MASTER THESIS- NATURAL RESOURCES MANAGEMENT AND DEVELOPMENT

TH Köln-University of Applied Sciences-Institute for Technology and Resources Management in the Tropics and Subtropics

and

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IMPROVING HUMAN-WILDLIFE CO-EXISTENCE
LANDSCAPE LEVEL STRATEGIES TO ENHANCE WILDLIFE MOVEMENT IN AMBOSELI-TSAVO ECOSYSTEM, KENYA

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Abstract

Amboseli-Tsavo Ecosystem is a unique landscape in Kenya's semi-arid rangelands to the border of Tanzania. It is characterized by high abundances of wildlife which frequently disperses between three National Parks, namely Amboseli, Tsavo West and Chyulu Hills. Due to an increased population and a land-use change from prior nomadic pastoralism to sedentary farming activities, the land became highly fragmented and transformed into a human-dominated area. Increasingly wildlife migration routes are becoming blocked, leading to isolation of the National Parks and multiplied human-wildlife conflicts. The African elephant (*Loxodonta africana*) is sadly famous as the most common conflict animal causing damage to properties, cropland and injuring or killing livestock and, in the worst case, people. However, elephants are at the same time a flagship species and represent the backbone for tourism activities around Amboseli. Therefore, the elephant is both a very valuable and problematic asset in the area. Unfortunately, wildlife conservation practices over the last decades, favoring animals over humans, have led to a negative perception of wildlife among the population in the ecosystem which challenges appropriate conservation mechanisms.

To maintain the tourism attraction of viewing elephants and to minimise the conflicts between local communities and animals, migration routes should remain open. The concept of landscape connectivity ensures biodiversity conservation, particularly for far-distance migration animals such as elephants. The elephant was therefore chosen as a keystone species in this study on which the analysis is based.

Using a least-cost path analysis (LCP) in ArcGIS, "cheapest" travel routes of *Loxodonta africana* between the three National Parks were identified. Factors included were selected and weighted by information gathered in expert interviews. Satellite imagery were classified using ESA SNAP toolbox to obtain vegetation covers and waterbodies for two different seasons (dry and wet), aiming to illustrate the temporal variability of potential connectivity paths. Additionally, key informant interviews and interviews of Group Ranch members around Amboseli National Park were conducted to gather information regarding the current state of management in the ecosystem and perceptions about wildlife management. A subsequent SWOT Analysis on three optimum routes obtained through LCP, takes the social-political factors and information obtained into account to discuss the different options for their conflict solving potential.

On the one hand, recommendations resulting from this study identify possible elephant migration routes that should be maintained by using a participatory conservation approach to secure landscape

connectivity in long-term. On the other hand, management recommendations include a design for improved relationships between Group Ranch members and the responsible governmental institutions by equally distributing benefits, implementing financial benefits and establishing a functioning and adequate compensation scheme. By ensuring peoples' active participation in conservation and wildlife management, a more positive attitude towards wildlife might be induced, which will positively influence the wildlife conflict in long run.

Key words: Human-Wildlife Conflict, Least-Cost Path Analysis, Sentinel-1 and -2, African elephant, Analytical-Hierarchy Process, Connectivity

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Explanations of Abbreviations

ACC	African Conservation Center
AEMP	Amboseli Ecosystem Management Plan
AERP	Amboseli Elephant Research Project
AET	Amboseli Ecosystem Trust
AHP	Analytical Hierarchy Process
ATE	Amboseli Trust for Elephants
ATGRCA	Amboseli/ Tsavo Group Ranch Conservation Association
ATGSA	Amboseli/Tsavo Game Scouts Association
CWA	Community Wildlife Association
CWCCC	County Wildlife Conservation and Compensation Committee
DAAD	Deutscher Akademischer Austauschdienst (German Academic Exchange Service)
ESA	European Space Agency
GIS	Geographic Information Systems
GoK	Government of Kenya
GR	Group Ranch
GRC	Group Ranch Committee
HEC	Human-Elephant Conflict
ICRAF	World Agroforestry Centre
IFAW	International Fund for Animal Welfare
ILRI	International Livestock Research Institute
KWS	Kenyan Wildlife Service
LCPA	Least-Cost Path Analysis
MWCT	Maasai Wilderness Conservation Trust
NDVI	Normalized Difference Vegetation Index
NEMA	Ministry of Environment & Natural Resources
SNAP	Sentinel Application Platform
STE	Save the Elephants
SWOT	Strengths, Weaknesses, Opportunities, Threats
WCMA	Wildlife Conservation and Management Act
WRI	World Research Institute

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„If we can't make it in Amboseli, we can't make it anywhere."

(Vicki Fishlock, about connectivity in Amboseli-Tsavo Ecosystem, personal communication, June 2017)

1 Introduction

1.1 Theoretical Framework

1.1.1 Landscape Connectivity

Landscape connectivity is defined by Taylor et al. (1993) as "the degree to which the landscape facilitates or impedes movement among resource patches" (pp. 571). The concept of landscape connectivity tackles the problem of fragmentation by connecting landscape elements to counteract species extinction, loss of biodiversity and affects the distribution and abundance of organisms (IUCN, 2003).

It includes the differentiation between functional and structural connectivity. Functional connectivity refers to a single species' movements, its “resource needs and behavioral responses to landscape elements and patterns” (Wiens, 1997 and Lima and Zollner, 1996 cited in Wade et al., 2015, pp. 5). Reduced landscape connectivity correlates with isolation of individuals or populations due to limits in migration movements and limited dispersal and foraging possibilities. In comparison, structural connectivity of the landscape refers to physical patterns, e.g. topography, vegetative cover and human land use patterns, among others. Structural connectivity does not automatically ensure functionally connectivity or the other way around, but, they may come along with one another (Wade et al., 2015).

Landscape connectivity is based on three ecological fields, namely island biogeography, metapopulation and landscape ecology. Its origins lays in the theory of island biogeography, which was first described by MacArthur and Wilson (1967) and refers to the insularisation of habitat patches in a surrounding unsuitable matrix (Wade et al., 2015). The theory of metapopulation relates to the dispersal movement areas between different local populations of organisms “to create a larger, interconnected system of populations”, so called metapopulations (Wade et al., 2015, pp. 6). The two described theories accumulate in the newest theory of landscape ecology, which describes “a

patch-corridor-matrix", where patches refer to biodiversity rich land fragments with a surrounding, mostly extensively used, matrix (Wade et al., 2015). Those patches might be connected through corridors or linkages through certain landscape elements.

Functional connectivity can be identified in a landscape and associated therewith the assumption that animals move between patches of most preferred habitat. Physical corridors however can be of any shape and provide both functional and structural connectivity across the landscape. Focal species of a connectivity design is a selected species aiming to represent the movement needs of all wildlife species in the linkage area (Beier et al., 2006). The African elephant has often been employed as focal species due to their wide dispersal movement areas, because conserving elephant movement corridors at the same time preserves habitat and potential landscape linkages for other wildlife species (Epps et al., 2011). Moreover, biological corridors show various benefits such as carbon sequestration through the higher number of trees and improved growing conditions under extreme weather conditions through shade and improved infiltration at the same time (Minang et al., 2015). In this study, functional connectivity for the movement range of *Loxodondra africana* is modelled. One problem when linking protected areas with biological corridors is land grabbing, making connectivity conservation a challenging topic (Goldmann, 2009). Hence, land ownership is one of the main factor to be considered when talking about implementation strategies for any kind of corridor (Minang et al., 2015).

1.1.2 Biodiversity and Wildlife Conservation in Kenya

The study takes place in Kenya, a country characterized by unique savannah landscapes, rich coastal areas as well as dense forests in the highlands. The country is rich in biological biodiversity, in particularly in terms of wildlife resources, which includes an enormous variety of bird species and both small and large mammals. Very large herbivores such as hippos, buffalos and giraffes live alongside with medium-sized herbivores such as zebras, wildebeests, gazelles, oryx and waterbuck. Tourism is one of

the biggest foreign exchange incomes, generated about US $ 1 billion in 2010 (Wanyonyi, 2012). The sector accounts for about 10% of the gross domestic product (GDP) just after agriculture and manufacturing (Wanyonyi, 2012) and accounts for about 9-10% of the wage employment sector (Ondicho, 2010). Healthy wildlife populations are therefore highly important for the Kenyan economy. National Parks and wildlife safaris are the main activity among tourists visiting Kenya, with Amboseli National Park (NP) in southern Kenya on the border to Tanzania as one of the most popular ones (Map 1). Amboseli-Tsavo ecosystem is famous for its elephant populations, its vast savannah inhabited by Maasai communities and its stunning views of Mount Kilimanjaro. Amboseli is also recognized by Birdlife International as one of the world's important bird areas (Bulte et al., 2008). The government values wildlife as an essential source of income and puts great effort in its conservation. However, the country faces multiple challenges in wildlife and biodiversity conservation including climate change, habitat degradation and loss, forest depletion, pollution, illegal trade in wildlife species and products and increasing human-wildlife conflicts among others. Okech (2011) names loss of biodiversity as the main threat Kenya is facing. An effective wildlife conservation strategy must be followed to maintain healthy wildlife populations that will still generate income through tourism in future.

Conservation History in the Country

To understand current challenges and effectively tackle mentioned problems, it is necessary to give a small review of the conservation history of the country.

Formal wildlife management began with the arrival of the British colonialists around 1895. Colonial and post-colonial conservation strategies are characterized by displacement of people for conservation purposes, leading to a lot of frustration among local communities (Ondicho, 2005 cited in Ondicho, 2010). The establishment of the first National Parks came along with rules and regulations such as the exclusion of traditional subsistence hunting and prohibition for entering the parks by the local communities. Other restrictions for example on resource use such as pasture and fuel wood collection were also part of this conservation idea. The Kenyan conservation

model follows the belief that protected areas are demarcated areas with clear boundaries, separating wildlife from development activities outside of the park (Ngure, n.d.) and prohibiting local communities to enter the park for resource uses. Land sections, which formerly belonged to local communities, were turned into state-owned protected areas (Gitahi & Fitzgerald, 2010). Since that time, wildlife populations were controlled and owned by state institutions. Protected Areas (PAs) such as National Parks (NPs), game or National Reserves have legal protection by legislation. The Amboseli-Tsavo Ecosystem consists of three big National Parks including Amboseli NP, Tsavo West and Chyulu Hills. Tsavo West was designated a game reserve in 1946. Two years later in 1948 Amboseli and West Chyulu were as well declared a game reserve (Moss et al., 2011). Amboseli NP was established in 1974 when a piece of land was set aside exclusively for wildlife through "the Act of National Parks of Kenya" and placed under the control of the National Parks Trustees. Management and control was from then on covered by national authorities and transferred from Kajiado County level to the national government. Provision of water services and park revenue sharing was promised to the surrounding Group Ranches, but people claim revenues never reached them until today (Western, 1994 cited in Gitahi & Fitzgerald, 2010). In 1991 the Amboseli Ecosystem was declared a UNESCO Biosphere Reserve due to its ecological importance on global scale (Fitzgerald, 2013).

The areas in between the National Parks is "unprotected" land and widely used by wildlife, since most of the parks are not fenced. It is estimated that about 65% of Kenya's wildlife move widely outside of the National Parks on private and communal lands (Western, Groom & Worden, 2009; Nelson, 2012). However, National Parks alone can't bear the number of wildlife, which makes dispersal areas and corridors irreplaceable (Bulte et al., 2008). Even now, translocations of big mammals from one park to another are taking place, but are an expensive and cumbersome strategy to distribute animals. It is widely known that wildlife in protected areas depend for their survival on compatible management of the surrounding areas of land (KWS, 2012; Moss, et al., 2011). Dispersal areas are normally privately or communally owned. In the case of Amboseli, which is surrounded by Group Ranches inhabited by Maasai communities, land is shared and communally owned by its Group Ranch members.

However, land tenure is a very sensitive topic in Amboseli-Tsavo Ecosystem and should be considered when aiming to understand social and political dynamics in the study area. The topic is therefore shortly described in the following section.

Land Tenure

Land ownership in Kenya can be classified into three categories with different rules, regulations and laws including *i)* public land such as government forests, game reserves, water catchment areas, national parks, government animal sanctuaries, minerals, rivers and lakes. Ownership thereby is divided into county government and national government. All National Parks, game reserves, government forests and animal sanctuaries belong to the national government; *ii)* private land, hold by individuals or corporations in form of freehold or leasehold interest; and *iii)* Group Ranches (GR) as registered groups of people or a community (Laws of Kenya, 2010: sections 62-64). The Group Ranch system was introduced in 1968 through the Kenyan Government and two enacted laws. First, the Land Adjudication Act (Cap 284) (land can be owned by registered groups) and second, the Land (Group Representatives) Act (Cap 287) allowing the elected representatives of each group to be formed into a corporate body (DFID & CDC, 2002). The idea was to provide tenure security for Maasai communities who formerly lived without any boundaries or land titles across certain regions in Tanzania and Kenya. Group Ranch system aimed to settle down Maasai communities who traditionally live a nomadic, pastoralist lifestyle (Gitahi & Fitzgerald, 2010) and to push Maasai to invest in land improvement and to halt its degradation (GoK, 1970). Land previously used by all Maasai under traditional common ownership was demarcated and legally allocated to groups who from then on hold title deeds (certificates of ownerships) to a certain Group Ranch.

The Group Ranches are registered within the Ministry of Lands. Heads of each household are registered as members and compromise together with elected group representatives the legally recognized corporate body. Moreover, an elected Group Ranch Committee (GRC) is responsible for managing the Group Ranch (CDC & DFID, 2002) and taking over the executive functions of a Group Ranch. GRCs hold various responsibilities and management tasks, such as the implementation of development

projects, overseeing infrastructure development and loan repayments, enforcing grazing quotas and grazing management. Group members communally hold rights in grazing management, tillage and water resources. GRC can also allocate land to individuals or enter into third-party agreements with tour operators to give access to communal land (Nelson, 2012).

However, the whole act of registering and forming Group Ranches was already failing in its beginning due to a lack of awareness and knowledge about the process and its consequences for Maasai communities and is nowadays mainly described as failed (Mwangi, 2005; Okello, 2011). Today, subdivision of Group Ranches into individual land parcels is taking place. Subdivision of Group Ranches started around 1980. Kimana GR around Amboseli NP was subdivided among its 843 registered members into privately owned parcels and land titles are now hold by individuals (Kioko and Okello, 2006). New land owners are often outsiders who have bought land for low prices from Maasai, who consequently became landless. Subdivision became a common practice and has started to take place in most of the ranches. Formerly Kimana GR is often set as a poor example of uncontrolled subdivision, resulting in landlessness and increased poverty among Maasai communities. Farming practices are a common livelihood strategy by individual land owners and hence, increased agricultural productivity can be observed around the fertile swamps of former Kimana GR. Nevertheless, many Group Ranch members wish to hold individual land title deeds to be independent, manage their own parcel of land and to be able to lease or sell land based on own decisions. The decision to subdivide is taken by the committees and the different members of the Group Ranch who decide collectively on ownership rights (Gitahi & Fitzgerald 2010). Because of this history of land allocation and subdivision, land ownership is a sensitive topic in the area. At the same time, it is the basis of all kinds of activities and conservation management. Illegal allocation of community land is a common practice, sometimes marred with political manipulation or manipulation of Group Ranch registers, unplanned subdivision or the mismanagement of Group Ranches as recognized by Kajiado County Government (2014) and Mwangi (2005).

