• Commodity cooperative	0.0	2.0	2.9	2.6
• SACCOS	4.3	0.2	0.3	0.0
• Private company	0.0	5.5	3.3	4.0
• NGO	13.0	0.4	2.4	1.9
• Faith-based organization	0.0	1.8	0.8	1.1
• Media	62.5	58.0	58.8	62.5
• Others	0.0	3.3	2.0	0.0
Output markets				
• Agro-vet dealer	3.1	5.3	4.7	4.8
• Research Institute	1.5	1.6	1.9	1.8
• Government extension	26.9	33.2	35.6	34.7
• Commodity cooperative	0.0	7.8	6.9	7.0
• SACCOS	0.0	1.9	1.8	1.8
• Private company	43.1	26.0	17.6	20.6
• NGO	4.6	0.1	0.9	0.8
• Farmer-to-farmer	20.0	20.7	26.7	24.9
• Others	0.8	3.4	3.8	2.8
Veterinary services				
• Agro-vet dealer	34.3	24.9	28.1	27.6
• Research Institute	1.4	1.8	2.2	2.1
• Government extension	54.5	29.2	28.6	29.5
• Private company	0.7	41.3	37.6	37.4
• NGO	1.4	0.4	1.4	1.1
• Farmer-to-farmer	7.7	1.1	1.0	1.2
• Others	0.0	1.4	1.1	1.1

Source: Calculated from the Kenya Agricultural Sector Household Baseline Survey, 2013

Table A 3: Number of farmers served by one public extension agent in SSA

Country	Number of farmers (000) served by one public extension agent
Zimbabwe	1.50
Ethiopia	1.64
Sierra Leone	5.16
Kenya	5.97
Malawi	6.16
Rwanda	6.83
South Africa	8.71
Ghana	9.77
Zambia	11.46
Liberia	16.09
Mozambique	23.11
Sudan	37.81
Cameroon	53.48
DRC	82.20
Nigeria	205.93
Sub-regional average[a]	
• Central Africa	67.84
• East Africa	10.78
• Southern Africa	10.19
• West Africa	59.24

[a] Based on countries with available data

Source: Computed from Swanson and Davis 2014

Annex 4: Indigenous knowledge

One common practice of indigenous pastoral rangeland management is enclosures or forage banks, which are widely used in SSA and in the Kenyan ASAL. Enclosures are not grazed during the rainy season to allow grass to grow for use in the dry season when there is a shortage of forage in the surrounding rangelands (Angassa and Oba, 2010; Verdoodt et al. 2009). Enclosures reduce pressure on grazing lands, restore and preserve degraded forage, conserve biodiversity, improve soil ecology, improve restoration of soil, and prevents soil erosion and environmental degradation in general (Abate et al. 2010; Kamwenda, 2002). Research has shown that the restoration of degraded rangelands through the use of enclosures has positive effects on biodiversity (Verdoodt et al. 2009; Oba et al. 2001; Abebe et al. 2006). Moreover, enclosures have the potential to contribute to carbon sequestration. For example, in the *ngitili* (enclosures) of north-western Tanzania, approximately 23.2 million tons of carbon has been sequestered between 1986 and 2002 with a value of approximately US$213 million (Barrow and Shah, 2011). The nomadic livelihood practiced by pastoral communities in the ASAL is also meant to allow grasslands to recover and to utilize the different spatial and temporal pasture and water availability (Reid et al. 2016). Mapinduzi et al (2003) reports the Maasai pastoralists in East Africa have rich indigenous knowledge on biodiversity, forage suitability and carrying capacity. For example, Ellis et al (1984) found that the Turkana pastoral communities sustainably harvested wood biomass by selectively cutting trees that they deem causing minimal harm to sustainability of woodlots. Another study showed that Turkana pastoralists use some plant species to assess grazing suitability and carrying capacity during dry and wet seasons (Oba 2012). Additionally, they assess livestock production performances using milk yield, body hair condition, weight gain and mating frequency, all of which have scientific basis (Ibid).

Table A 4: Names of month in Turkwana language (in Turkana County) and their meaning

Month	Turkwana name of month	Origin Turkwana word from which it is derived	Meaning
January	Lomaruk	Akimaruk	Verb meaning formation of clouds, which is an early warning sign of an impending rainfall.
February	Lochoto	Akimaruk,	then comes rain. This is the month of rain. All the places become muddy
March	Titima	Akititimare	The process of pasture germination. During this month there is plenty of grass for livestock
April	El-el	Akielarr	To scatter. Botanically it means to blossom
May	Losuban	Akisub	To make. This is the month of ritual-festivities, i.e Akidodore Akisichumanakin, Akiuta/Akuuta etc. Farmers on their part Conduct 'Harvest festivals' around the same month.
June	Lotiak	Akitiak	To divide or separate. This is the month that divides the wet Season and the dry season
July	Lolong'u	Along'u	Arid, dry land, desert (Adesate). This is the month of livestock Movement in search for pasture and water. People and livestock experience hot temperatures
August	Lopo	Akipore	To cook. This is the lean month, in which people resort to Gathering of wild fruits and cooking wild berries and drawing blood from animals (edung or edapal)
September	Lorara	Araraun.	This is the month when the trees shed their leaves. It is the month of extreme hardship where people use hooked sticks (Eseger to shake acacia trees to get dry leaves (ng'atur) and dry seeds (ng'itit) for both people and their animals.
October	Lomuk	Akimuk.	During this month, the sky is covered by scattered clouds and short rains begin to fall.
November	Lokwang	Ekwang,	Bright – the month of sunshine and wind.
December	Lodunge	Adudung'iar	To fall. The month marks the fall of dry season and rise of wet season.