Elephants and Human-Wildlife Conflicts

The African elephant is listed as endangered species under Appendix I of the Convention on the International Trade in Endangered Species of Fauna and Flora (CITES, 2017). Elephants are important seed dispersal animals and therefore play a crucial role in biodiversity conservation (KWS, 2008a; Western, 1989). Besides the socio-political importance of elephants as revenue earners through tourism for national economies or in certain cases for local communities, elephants are important landscape forming animals and play a significant ecological role in shaping habitat structure and heterogeneity by forming plant compositions. They are therefore also beneficial for other animals. For these reasons, elephants are often used as keystone species in conservation approaches (Moss et al., 2011; Blanc et al., 2007).

The elephant population in Amboseli-Tsavo Ecosystem is estimated to be around 1,500 animals (KWS, 2008a). After a high drop in numbers of the elephant population in the 1970s due to poaching, its population started to increase again after various conservation strategies have been implemented and raised from 600 to the current number (Moss et al., 2011; Gara et al., 2016). Amboseli elephants use the National Park as a safe refuge area. However, the dispersal areas between the parks are used frequently. It is said that about 80% of African elephant's habitat in Kenya lay outside of protected areas (Hoare, 1999, cited in Okello et al., 2016b). Animal groups from Amboseli NP may overlap with elephants from Tsavo West and Chyulu Hills NPs in the Kimana Community Wildlife Sanctuary (today named Sidai Oleng Sanctuary) (Moss et al., 2011).

Maasai communities have been living harmoniously side by side with wildlife for decades. However, the described subdivision and sedentarization processes have a great impact on wildlife and their movements across the human-dominated areas, leading to multiplied conflict situations in particular around croplands. Moreover, increased competition with pastoralists for grazing and water resources is recognized (Burnsilver et al., 2008; Okello et al., 2016b). Human-wildlife conflicts, in relation to livestock killings, include various animals in particularly lions, hyenas and baboons (MWCT, 2016). Elephants are rather destructive animals and known to destroy housings, crops and farmland, but in exceptional cases, also injuring or killing livestock

and humans (Okello et al., 2014). For instance, between 1989 and 1994, wildlife killed 230 people and 218 people were injured. Elephants account for 173 of these attacks (KWS, 1994 cited in Okello, 2005). In Tsavo-Amboseli region, elephants killed 15 people, 24 were injured during 1993 and 2004. During the same time frame, 44 elephants were killed by humans (Kioko et al., 2008). Negative interactions such as crop-raiding elephants, or even injuries or death result in illegal killing of elephants as response to the destruction and damage produced by the elephant. The increasing human-wildlife conflicts are recognized by the Government of Kenya, which names the blocking of wildlife migratory routes and uncontrolled encroachment of human settlements into important wildlife areas as conflict source (County Government of Kajiado, 2013). Strategies to mitigate human-wildlife conflicts can be differentiated into prevention, mitigation and protection (Kosei et al., 2017). Prevention strategies include to control the size of animal populations through controlling reproduction or controlled killings. Other strategies include farm-based early warning systems and deterrence methods e.g. certain plant compositions to keep animals away, chemical repellants, noises and lights as fear provoking stimuli and electric fences as physical barriers keeping elephant out of certain areas. Mitigation and protection strategies aim to minimise impacts through problem animal control, translocations, compensation system or natural resources management (KWS, 2012; Kosei et al., 2017).

1.1.3 National Legal and Institutional Framework for Conservation

A wide range of organizations and conservation bodies are taking part in research, wildlife management and conservation in Kenya and the Amboseli-Tsavo Ecosystem. Five levels of administrations are given through the central government. These include 1. Province (provincial commissioner), 2. District (District Commissioner), 3. Division (Divisional Officer), 4. Location (Chief) and 5. Sublocation (Assistant chief). For Maasailand, a sixth level of administration is added, which is the Group Ranches executive committee. Group Ranch committees (elected Group Ranch representatives) are supposed to act on behalf of the collective benefit of all group members. An elected

committee assists and encourages members to manage the land or graze livestock in accordance with certain principles (CDC & DFID, 2002).

Governmental Sector

Defined by the constitution of Kenya 2010, two levels of government exist. First, the national government that has the responsibility for the overall conservation of wildlife. Secondly, the county governments are responsible for land-use planning. Wildlife management requires both levels of governance. On the county level, the two most important ministries concerning about wildlife management include the County Wildlife Conservation Compensation Committee (CWCCC) which was created within the new Wildlife Conservation and Management Act (WCMA), 2013. The institution aims to represent a consolidating body between community and governmental officials.

Others relevant stakeholders include various ministries such as the Ministry of Environment and Natural Resources, the Ministry of Land, Ministry of Wildlife and Tourism, Kenyan Forest Service (KFS) and NEMA, the National Environment Management Authority, which oversees all environmental related issues in the country (Kameri-Mbote, 2005).

Public Sector

Between 1976 and 1987 National Parks were administrated and managed by the Wildlife Conservation and Management Department (WCMD) within the Ministry of Tourism and Wildlife. WCMD was replaced by the Kenyan Wildlife Service (KWS) in 1990, which since then holds responsibility for wildlife management and conservation (Article 3A of the Wildlife Management and Conservation Act Cap 376 (GoK, Kenya, 2013). The public sector is therefore only represented by KWS, the semi-autonomous, parastatal organisation, responsible for managing all National Parks and Reserves on behalf of the state. Income generated through tourism, such as entrance fees in the parks, is used to conserve and maintain wildlife within parks (Ngure, n.d.). All wildlife

resources are by law owned by the state, no matter on whose land they are found (Kameri-Mbote, 2005).

KWS was one of the main actors in developing the 10-year Amboseli Management Plan 2008-2018 (KWS, 2008a). The plan tackles problems arising from human-wildlife conflicts, environmental problems such as water pollutions and unsustainable use of natural resources. It proposes wildlife migration corridors and the establishment of various conservancy areas along key travel routes. It is a rough guideline bringing various stakeholders together and starting to elaborate approaches tackling conservation issues. One outcome of the plan was the establishment of Amboseli Ecosystem Trust (AET) as a management body overlooking all kind of activities taking place in the ecosystem (Goss 2017, pers. comm., July 27th).

The plan notes that major threats in the Amboseli Ecosystem include uncoordinated and extensive farming activities, land subdivision and unplanned tourism development. Proposed solutions on the identified threats include a zoning of the area into high use (tourism zone), exclusive use (existing and proposed conservation areas) and low use zones (any other) (KWS, 2008a).

Private Sector

Non-governmental Organisations (NGOs) are the backbone of conservation management in the country and the study area. There are more than 30 national in international NGOs registered in Kajiado County (County Government of Kajiado, 2013). NGOs are responsible for research, capacity building and bridging governmental conservation strategies with the community. The most popular NGOs in the Amboseli-Tsavo region include Big Life Foundation, Amboseli Trust for Elephants (ATE), Save the Elephants (STE), African Wildlife Foundation (AWF), Amboseli Ecosystem Trust (AET), African Conservation Center (ACC) (in no specific order). NGOs are legally constituted without participation or representation of the government and are addressing issues that are not covered by responsible authorities and to supplement their work.

Several other Community Based Organisations (CBOs) are working with groups or individuals that have generally been excluded in development activities. There are more than 2,000 CBOs registered in the county and several in particularly in the study area (County Government of Kajiado, 2013). For instance, the organisations Neighbors Initiative Alliance (NIA) and Illaramatak le Mpusel, which were also interviewed during the study. Besides that, a variety of self-help, women and youth groups are involved in certain activities (County Government of Kajiado, 2013).

Community wildlife conservation initiatives include the Amboseli/Tsavo Group Ranch Conservation Association (ATGRCA) and the Amboseli/ Tsavo Game Scouts Association (ATGSA). ATGRCA was established in 1995 consisting of Group Ranch representatives who coordinate conservation activities across Group Ranch boundaries and aims to unite the neighboring Group Ranches for conservation purposes. ATGSA was created under the ATGRCA as an umbrella body coordinating game scout activities throughout the ecosystem (DFID & CDC, 2002).

Today, conservation organisations as well as tourism groups are involved in conservation management. By now, a wide variety of sanctuaries and conservancies can be found throughout the country. Unlike NPs, conservancies are set up on private or communal lands and initiated by land holders or group associations who organize themselves. Based on their own decisions, land is set aside for conservation and tourism purposes and owners benefit from wildlife and ecosystem services through financial and non-financial benefits. Community conservation through conservancy areas have started about 20 years but were only added to the new WCMA, 2013 through which they gained legal status. The term describes an area on communal land (trust land) as a protected area mainly for wildlife conservation purposes (Nelson, 2012). Like in National Parks, conservancies come along with some restrictions and tradeoffs for landowners including the prohibition of fencing, conditions or restrictions on housing or settlements and controlled grazing schemes. Moreover, farming in core areas of conservancies is prohibited (Ykhanbai et al., 2014).

Laws and Regulations

Various laws regulate the wildlife and tourism activities. The most important policies and laws related to wildlife conservation are summarized in Table 1. In 2013 the new Wildlife Conservation and Management Act (WCMA) was enacted on 24th of December and became operational on 10th of January 2014, however, it is not fully implemented yet. The new Act repeals its prior version, the Wildlife Conservation and Management Act Cap 376 and comes along with a few improvements including active community participation opportunities and an improved compensation scheme. The new act has some renewals compared to its prior version and indicates a stronger focus on community participation in wildlife management. Section 40 of the Act for instances provides the option of creating community wildlife associations (CWAs). The new Act has therefore often been described as a great improvement regarding wildlife conservation- a bottom-up approach rather than a top-down approach.

Table 1: Wildlife related policies and legislation (KWS, 2012)

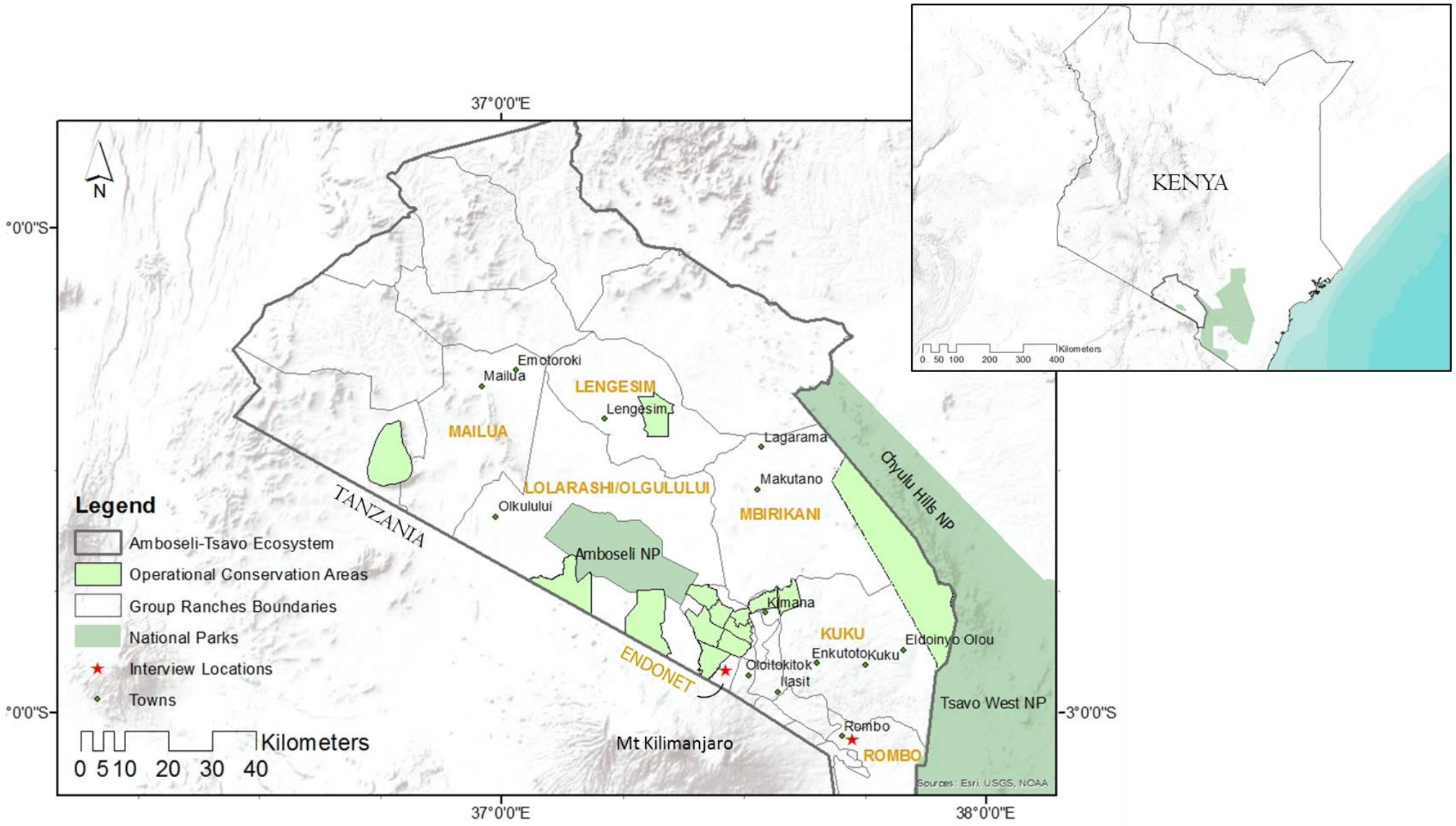
Wildlife Policy and Legislation	Environmental Policies
The Wildlife Policy (Sessional Paper No. 3 of 1975)	The Environmental Management and Coordination Act, 1999
The Wildlife (Conservation and Management) Act Cap 376, 1976 Rev. 1985 & Amendment Act No 16, 1989	Sessional Paper No. 6 on Environment and Development, 1999
KWS Policy Framework and Development Programme 1991- 1996. Annex 7B Elephant Conservation Management	National Biodiversity Strategy, 2000
KWS Strategic Plan 2005- 2010 & 2008- 2012	Vision 2030
Ministry of Tourism and Wildlife, Draft Wildlife Policy, 2007 and the The Wildlife (Conservation and Management) Bill, 2007	
Wildlife Conservation and Management Act (WCMA), 2013	

The policies and legislations listed in Table 1 also demonstrate the development of conservation ideas from the 1980's until today. The latest governmental documents include the Vision 2030, Kenya's long-term development plan (GoK, 2008). Though not

explicitly about wildlife, it represents an important development strategy, emphasizing the importance of wildlife conservation in the country.

The Conservation and Management Strategy for the elephants in Kenya 2012-2021 (KWS, 2012), Amboseli-Tsavo Ecosystem Management Plan 2008-2018 (KWS, 2008a) and its follow-up plan, which is currently developed (Mwinzi 2017, pers. comm., July 21st), are specific plans tackling issues of human-wildlife conflicts and wildlife conservation. The long-term vision in the Conservation and Management Strategy for the Elephant in Kenya 2012- 2021 is to "secure future for elephants and their habitats, based on peaceful and beneficial co-existence with people […]." (KWS, 2012, pp. 20). This includes maintenance and expansion of elephant habitat aiming to extent its distribution rate in suitable areas, enhance security to elephants, reduce human-elephant conflicts and increase the value of elephants to people and habitat (KWS, 2012). Other important policies regarding wildlife include sessional papers, ministerial statements and development plans. Land use, land tenure and local zoning laws also play a significant role in wildlife conservation.

The country has continuously improved their legal framework for wildlife and conservation management as the listed laws and regulations indicate. The new WCMA (2013) paves the way towards a community oriented management approach.



Map 1: Amboseli-Tsavo Ecosystem located in southern Kenya on the borderline to Tanzania (Data Source: WRI, 2007; ILRI, 2007)

1.2 Study Area

1.2.1 Biophysical Context

The Amboseli-Tsavo Ecosystem is about 8,000 km² in the South Rift region in East Africa. It stretches along the Kenya-Tanzania boundary, laying between the northern slopes of Mount Kilimanjaro (5,895 m) and Chyulu Hills Range (2,300 m) to the east of Kenya (Moss et al., 2011). Amboseli NP is the core area of the ecosystem with around 392 km², approximately 5% of the total area of the ecosystem (Map 1). The Tsavo conservation area including Tsavo East NP, Tsavo West NP and Chyulu Hills covers a total area of 21, 000 km². It is one of the largest protected areas, taking 4% of the total land area in Kenya (KWS, 2008b). The climate in the ecosystem is influenced by its geographic conditions and characterized by its bimodal rainfall patterns including the "short rains" from November to December and the "long rains", from March to May. Over the year a total of 340 mm rain falls on average, but rainfall is generally described as unpredictable (Moss et al., 2011). This small amount of rainfall throughout the year results in a semi-arid region. According to the classification of Köppen-Geiger the region is located in between two climate zones namely Aw (tropical climate) and BSh (semi-arid savannah, with no average monthly temperature below 18°C) (Forkel, 2012). Higher altitudes, including the slopes of Kilimanjaro and the Chyulu Hills, receive more rainfall than the rest of the area and therefore serve as important grazing areas. Amboseli NP is also an important dry season grazing zone for all herbivore species due to its permanent water resources (Moss et al., 2011). The dry and hot season is between January and February and from June to October when temperatures can reach up to 35°C. Low elevation and resulting rainfall patterns influence vegetation patterns. The main vegetation consists of trees, bushes and grasses. The area is dominated by *Acacia* savannah and scattered trees. The northern parts of the ecosystem are characterized by bush grassland, by the forest belt of Mt. Kilimanjaro towards the south and some dense forest towards the west on the volcanic soils of Chyulu Hills (BurnSilver et al., 2008).

Water is the most limiting factor in the whole ecosystem and existing waterbodies are almost all seasonal and dependent on the rainfalls during short and long rains. However, due to climate change and land use change, rain patterns are increasingly unpredictable and may not occur in the usual timeframes. Most of the rivers are seasonal streams that flow only for short periods. Some springs are perennial, but often fenced off for human consumption only. Swamps spread around the ecosystem are important water sources for humans both for agriculture and domestic water uses; and for livestock and wildlife as forage and drinking points. Springs and boreholes are perennial, but not all of them accessible for wildlife (Moss et al., 2011). Yet, most of the boreholes are not secured and frequently visited by both wildlife and humans as a year-long source for water (Goss 2017, pers. comm., July 10th). Boreholes are widely spread throughout the ecosystem, sometimes constructed by individual land-owners, sometimes implemented by the government. A subterranean water pipeline runs from the southern part of Kuku GR up to the north through Mbirikani GR towards Nairobi. Some dams and wells across the ecosystem capture rainfall. The described climatic conditions have influenced land-use patterns throughout the ecosystem, as outlined in the following section.

1.2.2 Social- Economic Context

Amboseli-Tsavo Ecosystem is part of Kajiado County in Loitokitok District. Amboseli NP is surrounded by six Group Ranches (Map 1): Rombo, Kuku, Imbirikani, Lolarashi/Olgulului and Lengesim/Eselenkay and former Kimana Group Ranch, which today is subdivided into various individual parcels. The Group Ranches differ in number of registered members as shown in Table 2.

Table 2: Number of members of Group Ranches surrounding Amboseli NP (Mpelele 2017, pers. comm., July 19th)

Group Ranch					
Eselenkei	Lolarashi/Olgulului	Imbirikani	Kimana	Kuku	Rombo
2,526	11,485	8,700	840	3,500	3,665

Yet, Group Ranches are located within legally defined boundaries, on the ground these boundaries are poorly defined. Moreover, Group Ranches vary considerably in their level of management, protection and patrolling (Ngene et al., 2013). The Amboseli-Tsavo Ecosystem is home to Maasai communities, who are traditionally nomadic pastoralists moving with their cattle and livestock depending on the seasonal climatic conditions (BurnSilver et al., 2008). This nomadic pastoral lifestyle has allowed them to live in harmony with wildlife for millennial of years (KWS, 2008a). By today, many other people are permanently resident in the villages across the ecosystem, in particularly, around the agricultural areas in prior Kimana GR. Kajiado county has a population of 687,312, with an annual population growth of 5.5 % (Kajiado County Government, 2014). A high population growth is recognized and explained by both increased birth rates and people moving into the area. The socio- economic context is highly influenced by land tenure regulations and changes, as explained in chapter 1.1.2.

The environmental conditions allow pastoralism as the most efficient livelihood strategy in the area (Okello and Amour, 2008). Nowadays, a shift towards semi-pastoralism and farming, both rain-fed and irrigated, can be observed. However, farming is only possible around swamps and riverbeds, which today are cultivated all over predominantly by foreigners who are more experienced in farming activities (Okello and Amour, 2008). Farming is traditionally not practiced by Maasai communities, as digging the soil is believed to be harmful (Okello et al., 2015). Yet, today, farming is increasingly practiced by the Maasai, who benefit from this additional income or as additional food supply. This change in land use, particularly around wetlands and swamps, puts a lot of pressure on the scarce water resources throughout the ecosystem. These extensive land use practices and a resulting land cover change, lead to an increase in drought frequency and severity of the latter over the past decades (Voelker et al., 2013). A shift from prior nomadic towards a sedentary lifestyle is recognized (BurnSilver et al., 2008) leading to fragmentation of the area by human settlements and the increasing sedentary farming and living practices.

Depending on the location, infrastructure development in terms of roads, boreholes, water pipelines and public services such as schools and medical facilities, are difficult

to access. Some places are still lacking basic services and infrastructure. BurnSilver et al. (2008) identify the area north of Amboseli NP as such an area of poor infrastructure. One tarmac road in the area connects Nairobi and Loitokitok, subsequently crossing to Tanzania. Other towns and places in the different GRs can only be accessed through dust roads and, depending on the season, this becomes challenging. Although, the area is a tourism dependent zone with excellent views on Mt Kilimanjaro and a unique landscape, the area between the National Parks are incredibly poor and benefits from tourism seem not to trickle down to the ground. A wide range of different conservancies have been established in the area and are managed by either community representatives, private land owners or investors. There is an increasing pressure on the Maasai communities in the face of rapid urbanization and industrial development. A high illiteracy rate of about 35% in Kajiado and associated poverty therewith among the local population is one of the major development problems recognized by the County Government (Kajiado County Government, 2013 & 2014).

Main threats in the ecosystem are the spread of farming, water diversion, subdivision of land, habitat loss, degraded grazing areas (falling pasture productivity) and poaching (Western, 2007). Other problems in the ecosystem include uncontrolled and illegal tree cutting, unsustainable charcoal production and a weak regulation of outsiders using natural resources (KWS, 2008a).

1.3 Justification of the Study

The research aims to show possible strategies to enhance wildlife movement across the landscape while at the same time reducing human-wildlife conflicts. Landscape connectivity is a conservation concept that tackles the problem of fragmentation. Benefits and advantages of interconnected patches yield more viable faunal and floral populations and improved ecological processes, in comparison to landscapes that are fragmented, leaving important natural habitats such as National Parks left behind as isolated parcels of biodiversity (Laurence, n.d.). Landscape connectivity can be achieved through the provision of wildlife corridors. By doing so, both habitat connectivity of certain species and ecological connectivity of important ecosystem processes are enhanced (Pulsford et al., 2015). The survival of an animal population depends highly on its movement range and migratory patterns (Bennett, 2003). Amboseli NP is a small park that couldn't hold the same number of animals if it was fenced. Even now, translocations of large mammals to other parks happen, but are a costly and often unfeasible solution. For the long-term survival of the elephant population it is therefore mandatory to keep migration routes open between the parks.

Management for landscape connectivity occurs within a social and political context and is often not recognized by all affected parties, conservationists and governmental institution (Bennett, 2003). Kenya's wildlife policy follows and has always followed the western model of conservation guidelines. Conservation and management of wildlife is organized by national parks and reserves, excluding local communities form active participation (Ngure, n.d.) and keeping conservation issues limited to the parks. Benefits of wildlife conservation do often not trickle down to people at the ground who at the same time face most of the conflict situations and are confronted with a variety of problems by sharing land with the animals. Therefore, well defined migration routes for wildlife are suggested, implemented through the active participation of local communities in conservation management aiming to improve the co-existence between humans and wildlife. Results of this study will contribute to conservation planning in Amboseli-Tsavo Ecosystem in two ways. First, they inform better designing and implementation of movements corridors in the ecosystem by taking both social,

political and geographical dynamics of the region into account. Local communities' perception on wildlife conservation will be set in comparison with other stakeholders' interests. Second, results of the study will enhance the knowledge database on the ecosystem, important for further research and management strategies. Therefore, the study will add extra value to the prior conducted research and extent the already existing knowledge.

2 Objectives and Research Questions

2.1 Main Objective

The main objective of the study was to assess the socio-geo-political dynamics in Amboseli-Tsavo Ecosystem to analyse the landscape connectivity potential between protected areas. To effectively elaborate on the main objective of this research project, three research questions were defined.

2.2 Research Questions

1. i) What are the current management ideas among the various stakeholders concerning the current and future management of the ecosystem?

ii) How do those plans vary between the different stakeholders i.e. landowners', pastoralists, governmental and non-governmental organisations?

2. What characterizes landscape connectivity in the Amboseli-Tsavo Ecosystem?

3. What possible management scenarios exist to improve the Amboseli-Tsavo Ecosystem connectivity?

3 Methods

The methodology includes both a social and a geographical analysis. After those, results from both methods are used to find potential connectivity routes in the study area. Methods applied to accomplish the overall objective and to answer the research questions are described below and illustrated in Figure 1.

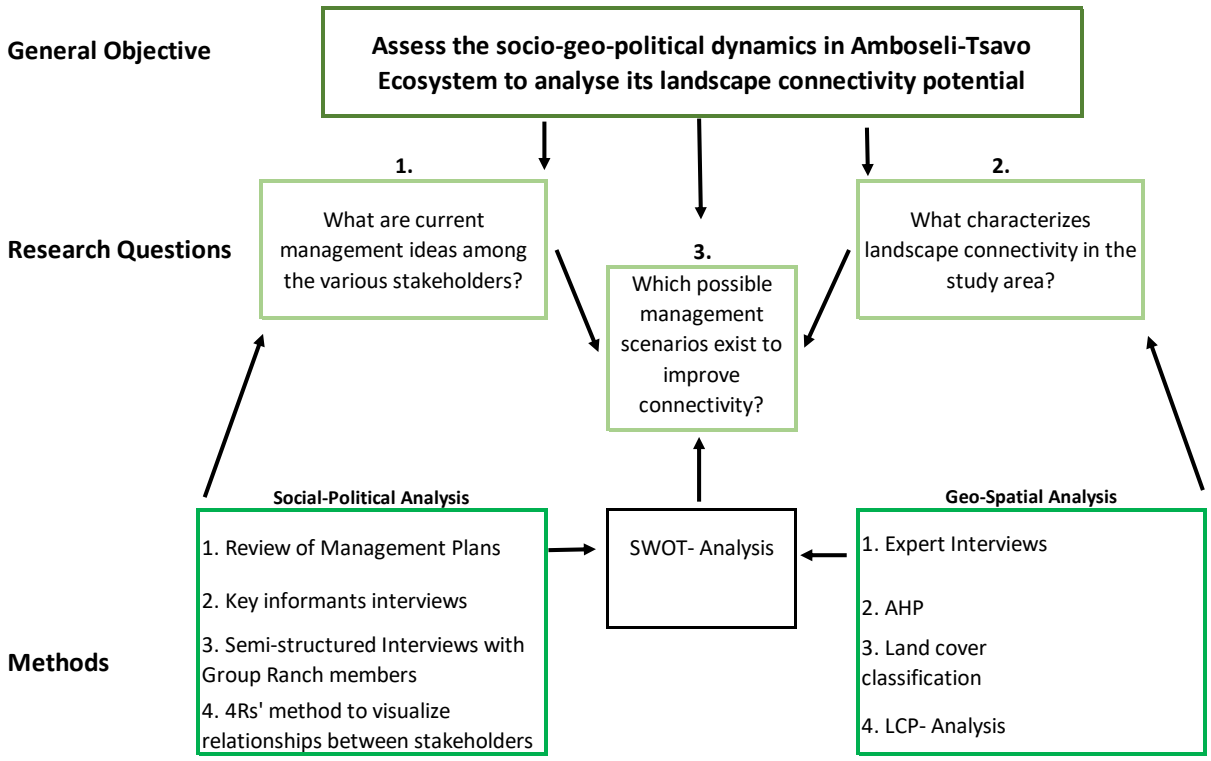


Figure 1: Methodological Framework illustrating Objectives, Research Questions and applied Methods

3.1 Social-Political Analysis

The social-political analysis includes a comparison of the different ideas and plans among the stakeholders regarding wildlife conservation. Overlaps and differences were identified using the four Rs' method. The four Rs' (rights, responsibilities, returns, relationships) is an analysis tool to clarify roles of each stakeholder and to identify relationships between one another. The analysis consists of three main parts including 1. Stakeholder Identification, 2. Analysis characteristics of stakeholders and 3. Identification of power and influence of each stakeholder (Mayer, 2005), as represented in figure 2. Stakeholders can be described as groups or individuals that are affected by the outcome of a conflict, as well as those who influence the outcome (FAO, 2005).