Annex 5: Comparison of Wajir county and national level budget allocation

Figure A 3: KES6.76 billion Budget Allocation for Wajir County, 2014/15

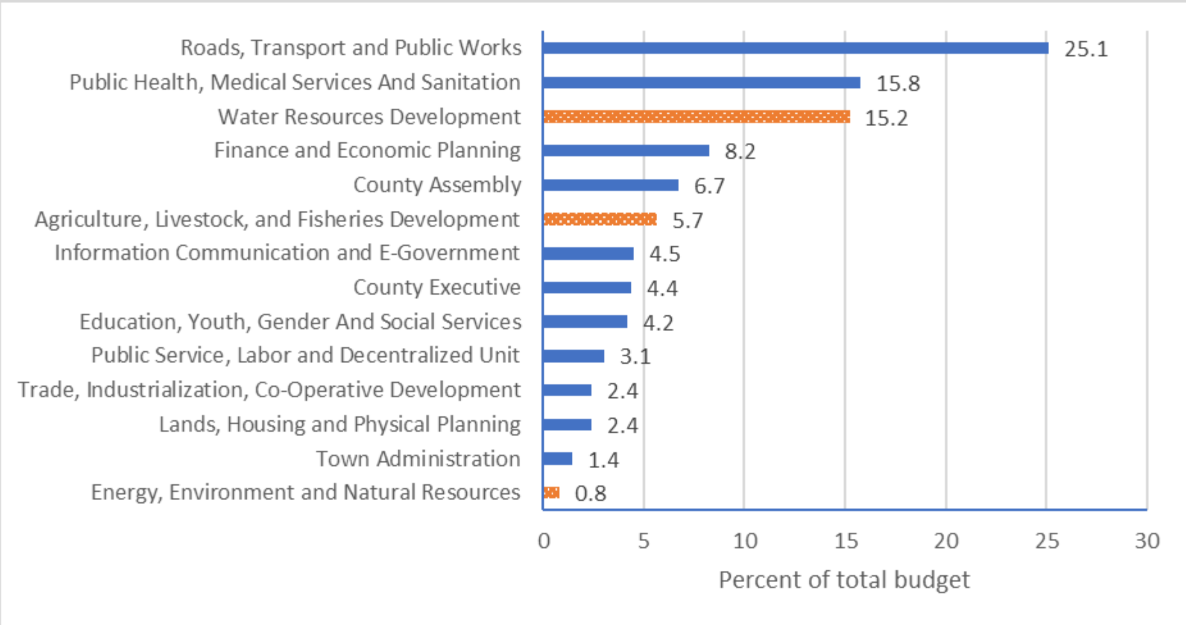
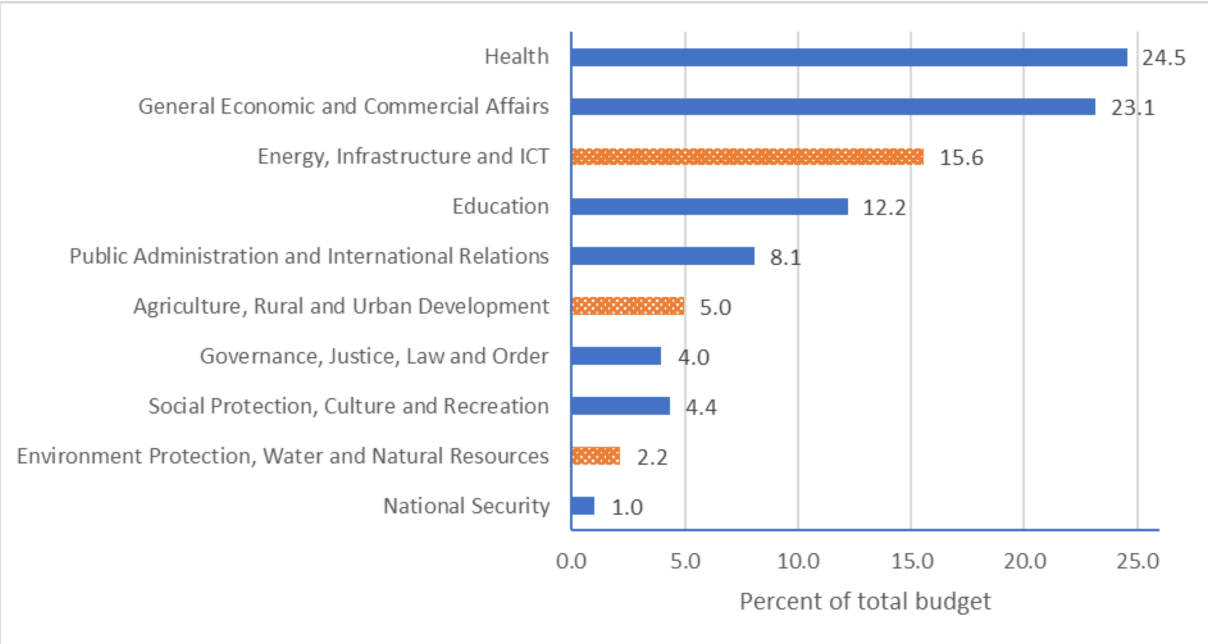


Figure A 4: KES 1,498 Billion National Budget for 2016/17



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