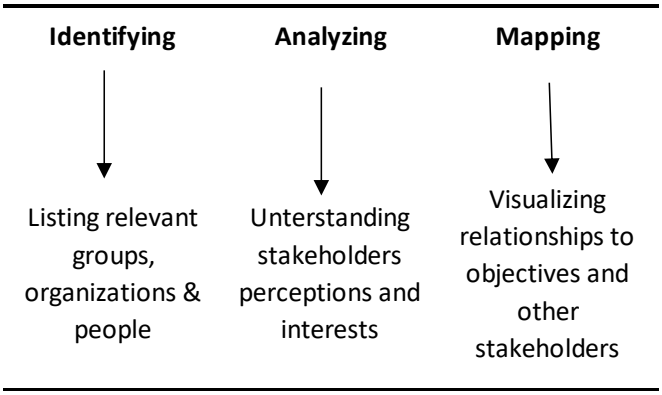


Figure 2: Approach for the Stakeholder Analysis (adapted from Mayer, 2005; Reed et al., 2009)

The main objective of the stakeholder analysis is to identify vulnerable groups when implementing certain strategies. Understanding values and interests of involved and affected parties helps to establish certain mechanisms.

The Analyzing process was done by using the following methods:

i) Review of current management and strategy plans including the Amboseli Ecosystem Management Plan 2008-2018 (KWS, 2008a), the Conservation and Management Strategy for the Elephant in Kenya 2012-2021 (KWS, 2012), Kenya's Vision 2030 Flagship Project "Securing Wildlife Migratory Routes and Corridors" (Gordon et al., 2017) and the County Integrated Development Plan 2013-2017 (County Government of Kajiado, 2013) aiming to identify different ideas and visions regarding the management of the ecosystem.

ii) In-depth interviews with key informants with a semi-structured guideline. Stakeholders included representatives of KWS, NGOs, conservancy areas and tourism managers. Participants were asked about the current situation in the ecosystem, their management practices and perception about current and future wildlife conservation. Interviews were audio recorded with permission of the participants and transcribed the same day. Transcripts were then analyzed thematically. Some participants were not available in person and in these cases questionnaires were handed in via email. Key informants were identified through the snow-ball-sampling method (Reed et al., 2009). Guiding questions used for the interviews can be found in Annex III.

Semi-structured interviews with Group Ranch members was based on a developed questionnaire. Two groups of people with each 15 individuals were interviewed, located in Rombo and Endonet GR. Participants were asked whether they were aware of any wildlife laws and regulations affecting them, what kind of benefits they would receive from living with wildlife and how they imagine living with wildlife. Both men and women were interviewed in a household. All generations and backgrounds were included to value natural heterogeneity of a group. Information obtained was coded and analyzed using the excel software. Guiding questions used for the interviews can be found in Annex IV.

Conducted interviews with Group Ranch members and key informants give evidence of the interests and influences each stakeholder holds. A developed "interest-influence" matrix based on Reed et al. (2009) illustrates the relationships between stakeholders.

3.2 Geo-Spatial Analysis

Geographic Information Systems (GIS) are a common and effective tool when planning and designing landscape connectivity. Required shapefiles for the geo-spatial analysis where either obtained from open source data bases (ILRI, 2007; WRI, 2007) or kindly shared by local NGOs (Big Life & MWCT), as shown in Annex I.

The African elephant was selected as flagship species on which the geographic connectivity analysis is based. To validate main criteria for elephant movements five expert interviews were conducted. Experts include professionals working with elephants in the ecosystem either in research or conservation management. An Analytical-Hierarchy Process (AHP) was applied to weight the prior selected criteria. A land classification was performed using sentinel-2 imagery to obtain the vegetation cover for two different seasons. Finally, a Least-Cost Path analysis (LCPA) was performed by using ArcGIS 10.1 and illustrative maps presenting the connectivity routes were developed. Through these methods the most preferred travel paths by the elephants to cross the matrix was determined and later combined with the social factors. Following a short description of the single methods used during the geo-spatial analysis.

3.2.1 Analytical Hierarchy Process (AHP)

The AHP is a multicriteria decision making approach in which various factors are compared among each other (Saaty, 1990). The weighting system of the selected factor is the backbone of the methodology and each factor must be assigned with weights. Weighted layers sum up to suitability or resistance layer, which will be used for the least-cost calculation. The AHP method is recommended in cases where empirical data are lacking. Instead expert opinions can be used to help selecting and weighting factors (Zeller et al., 2012; Beier et al., 2006). In a first step, several natural and anthropogenic factors influencing elephant movements were pre-selected, based on information

obtained from literature. Factors were all discussed and validated during the expert interviews. Participants were free to add or change factors according to their knowledge. Selected factors are shortly described in the following table (Table 3).

Table 3: Pre-selected factors influencing elephant movements according to literature, which served as a foundation in the AHP-part

Factor	Description
Proximity to Water bodies	Described as the main influencing factor by many authors (Ngene et al., 2009; Pittiglio et al., 2012; Cushman et al., 2010). Elephants travel less during dry season and stay close to water points, but would also travel larger distances to reach them (Loarie et al., 2000). Elephants are highly dependent on water resources and drink about 150 – 300 l of water per animal per day. Additional amounts are required for bathing. Males are known to be more flexible regarding drinking and can go for three days without water if necessary. However, females are more dependent and need to drink almost every day. Elephants can walk about 30-50 km in search for water (Goss 2017, personal communication, July 10th; Okello et al., 2016).
Type of Vegetation	Various studies highlight the importance of heterogeneity in the habitat selection. Wood and bushland most preferred by elephants (Okello et al., 2015). Ngene et al. (2009) describe a mosaic of forest and savannah important for elephant populations since they provide vital resources such as food, shelter, saltlicks and water. Dominated habitats include bushland, woodland and grassland in different densities (Kioko et al, 2006). During dry season closed woody vegetation areas and closed shrubs strongly associated with elephants (Pittiglio et al., 2012). *Acacia xanthophloea* riverine woodland and *Acacia tortilis* woodlands are highly associated with elephants during dry season, due to its reliable shade, forage and escape cover (Kioko et al., 2006).
Slope	Preference for flatter areas, but steep slopes can be crossed if necessary (Wall et al., 2006; Fishlock 2017, pers. Comm., June 24th). According to Wall et al. (2006), a slope of 30 degrees is the maximum angle elephants tolerate.
Distance to settlements and roads	Elephants are more likely to avoid settlements and humans, but that highly depends on the area (Roever et al., 2012). Major roads would rather be avoided but do not have a big impact on movements around Amboseli, since most of the roads minor dust roads (Fishlock 2017, personal communication, June 24th). The more noise come from roads the more likely wildlife stays away or tries to avoid it since noise is associated with a certain level of threat. Elephants can cause more damage to a car than the other way around, but for other wildlife roads and traffic represents a certain threat (Okello, 2011).

Experts were provided with a pair wise comparison matrix of all variables and asked to rank each criterion over another. The weighting score were structured from 1 (equally strong) to 5 (extremely strong), following the format by Bhushan et al. (2004), as illustrated in Table 4. The complete matrix schemes handed to experts can be found in Annex II. Participating experts include two staff members from Big Life Foundation, one research scientist from Save the Elephants (STE) and one research scientist from Amboseli Trust for Elephants (ATE).

Table 4: Applied format for pairwise comparison (adopted from Bushan et al., 2004)

	Factor weighting score									
A	5 extremly strong	4 very strong	3 strong	2 marginally strong	1 Equally strong	2 marginally strong	3 strong	4 very strong	5 extremly strong	B

The individually filled preference matrices were used to calculate weights for each matrix by transferring them into an excel spreadsheet with a comparison matrix holding the given preference values. The scale ranges from extremely strong to equally strong (5 to 1, respectively). Matrices were then completed by filling either the actual judgement value (5, 4, 3, 2) or the reciprocal value (1/5, 1/4, 1/3, 1/2), depending on the side of the given value. Value 1 was assigned if two factors were weighted as equally strong. The calculation followed the steps explained by Bunruamkaew (2012): after calculating sum-values for each row, the matrix was normalized by totaling the numbers of the sum-column. Each entry in the column is divided by the column sum to yield its normalized score, which results in the calculated weight. Calculated mean values from individual results were then transferred to percentage values. Since it is only possible to enter whole numbers into the final LCP-model in ArcGIS, numbers were rounded. Table 5 shows the individual weights for each factor obtained through the pairwise comparison. To clearly illustrate differences between certain factors, it was necessary to adjust values, as shown in table 6.

Table 5: Weights obtained through pairwise comparison (AHP)

Factor	Proximity to Water Bodies	Vegetation	Distance to Settlements	Distance to Roads	Slope
Mean Weight	0,3357	0,3354	0,1655	0,084	0,0793
Percentage %	33,57	33,54	16,55	8,40	7,93

Waterbodies in the study area include rivers, wetlands and boreholes. Rivers and wetlands were further divided into permanent and seasonal water bodies to differentiate between dry and wet season (July and December, respectively). Springs and boreholes are perennial but not always accessible by wildlife. It was generally assumed that they were accessible for wildlife unless I was informed differently, such as the swamps around Namelok and Kimana. According to Kioko and Okello (2006), permanent rivers include Nooltoresh and Kikarankot river, as shown on map 6 in the result section.

Vegetation classes were differentiated in bushland, grassland and forest. Crops on agricultural plots were considered as easy accessible forage possibilities and therefore included into the vegetation cover. Forest was considered as a single factor due to its different weighting by experts.

The main towns in the ecosystem are Kimana and Oloitokitok. Both have been growing over the last years, but reliable population estimates were not accessible. According to my communications with the residents, elephants avoid these towns, but sometimes they do come close. Smaller accumulations of settlements or *bomas*[1] do not fall under this raster and are often directly affected by elephants passing through. One tarmac road connects Nairobi with Oloitokitok, through Mbirikani Group Ranch, leading to

[1] B*oma* is the Swahili word for livestock enclosure (Source*:* https://en.oxforddictionaries.com/definition/boma*).* In Maasai land the term can also describe a village or community made up of several huts enclosed by a fence.

Tanzania. Although, roads, either tarmac or dust road, represent a certain threat, they are not completely avoided and generally crossed by elephants at any time (Fishlock 2017, pers. comm., June 24th). Settlements were selected based on data obtained from WRI (Annex I) and a comparison with Google Earth imagery. Only clear visible settlements with an accumulation of more than ten houses were selected.

3.2.2. Remote Sensing and Analytical Workflow

The first step in the analysis was a land classification to visualize the different vegetation types relevant to the movement of the African Elephant. Secondly, open surface water bodies were detected using Sentinel-1 Radar Imagery and open source shapefile layers. Both processes are subsequently described.

Sentinel 1-Radar Imagery and Open Source Data for Detection of Waterbodies

S1-Radar satellite imagery was used to detect open surface waterbodies. Sentinel 1A is a European radar imaging satellite, which was first launched in 2014 as part of the European Union's Copernicus program. The radar provides continuous all-weather imagery at C-band, during day and nights. It is operated with a swath of 250 km and high geometric and radiometric resolutions (typically 20 m), which is suitable for most applications (ESA, 2017a).

Satellite imagery of Sentinel 1A with 10 m spatial resolution was acquired from July and December 2016 and used to detect open surface waterbodies (Data Source: Annex I). The data is freely available at the Sentinels Scientific Data Hub (Copernicus, 2017). Sentinel-1 images must be preprocessed before being used for further data analysis. Corrections are made with the open-source Sentinel Application Platform toolbox (SNAP) in the following steps shown in figure 3:

Figure 3: Procedure for acquisition of waterbodies

Results were compared with available open access shapefile layers, gathered from WRI and IlRI. Boreholes and springs were kindly provided by Big Life Foundation and MWCT (see Annex I).

Sentinel-2 Multispectral Imagery: Landcover Classification using K-Means Cluster Analysis and NDVI

To obtain the vegetation cover of the area a landcover classification using high resolution Sentinel-2 imagery (10 m) and SNAP toolbox (Sentinel Application Platform) provided by ESA (European Space Agency) was used. Data analysis was performed with K-Means cluster analysis as an unsupervised land classification, where an algorithm identifies clusters or groups of pixels with similar properties (spectral signatures). This classification process was repeated for both seasons. Classes were then identified by comparing the results with the google satellite imagery and NDVI images. The NDVI (normalized difference vegetation index) is widely used to classify vegetation cover and can be defined as:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Red and NIR represent surface reflectance averaged over visible (λ∼0.6µm) and near infrared (NIR) (λ∼0.8µm), represented by band 8 and 4, respectively, for Sentinel 2 (ESA, 2017b). NDVI values > 0.2 correspond to bare soil, values between 0-2 and 0.5 represent sparse vegetation such as shrubs, bushes or grasslands. High NDVI values (> 0.5) are associated with dense vegetation such as forests (USGS, 2015).

Agriculture and settlements were not included as classes are difficult to distinguish these land cover types with others. Cropland were added as polygon shapefiles kindly provided by Big Life Foundation and compared with current Google Earth imagery. The workflow to obtain the vegetation cover is illustrated in Figure 4.

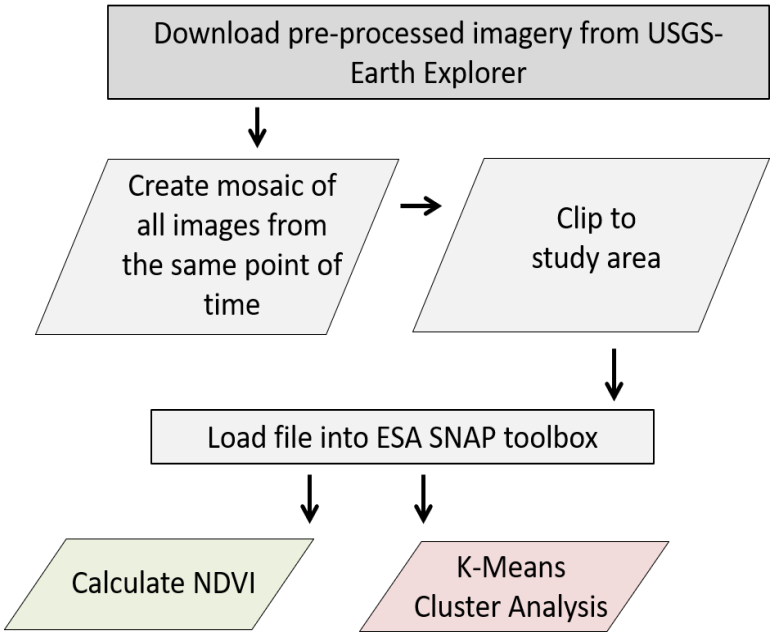


Figure 4: Procedure to obtain vegetation cover in the study area.

Images from July and December were selected due to their high quality in resolution, low percentages in cloud cover and to illustrate temporal variability of connectivity to differences in water availability and forage possibilities. Precipitation means for the year 2016, shared by ATE and the Baboon Research Project, are illustrated in Table 6. The short rains in December 2016 failed resulting in very dry and harsh conditions during that time and influencing water availability and vegetation cover.

Table 6: Mean precipitation values from two different meteorological stations in Amboseli-Tsavo Ecosystem obtained from Baboon Research Project and University of Notre Dame (2017) and ATE (2017, pers. comm.) [mm]

Measuring Station	*January*	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*
Baboon Research Project	84,9	35	16,8	87,6	14,2	5,5	0	0	0	0,8	69,4	3,2
ATE NP	69	38	0	56	27,5	0	0	0	0	4,5	93	1

3.2.3 Least-Cost Path Analysis

For the Least-Cost Path creation, all shapefiles were converted to raster layers and standardized to a common cell size of 10 m. All selected layers were projected to the coordinate system WGS 84/UTM zone 37S. For the distance factors (roads, settlements, waterbodies) a proximity analysis was performed using Euclidean Distance tool in ArcMap. The prior determined NDVI raster was used as vegetation input, open source shapefiles showing rivers, wetlands and boreholes, represent water bodies. Subsequently, all factors were reclassified to a common scale ranging from 1 to 10. Reclassification values for each criterion are illustrated in Table 7. The results of the reclassified raster layers and the weights (influence value) obtained through the pair-wise comparison were used to develop a cost-surface (weighted overlay). The applied evaluation scale in the weighted overlay tool ranges from 1 to 9, with 1 representing lows costs, 9 high costs and 6 intermediate costs. The weighted overlay tool assigns values to each cell depending on the applied weight-values (ESRI ArcGIS, 2017a). The output is a cost-surface, representing low cost areas with relatively safe and easy travel routes for an animal. High cost areas are dangerous or difficult to travel through. The procedure was repeated for both July and December, using different vegetation and water layers. To avoid edge effects as described by Wade et al. (2015), cost-surface development was created for the whole study area. Weighted overlay layers can be found in Annex V, Map 15 and 16. Once the cost-surfaces were developed, a broad overview showing connections between the three main protected areas, namely Amboseli, Tsavo West and Chyulu Hills, were identified. Specific paths between the National Parks and conservancies were subsequently calculated using the model builder in ArcGIS (Figure 5) and selected source and destination points as input raster layers. The procedure includes two steps. First, applying the cost distance tool and second, calculating the final cost path. The cost distance tool calculates the “shortest weighted distance from each cell to the nearest source point” (ESRI ArcGIS, 2017b) and a cost backlink, which is described “to retrace the least costly route from the source point over the cost distance surface” (ESRI ArcGIS, 2017c). These two output raster

layers were subsequently used as input layers to calculate the least cost path between specific conservation units.

All paths were calculated for both July and December, using the specific weighted-overlay. Analyzed routes include paths between 1. Amboseli-Selenkay-Chyulu Hills, 2. Amboseli-Motikanju- Chyulu Hills Conservation Area, 3. Amboseli-Tsavo West, 4. Amboseli-Namangahill. Obtained paths were converted to polygon layers and buffered with 150 m to avoid a pixel-width path, as described by Beier et al. (2008). Maps and prior studies were used assess whether the mapped output paths correlate with actual movement paths (Gordon et al., 2017; Osipova et al., in review). Additionally, information about movement behavior was gathered during expert interviews.

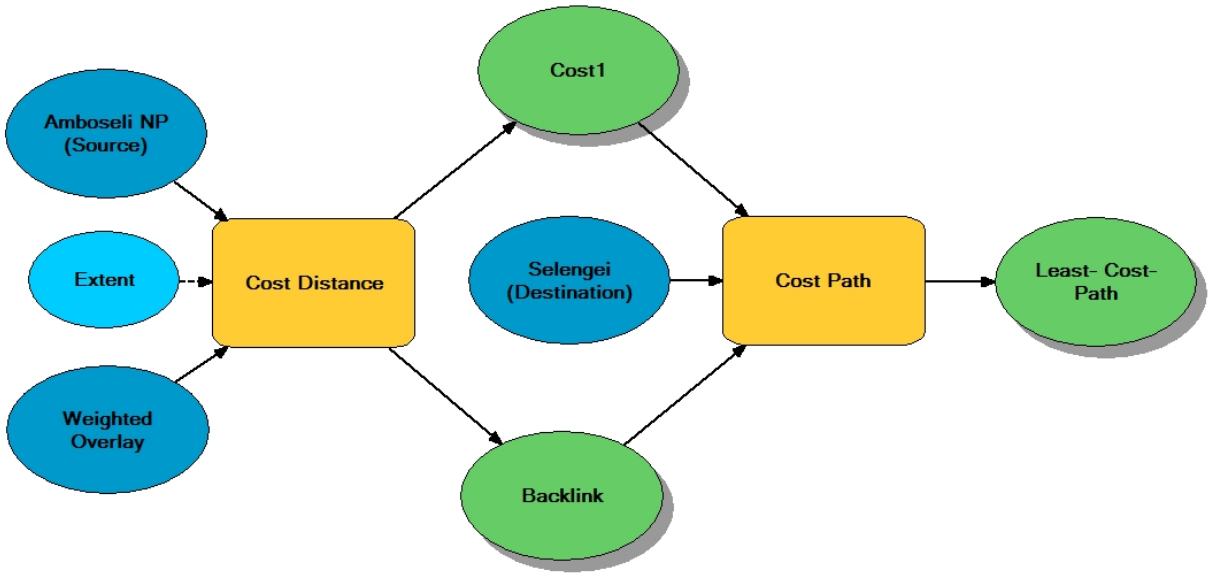


Figure 5: Relevant steps in the model builder to identify the most suitable path between two parks (source and destination), developed in ArcGIS 10.4.1 (orange= tool used from ArcGIS toolbar, dark blue= input layers, green= output layers)

Table 7: Reclassification of each factor and assigned evaluation values in weighted overlay tool: 1= low costs, 6= intermediate costs, 9= high costs

Factor		Reclassification		Weighted Overlay		
		Old values	New values	Evaluation Scale	Influence (%)	Description
	Vegetation	forest (0.51-0.82)	1	1	34%	cost of travel increases with decreasing vegetation
		bushland/ grassland (0.21-0.50)	2	2		
		bare soil (-0.17-0.20)	3	9		
	Slope (%)	0-3	1	1	7%	cost of travel increases with higher slope
		3- 8	2	2		
		8- 20	3	3		
		20- 45	4	6		
		45- 82	5	9		
Distance to	Roads	0- 500m	1	9	9%	cost of travel increases closer to roads and settlements
		500-1000m	2	8		
		1000-2000m	3	7		
		2000 - 4000m	4	6		
		4000 - 6000m	5	5		
		6000 - 8000m	6	4		
		8000 - 10.000m	7	3		
		10000 - 15.000m	8	2		
		15000 - 20.000m	9	1		
		20000 - 27.600m	10	1		
	Settlements	0-200m	1	9	17%	
		200-600m	2	8		
		600- 1000m	3	7		
		1000- 2000m	4	6		
		2000- 4000m	5	5		
		4000- 6000m	6	4		
		6000- 8000m	7	3		
		8000- 10.000m	8	2		
		10.000m- 15.000m	9	1		
		> 15.000m	10	1		
Proximity to	Waterbodies	0 - 500m	1	1	33%	cost of travel increases farther away from water
		500 - 2000m	2	2		
		2000 - 4000m	3	3		
		4000 - 6000m	4	4		
		6000 - 10.000m	5	5		
		10.000 - 15.000m	6	6		
		15.000 - 20.000m	7	7		
		20.000 - 25.000m	8	8		
		25.000 - 30.000m	9	9		
		30.000 - 35.000m	10	9		

3.3 SWOT Analysis

Finally, a SWOT (Strength, Weaknesses, Opportunities and Threats) analysis of determined scenarios based on the prior conducted geo-spatial analysis and additional information obtained through stakeholder interviews reveal the current management status of the ecosystem and possible solutions. By doing so, the current and future connectivity potential in the study area is illustrated. Additional information and shapefile layers, such as cropland and fences, were kindly shared by Big Life Foundation. Cropland was compared with Google Satellite imagery and obtained NDVI.

4 Results

4.1 Social Analysis

The result section for the social analysis is structured as follows. First, identified stakeholders are shortly represented (4.1.1). Secondly, information obtained through expert and household interviews were used to analyze identified stakeholders respectively (4.1.2) and finally, relationships between the various actors are presented in 4.1.3.

4.1.1 Stakeholder Identification

Stakeholders taking part in conservation throughout the ecosystem include both non-governmental organisations such as the Maasai Wilderness Conservation Trust (MWCT), African Conservation Center (ACC), Lion Guardians, Amboseli Ecosystem Trust (AET), International Fund for Animal Welfare (IFAW) and Big Life Foundation, among others; and governmental institutions such as County Wildlife Compensation and Conservation Committee (CWCCC); the Kenyan Wildlife Service (KWS) and various ministries. Moreover, several research projects located in the ecosystem, such as Amboseli Elephant Research Project (AERP), Save the Elephants (STE) or the Amboseli Baboon Research Project, among others, are part of research projects on effective wildlife conservation, elephant ecology and movement patterns. Other important actors include the Group Ranch Committees for each GR, the Group Ranch Association, which is the umbrella body of all Group Ranches including representatives from each GR. Last, privately or communally owned conservancy areas, as well as tourism operators are important actors throughout the ecosystem.

4.1.2 Stakeholder Analysis

The stakeholder analysis included interviews with Group Ranch members and key informants. Information given by key informants is presented first, focusing on rights, responsibilities and returns from each stakeholder. Results from the household interviews are represented subsequently. Last, interests and influences are set into relationship.

4.1.2.1 Key Informant Interviews

Rights and Responsibilities

Legal rights and claims among the stakeholders vary depending on their status and type. Table 8 summarizes rights for each stakeholder.

Table 8: Identified rights for each stakeholder

Stakeholder	Rights
KWS	Holds legal right over all wildlife in the country and all wildlife related actions must go through KWS
CWCCC Amboseli	Under the ministry for natural resources and environment. Participate in county land-use planning with a focus on community land
Kajiado Council & Rift Valley Provincial Administration	Represent the government and enforce law and order. Decision and prioritising rights in development projects
NGOs, Research Institutions & Development Initiatives	Report to KWS about their actions but are generally free in what they do throughout the ecosystem. Certain actions/ research activities must be agreed on prior to their implemention
Group Ranch Members	As joint owners of the Group Ranch, members have certain rights includindg to speak freely, be heard and to vote in general meetings, reside free of charge on group land together with familiy, rights for use of land, water rights, marketing arrangements etc. However, they have no access to National Parks, only for water supply during drought seasion. GR members are given a new role in the WCMA (2013)
Conservancy Areas and tourism operators	Operating on certain land areas where rules and regulations regarding land-use are set up on own behalf. Regulations often include restrictions on land-use and regulatory grazing schemes

The Kajiado Council and Rift Valley provincial administration represent the governmental body of the stakeholder complex and enforce law and order. They play a significant role in prioritizing and overseeing development projects. The county government for instance is responsible for all kinds of local services such as water supply and infrastructure development.

The Kenyan Wildlife Service (KWS) holds responsibility for all National Parks and manages all wildlife on behalf of the state. Its work is primarily wildlife oriented aiming to conserve the wildlife population throughout the country. KWS is the main actor fighting wildlife crimes and for this they cooperate in cross-border operations with Tanzania and Uganda. Other key activities include ecological monitoring, tourism management, education awareness, community partnership and all kinds of ecosystem operations. The operational range of KWS is wide and they are part of most conservation activities and projects or at least KWS must be informed about any external implementation mechanisms.

The CWCCC is a relatively new management body, implemented through the recently enacted WCMA (2013), under the Ministry for Natural Resources and Environment. CWCCC participates in the county land-use planning with a focus on community lands. They represent the interface between all stakeholders but describe themselves as primarily community oriented. CWCCC holds responsibility in overseeing preparation and implementation of management plans on community and private lands. Moreover, they ensure that benefits from wildlife are distributed equally among all stakeholders. They are also responsible for reviewing and recommending appropriate claims from human-wildlife conflicts and elaborate payment schemes for compensation. Other key activities include the establishment of user rights, education and public awareness, mobilization and participation of local communities as well as recommendations on ecosystem based management.

NGOs cover the entire range of problems within their work. They complement the work done by governmental institutions and therefore collaborate closely with KWS and other institutions throughout the area. NGOs, as the CWCCC, represent an interface body between KWS and the communities. They work mainly in dispersal areas around the NPs, implementing short and long-term projects in various fields depending on the

current needs. Most NGOs operate additional compensation schemes, supplementing the compensation offered by the government. Other key activities include technical assistance to local institutions and the government in form of education, trainings, financial support, project support and implementation and research activities. Close work with communities depend on certain needs ranging from educational projects, to human-wildlife conflicts, wildlife protection and health topics. NGOs are obliged to report KWS about any action they take, but are generally free in their operations. Actions directly affecting wildlife (e.g. collaring elephants) must be arranged with KWS. Projects are generally focusing on selected groups and for this, permissions must be given by either KWS for e.g. entering the parks or Group Ranch committees for working with members.

Conservancy areas and tourism operators are responsible for certain areas and correspondingly setting up rules and regulations regarding their land-use visions on the specific land. They usually operate grazing and compensation schemes, as well as education and employment support for the local communities from whom the land is leased.

Group Ranch members are joint owners of a certain GR and hold specific rights such as free use of natural resources across their GR. The establishment of National Parks have had severe impacts on the livelihoods of the local communities who from then on were excluded from that land and from the use of the resources. For example, communities are denied access to Amboseli NP and entering the park is only allowed for them to make use of waterbodies located inside the parks if there is a drought. Crossing the park with livestock to reach water points is permitted. However, the rights exclude grazing by livestock in the park, but is still practiced by livestock keepers by purposely taking the longest way to the water point (Nyagi, 2017, pers. comm., July 21st).

Returns

Financial benefits from National Parks through entrance fees are used to operate KWS and to maintain facilities etc. Group Ranch members are benefitting through educational bursaries, infrastructure development such as schools, hospitals, water supply facilities and revenues from tourism, in case they are part of a certain conservancy area or specific group. Returns also depend on Group Ranches and their specific cooperation with the government. Tourism operators and communities who are part of a conservancy area gain revenues from tourism and benefit from improved grazing area through a grazing scheme. Moreover, indirect benefits from improved ecosystem services for Group Ranch members were identified.

4.1.2.2 Household Interviews

In this section, general information obtained from the household interviews is presented first. Secondly, perceptions of Group Ranch members about wildlife and conservation management are illustrated and lastly, perception and relationships to management authorities are explained.

General Information

30 individuals between the age of 21 and 75 years participated in the survey, including both female (n=7) and male (n=23) attendants. All participants described livestock keeping as their main source of income. However, everyone described at least an additional source of income which is either farming (67%, n=20) or any other casual or formal form of labor (43%, n=13). One person mentioned involvement in tourism without any specification. One person reported extra income through land leasing. Additional farming was an extra source of income which can be practiced without many initial resources. Farming output is used both for subsistence supply and sale on markets. Participants in Olugului Group Ranch have their own land parcels, which they use for the cultivation of crops such as maize, tomatoes and onions. In Rombo Group

Ranch, respondents use community land both for livestock keeping and small farming practices, mainly used for their own consumption.

Asking the Group Ranch members what they think about subdivision, 67% (n=20) responded they would rather support subdivision. The most common argument for subdivision was independence and the possibility of developing the land according to own needs. Land would remain family-owned and hence gives security for the next generations. Moreover, others argue that subdivision would prevent land conflicts in the future when population is higher. Reasons given against subdivision 33% of the participants (n=10) include the fear of arising conflicts between Group Ranch members over land ownership and the fear that members might sell their allocated land for short term income rather than keeping it.

Perceptions on Wildlife and Conservation Management

Four major aspects involving human-wildlife coexistence and conservation management were identified: 1) direct or indirect benefits resulting from living in a wildlife rich area; 2) threats people are facing because of wildlife; 3) future perspectives, visions about co-existence and proposed conservation strategies; 4) willingness to participate in conservation. Results are represented question by question. It is noteworthy, that participants could give multiple answers to the questions, resulting in uneven percentage numbers.

1. **Do you have any direct or indirect benefits from living with wildlife or community conservation?**

Most of the participants expressed negative feelings about wildlife and conservation management. The majority state that wildlife would be a liability rather than asset. People see wildlife as a burden and feel disadvantaged by living in the dispersal areas. 22 (73%) of the respondents stated that they do not receive any benefits from wildlife. However, when asking specifically about benefits such as infrastructure development or school bursaries, people admit they have seen infrastructure development or that they receive school bursaries for their children (see Figure 6).

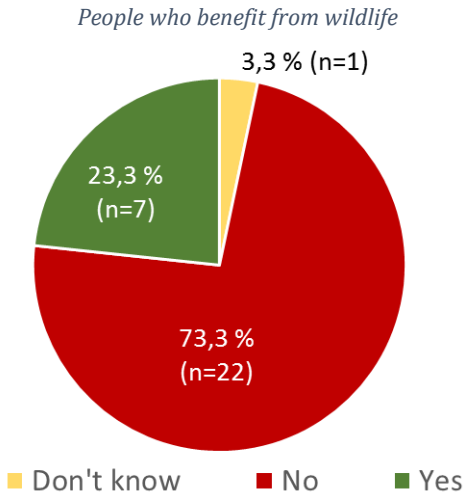


Figure 6: Responses of GR members if they would benefit from wildlife

2. **What are the main problems with wildlife you are facing?**

Main problems that people are facing due to wildlife include crop raiding, competition for water and grazing areas, to the point of injuries and killing of humans and livestock. People also feel restricted in their movements, hindered by elephants being the first at water points.

3.

i) **How do you think the conflict between wildlife and humans could be solved?**

ii) **How do you imagine living with wildlife in the future?**

Participants were then asked how they think the conflict could be solved and how they imagine living with wildlife in the future. Different ideas of how the conflict could be solved were illustrated. The most common response was to put wildlife back to the parks and keep the land in between only for humans. Spatial separation of humans and wildlife with electric fences and designated areas for wildlife was the most common answer by 85% of the participants (n=25), 17 of these respondents state they wish

animals to be only in the parks and not on the communal land. Employment of more patrols and guards responsible for securing the area (30%, n=9) was also a common response. See Figure 7 for an overview of responses.

Improved management of the area includes funds for communities to live with wildlife, the establishment of conservancy areas and the provision of water and forage in the parks for livestock.

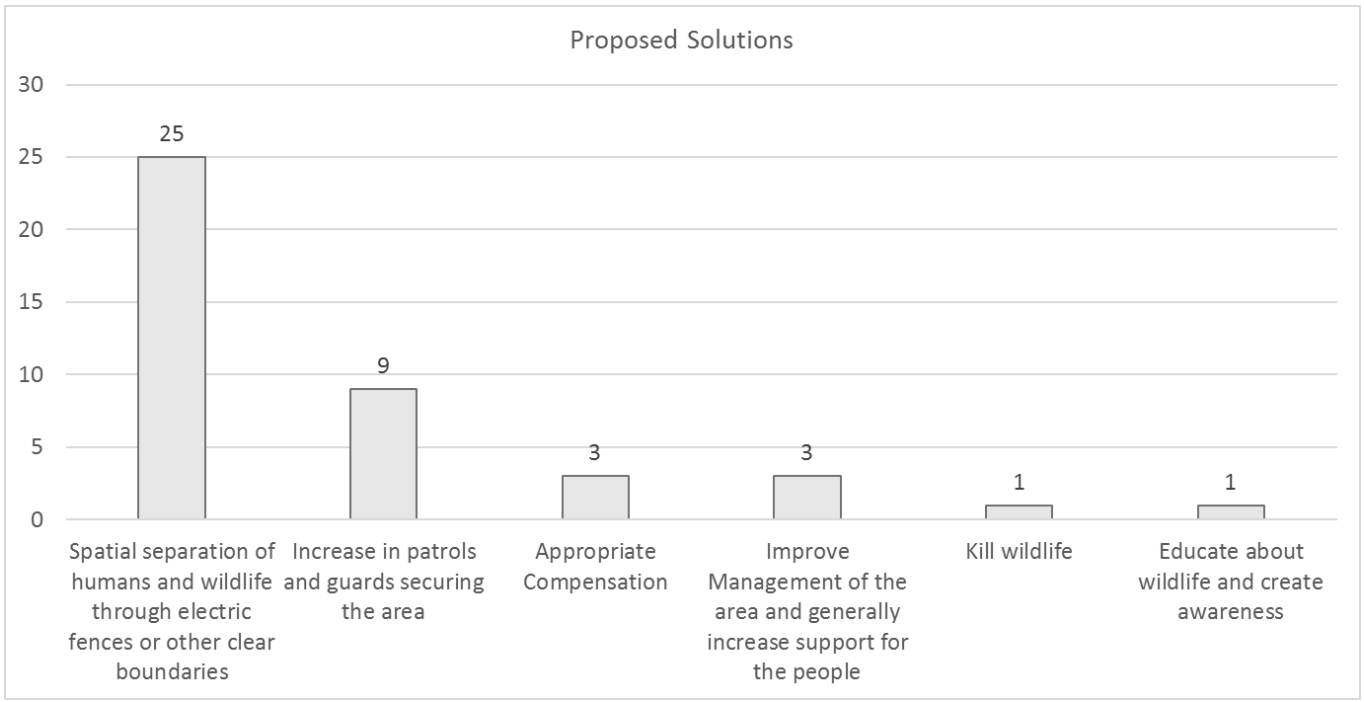


Figure 7: Recommendations given by Group Ranch members regarding wildlife management (n = 30, total number of participants)

> *"If there would be a special strategy by those who are responsible for wildlife management, it will provide jobs for the community, for example as guards and patrols."* (Participant in Olgulului Group Ranch)

Counteracting conflict situations between humans and wildlife, sufficient resources must be provided. Water is the scarcest natural resource in the area, followed by insufficient grass available for cattle. One participant stated:

> *"If water and food would be provided to wildlife, the conflict would reduce rapidly."* (Participant, Olgulului Group Ranch)

Grazing areas are a complicated issue and people hardly understand why they must share grazing areas with wildlife, while wildlife on the other hand, is free on communal land. The prohibition of entering the park with livestock is recognized as an unfair regulation. It became clear that people have different explanations for the poor conditions of resources such as grazing lands. Climate change and the insufficient rainfall are mentioned most frequently causing the problems. Some people see Group Ranch committees and community elder as responsible for managing grazing schemes, others do not know who is responsible but also do not see a problem in the management. Yet, others say it is communally land and grazing would therefore not be regulated by anyone. However, there was no clear answer about management and strategies that have been put into place or parties explicitly mentioned to have responsibility over that task. Some responses include the wish for support in these activities but for most of the people it seemed too complicated to be effectively solved.

4.

i) Would you like to take part in conservation?

ii) If yes, how would you like to take part?

The majority responded not being involved in wildlife management, unless reporting incidents of conflicts such as crop raiding, sighting of poachers or injured animals. However, 25 (84%) of the participants would like to take part in conservation (Figure 8). Being employed in tourism or conservation management and to create awareness about the importance of wildlife and deforestation was the most frequent answer. To the question "*Would you like to take part in conservation*?", only one person answered with "*No*", explaining: "*we don't want to give any land for that*".

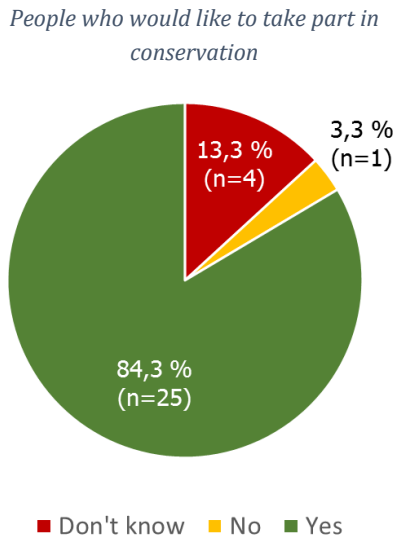


Figure 8: Number of participants who would like to take part in conservation

Relationships to authorities

Other information obtained through the household interviews include perceptions on the current management and the responsible authorities. Participants were asked if they would know who they can contact in case of their mentioned problems. Named actors include NGOs, namely IFAW and Big Life Foundation, GR committees and KWS. Work done by KWS was described as poor, GR committees as corrupt and NGOs as okay and as the most trustworthy body in the complex system of organisations responsible for ecosystem management. Relationships are explained more closely in the following section (4.1.2.3).

Summarized the main ideas and visions obtained through the household interviews by Group Ranch members:

- Wish for involvement in conservation (management and decision-making, but also simply to be informed about current laws and regulations)
- Wish for employment and job opportunities through wildlife conservation

- Wish to be educated about wildlife and environmental topics; and to teach others (creating awareness)
- To be sufficiently compensated for loss and damages through any wildlife
- Wish for subdivision with the intention to be independent and to be able to take care and develop land
- Unclear roles of responsible authorities taking care of the ecosystem and the problems people are confronted with.

4.1.2.3 Interest-Influence Analysis

The following evaluation scheme was developed on the prior presented information obtained through interviews with key informants and Group Ranch members, aiming to represent each stakeholder on an interest-influence matrix. Table 9 shows given interest-points for certain topics (“main concerns”) and Table 10 power and influence-points for each stakeholder. The outcome of the evaluations results in the interest-influence matrix illustrated in figure 9.

Table 9: Framework developed to evaluate different dimension of stakeholder "interest" in selected topics, divided into high (+++), moderate (++), low (+), insignificant (-); (adopted from Reed et al., 2009)

Interest/Stake					
Stakeholder	**Main concerns**				
	Wildlife Conservation	Community Participation in Wildlife Conservation	Benefit Sharing	Employment & Education	Free ranging Wildlife in Dispersal Areas
KWS	+++	+	+	++	++
CWCCC	+++	+++	++	++	++
NGOs	+++	+++	++	+++	+++
GR committees	+	n.a.	n.a.	n.a.	n.a.
GR members	++	+++	++	+++	+
Farmers/Outsiders/ Agricultural businesses	(-)	(-)	+	n.a.	(-)
Conservation Areas	+++	+++	+++	+++	+++

The column "Wildlife Conservation" refers to the interest in long-term wildlife conservation and importance that wildlife continues living in the ecosystem. Participants showed different ideas in how they imagine living with wildlife in the future. Ideas can be divided into free ranging wildlife, as it is the current situation, and spatial separation of humans and wildlife through either designated areas or fences. This was evaluated in the column "Free ranging Wildlife in Dispersal Areas," implying the wish for fences as opposite interest. "Community Participation in Wildlife Conservation" refers to the idea of including individuals and communities in conservation approaches as much as possible and to share responsibilities. Other dimensions include interests in "Benefit Sharing" and "Employment and Education".

Table 10: Framework developed to evaluate different dimension of stakeholder "influence". High (+++), moderate (++), low (+), insignificant (-); (adopted from Reed et al., 2009)

Influence in Ecosystem						
	Instruments of Power			**Sources of Influence**		
Stakeholder	Condign	Compensatory	Conditioned	Personality	Property/ Access to Parks	Organisation
KWS	+++	+++			+++	
CWCCC	+++	+++				+++
NGOs		+++	++			+++
GR committees	+			+++		
GR members	++					+
Farmers/Outsiders/ Agricultural businesses	+				+	
Conservation Areas		++	++			+++

The evaluation scheme for influence distribution among stakeholders was based on Galbraith (1983) cited in Reed et al., (2009) and the theory of power distribution. According to the theory of Galbraith, instruments of power are divided into condign, compensatory and conditioned. "Conditioned" power refers to public opinion and the free will of people to behave or participate in a certain way. Corresponding instruments include for instance education and persuasion. "Compensatory" power includes exchange, for instance materials, resources or financial rewards and benefits. The principle instrument of compensatory power are often money or other bursaries. "Condign" power means the ability to enforce rules and regulations and inflict punishment if necessary.

Galbraith further divides three sources of power including personality, property and organisation. "Personality" means leadership by a single person based on certain characteristics. "Property" refers to access to land and ownership of land. "Organisation" means effectiveness in implementing plans.

A graphical representation of stakeholders was developed in an interest-influence grid, shown in Figure 9 based on the previous evaluation scheme shown in table 9 and 10.

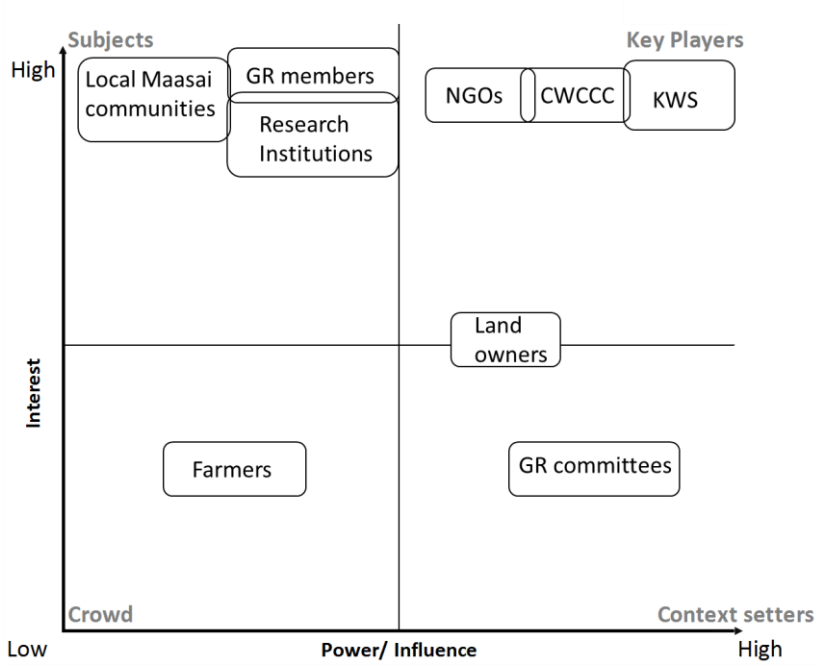


Figure 9: Interest-Influence matrix for stakeholders

The graph identifies four different categories of people, namely subjects, key players, context setters and the crowd, following the structure defined by Reed et al. (2009). Key players represent stakeholders with both high interests and high influence over wildlife conservation. These include the different NGOs and development organisations. Context setters are highly influential, but show little interest in appropriate conservation mechanisms. Because of this, they might be a significant risk and should be monitored (Reed et al., 2009). Context setters include the Group Ranch committee and the Group Ranch Association. Subjects show high interest but have low influence. They are usually supportive, but lack the capacity for any impact and are highly affected by actions taken by key players or context setters. Yet, they could become influential by forming alliances with other stakeholders. Subjects are Group Ranch members and local Maasai communities who are highly affected by wildlife conservation approaches, land-use planning as well as laws and regulations to be

implemented. Moreover, they lack influence and are unlikely to actively participate in decision makings or conservation activities. Unless community members are involved in a community conservation project or part of a conservancy area, benefits and return are very low or not present. The crowd represents stakeholders with little interest or influence over a desired outcome. Here outsiders moving to the area and starting farming activities or businesses were identified as being part of the crowd.

4.1.3 Relationships between identified Stakeholders

Group Ranch members as identified primary stakeholders are directly affected by decisions and activities taken by secondary stakeholders such as NGOs and the governmental authorities. Relationships and perceptions among the stakeholders' result from the power distribution and are illustrated in Figure 10. Understanding of relationships is based on information provided through interviews, field experiences and reviewed literature.

Strongest relationships were identified between Group Ranch members who are part of any conservation projects and therefore receiving higher benefits such as employment, education or improved ecosystem service, than Group Ranch members who are not actively participating. Despite that KWS works with ranchers and local communities in various projects, they are perceived as opponents working against the interests of Group Ranch members by most of the participants.

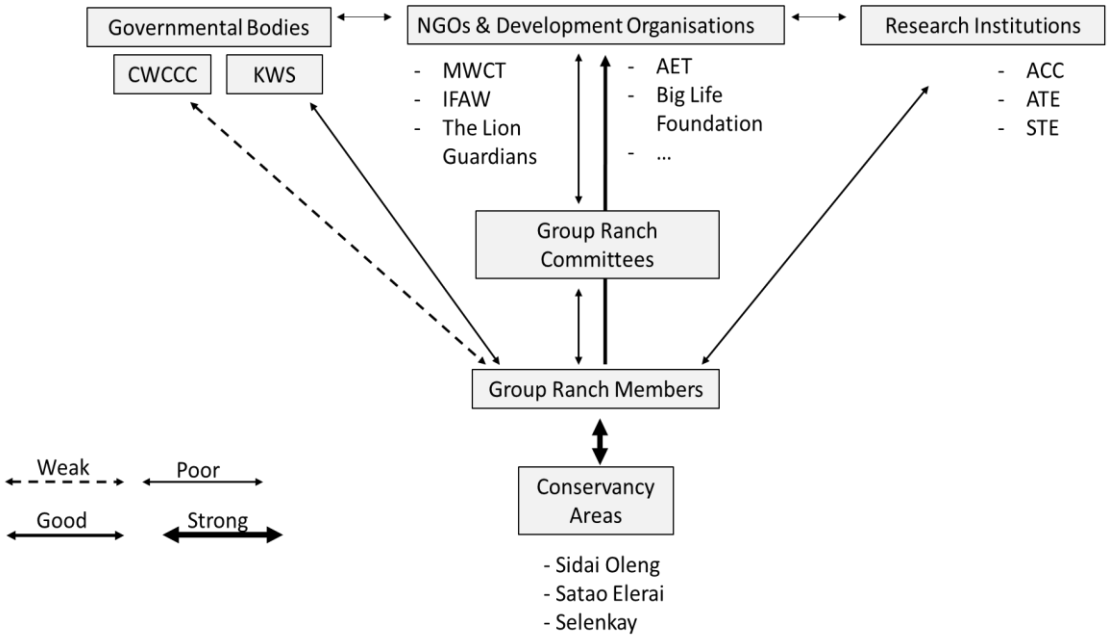


Figure 10: Stakeholder relationships

A strong need to improve the relationship between KWS and community committees was identified. People stated that they felt left alone by the responsible authorities. Not only mistrust but also anger was recognized. One participant told:

> *"If an elephant is killed, they will come with helicopters and everything. But if something happens to us, or our animals, nothing happens. There is no compensation. They [the government] value the life of wildlife more than their people."* (Participant in Olgulului Group Ranch)

However, KWS is reaching out to local communities to be partners in conservation initiatives and constantly working to improve collaboration and cooperation with locals. They combat wildlife crimes on national and international level. Nevertheless, their responsibility consists mainly of wildlife protection and only in recent years it was

recognized that conservation is more likely to be successful from a bottom-up approach by the inclusion of local communities rather than the previous top-down approach. Due to the fact that Amboseli NP was established under the jurisdiction of KWS, unsecure ownership and user rights, local people often feel disempowered to control and manage their land. There is a wish for active participation, which supportive stakeholders such as NGOs, KWS etc. are fostering. Through the new WCMA (2013) local communities get the opportunity to take responsibilities and a shift towards community oriented conservation approaches and participation was identified. However, the recently introduced CWCCC is not yet very popular among participating Group Ranch members, which is why the relationship is described as weak. Research institutions are known to exist, but it seems they are not in direct exchange with communities, leading to mistrust among Group Ranch members, who believed research would only be in favor of wildlife.

Participants in the interviews were not part of any conservation group, nor were they receiving any revenues from tourism. Relationships could be improved if people would be more actively involved in conservation topics. Moreover, people claim they would be excluded from decision makings, research activities and general practices in the ecosystem. Asking about their willingness to participate in conservation, almost all agreed. This would give them more responsibility with direct returns, which would improve the relationships and shift towards a more reliable partnership on an equal level.

NGOs, namely IFAW and Big Life Foundation, and the parastatal body KWS were named when asked about the responsible authority for recognized problems. NGOs are generally focusing on certain GRs, in which they are then well known and more active than in others. MWCT for example focuses on Kuku GR and Big Life Foundation on Mbirikani GR. Nevertheless, they are in constant exchange with each other and KWS. Yet, there was a common mistrust of GR members towards KWS, believing they would not care about their problems. Compensation in case of livestock being killed is often used as an example. According the new WMCA (2013), claims must be made to KWS. However, people prefer to claim their losses to one of the NGOs who operate their own

compensation schemes and work faster. Money would still be very little, but at least it would be paid in reasonable time (Group Ranch member 2017, pers. comm.). Group Ranch committees are interposed between NGOs and Group Ranch members. Hence, they must be contacted first, when trying to reach communities.

The analysis indicates that NGOs have close relationships with one another and KWS is involved in all kinds of activities. However, it seems that small development organisations are unlikely to be known and mainly do own projects, independently from the big NGOs and KWS. They must ask for permission for certain projects or if for example participating communities, located in the National Park or close by. Group Ranch members seem to be generally confused about the responsible actors and who occupies which tasks. Even on the lower level between GR members, the Group Ranch committees and Group Ranch Associations. It was unclear how responsibilities are distributed. Obscure relationships and structures that are hardly understood by Group Ranch members. Moreover, there was a general mistrust against the certain authority bodies such as the Group Ranch Committees. They were only described negatively and as a corrupt body, taking all benefits and not caring about members. Group Ranch committees are often the first body to be contacted aiming to reach the communities. After having their confirmation, projects can be started.

Relationships between responsible management bodies were largely reported as positive with strong interactions, information exchange and agreements. The main NGOs and KWS work in close relationships and developed Amboseli Management Plan 2008- 2018 (KWS, 2008a) in cooperation with one another.

The relatively new CWCCC carries the responsibility of connecting community members with KWS and other institutions, bringing all stakeholders together. They aim to put localized power on the county level. However, CWCCC were not mentioned by Group Ranch members and seem not to be very popular yet. The body carries a devolution function in comparison to KWS who has national government function.

Interest and influence is a dynamic process, changing over time. KWS was identified as key player who had changed over the last year to a more participatory conservation approach, recognizing the need to include communities into conservation

management. However, Group Ranch members expressed their mistrust against KWS, Group Ranch committees and sometimes the leaders of the community, complaining about a lack of transparency in decision-making and exclusion from management interests. NGOs and CWCCC could foster their mediating role aiming to improve the relationship between KWS and Group Ranch members. Higher participation possibilities and information provided to communities about wildlife management might change their perception about it. Increased benefits for Group Ranch members who are directly affected and restricted by wildlife might change their negative perception towards a positive attitude if conditions are changed.

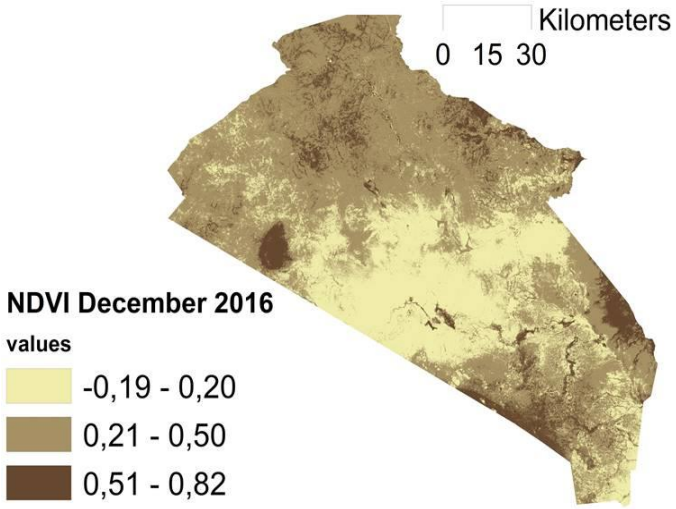
Organisations and KWS agree that wildlife should range freely in the Group Ranches. Fencing off the park, as wished by Group Ranch members, is not a realistic option. Strategies to be applied are the development of conservancy areas along wildlife migration routes. Construction of electric fences would be the ultimate solution to mitigate the conflict, if nothing else works due to the immense impact on fragmentation in the landscape.

4.2 Geo-spatial Analysis

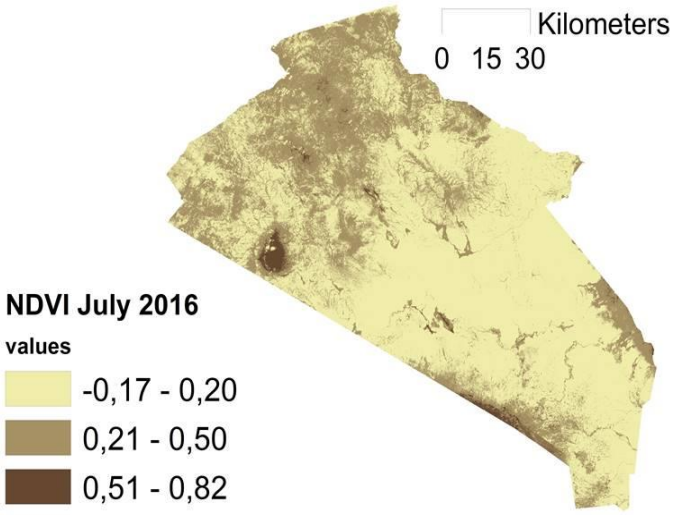
4.2.1 Remote Sensing and Landcover Classification

4.2.1.1 Vegetation Cover

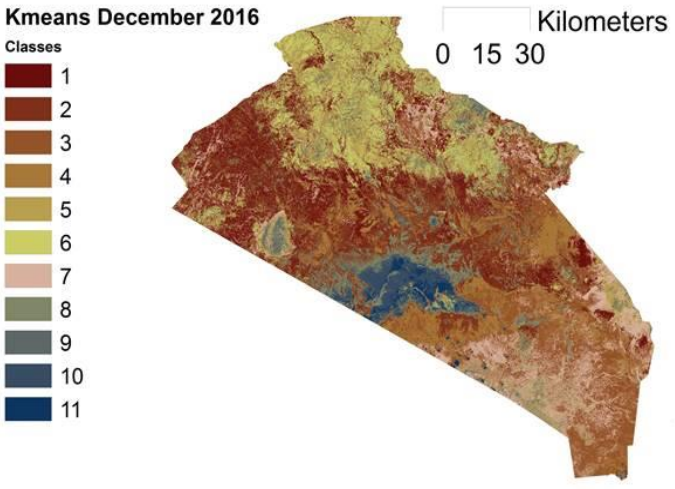
The vegetation cover was obtained by using two different methods. First, calculating the NDVI and second, performing a landcover classification with K-Means cluster analysis, both using Sentinel-2 high resolution imagery as input layers. Results are illustrated in Map 2 & 3 (NDVI) and Map 4 & 5 (K-Means) for December images (rainy season) and July images (dry season), respectively. NDVI values > 0.2 correspond to bare soil, values between 0-2 and 0.5 represent sparse vegetation such as shrubs, bushes or grasslands. High NDVI values (> 0.5) are associated with dense vegetation such as forests (USGS, 2015). The K-Means cluster analysis differentiates 11 classes with similar spectral signatures, which were each identified afterwards by comparing with Google Earth satellite imagery and the NDVI. However, classes could not be fully identified. Outputs of K-Means cluster analysis and NDVI were compared among each other. The NDVI shows more accurate results and was finally used as input layers for the least-cost path analysis.



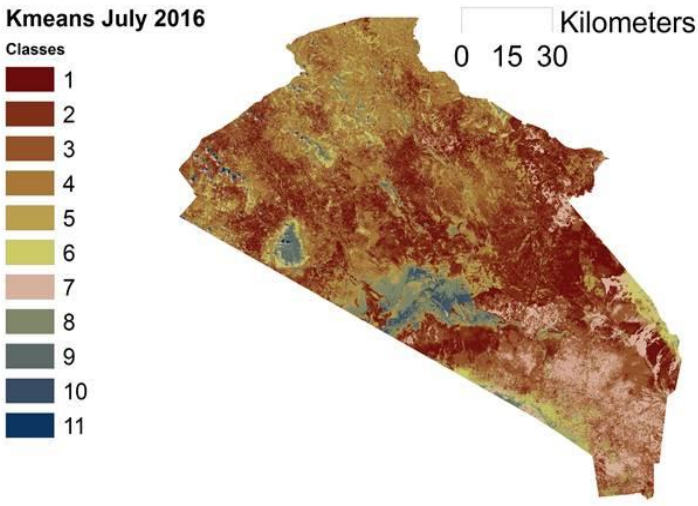
Map 2: NDVI values for Sentinel-2 Imagery in wet season (December). Data Source: Annex I



Map 3: NDVI values for Sentinel-2 Imagery for dry season (July). Data Source: Annex I



Map 4: Output landcover classification with K-means Cluster Analysis for Sentinel-2 Imagery in wet season (December). Data Source: Annex I

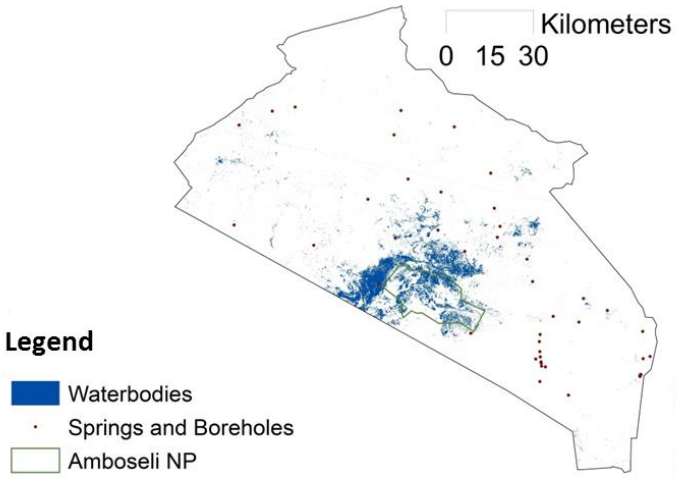


Map 5: Output landcover classification with K-means Cluster Analysis for Sentinel-2 Imagery in dry season (July). Data Source: Annex I

4.2.1.2 Waterbodies

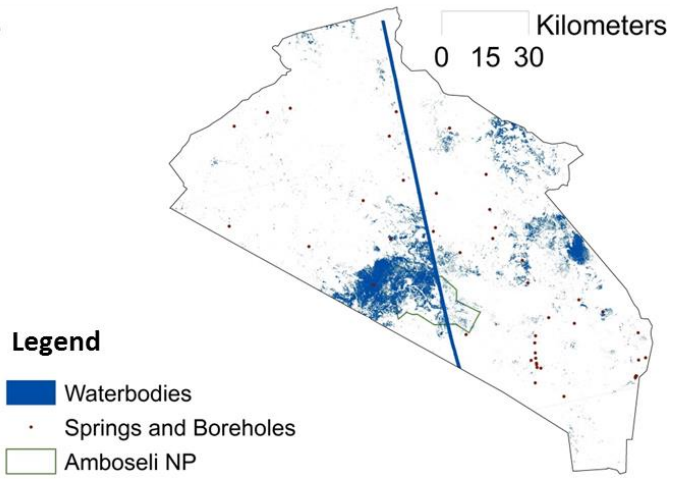
Waterbodies were detected using publicly available shapefile layers from WRI and ILRI and through a classification process of sentinel-1 radar imagery. Results are represented in maps 6 & 7 (open source shapefiles) and maps 8 & 9 (Sentinel-1 radar imagery) for December images (rainy season) and July images (dry season), respectively. Outputs were compared among each other. Open source shapefile layers were determined to show most accurate results and finally used as input layers for the least-cost path analysis.

Seasonal Waterbodies (December)
Sentinel-1



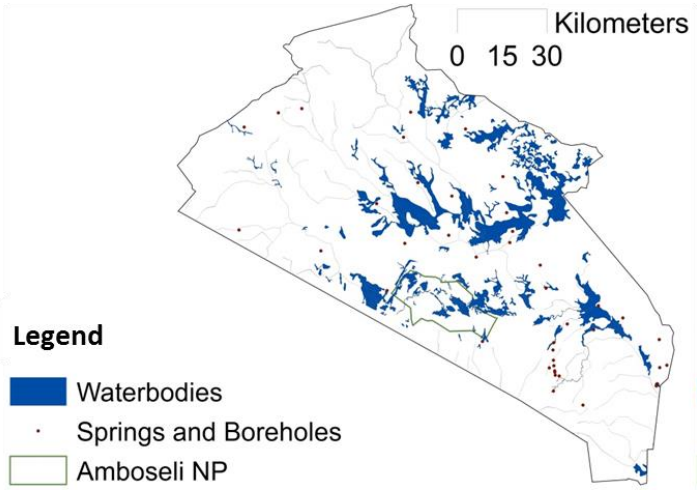
Map 6: Seasonal waterbodies obtained through open source shapefile layers representing wet season (December). Data Source: Annex I

Permanent Waterbodies (July)
Sentinel-1



Map 7: Permanent waterbodies obtained through open source shapefile layers representing dry season (July). Data Source: Annex I

Seasonal Waterbodies (December)
Open Source



Map 8: Seasonal waterbodies obtained through Sentinel-1 radar imagery representing wet season (December). Data Source: Annex I

Permanent Waterbodies (July)
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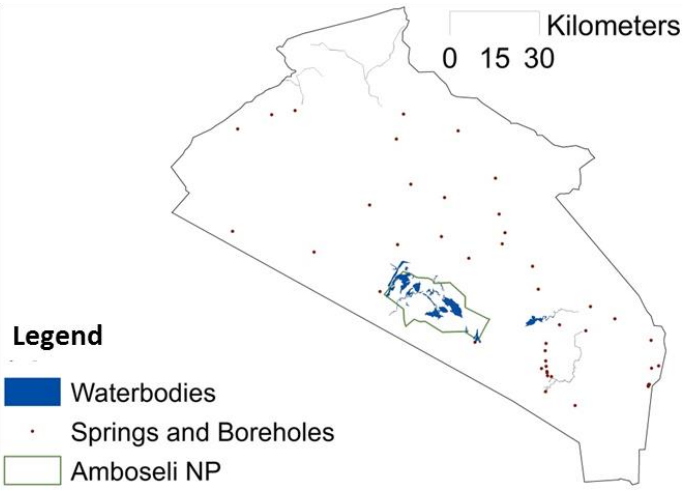
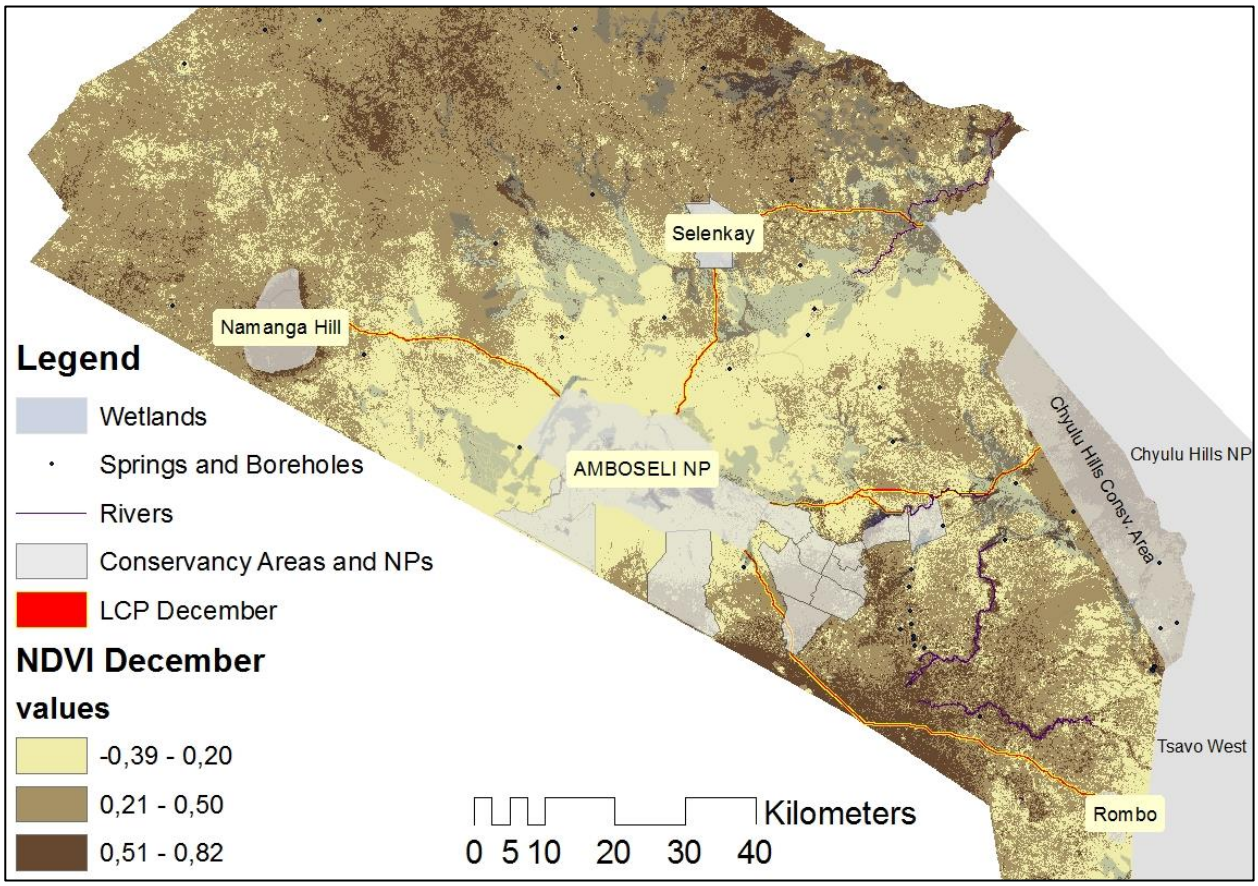


Map 9: Permanent waterbodies obtained through Sentinel-1 radar imagery representing dry season (July). Data Source: Annex I

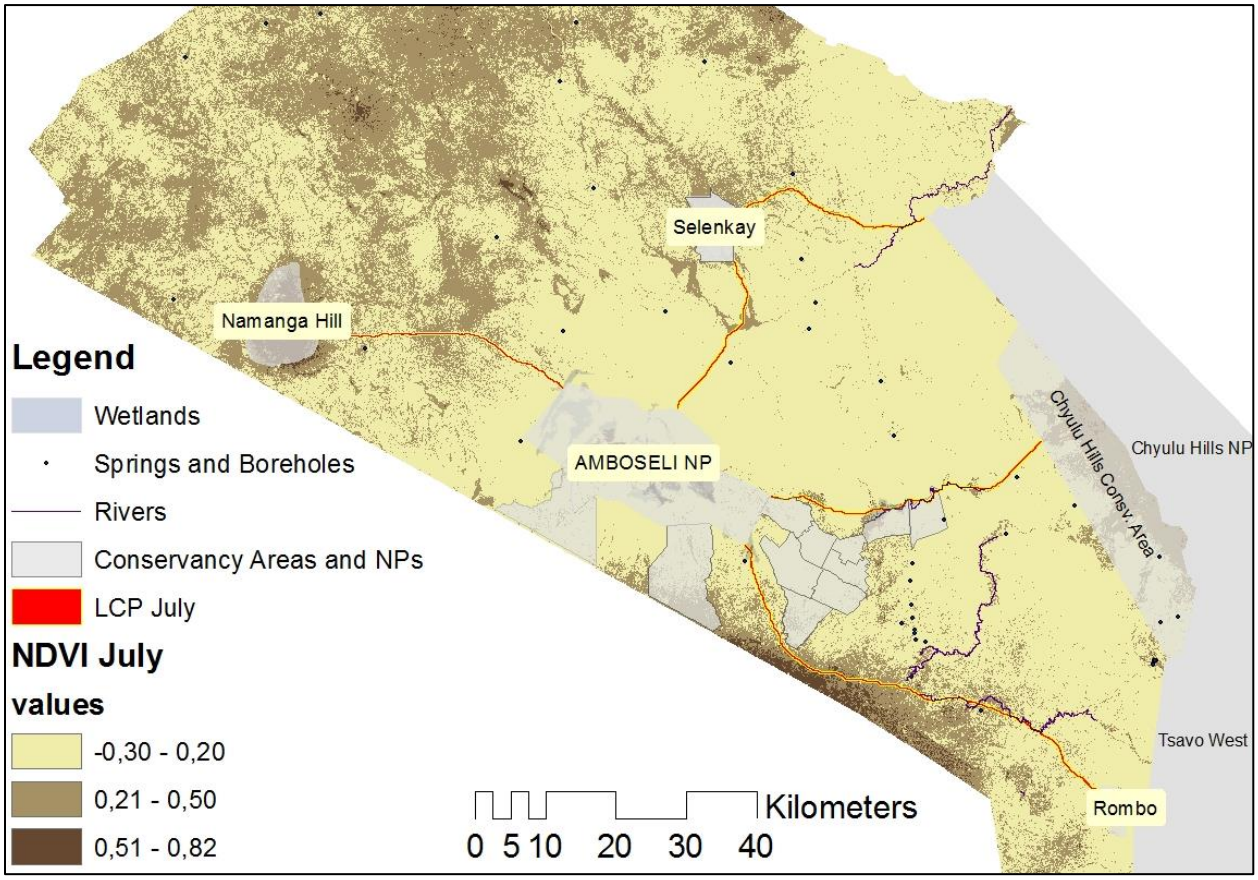
4.2.2 Least-Cost Path Analysis

4.2.2.1 Overview of Outcome

The least-cost path (LCP) is an approach to identify connectivity routes, whereby lowest resistance values over a cost-surface represent least costly travel routes for a certain species that could be used to move from one point to another (Parks et al., 2013). The results of the analysis are various lines representing most comfortable travel routes for the African elephant. Proximity to waterbodies, distance to roads and settlements, vegetation cover and slope were the factors considered for the construction of the paths. The process was run for December (Map 10) and July (Map 11), using different cost-surfaces. Important stepping stones are the running conservancy areas, which were therefore included as source and destination points in the LCP-Analysis.



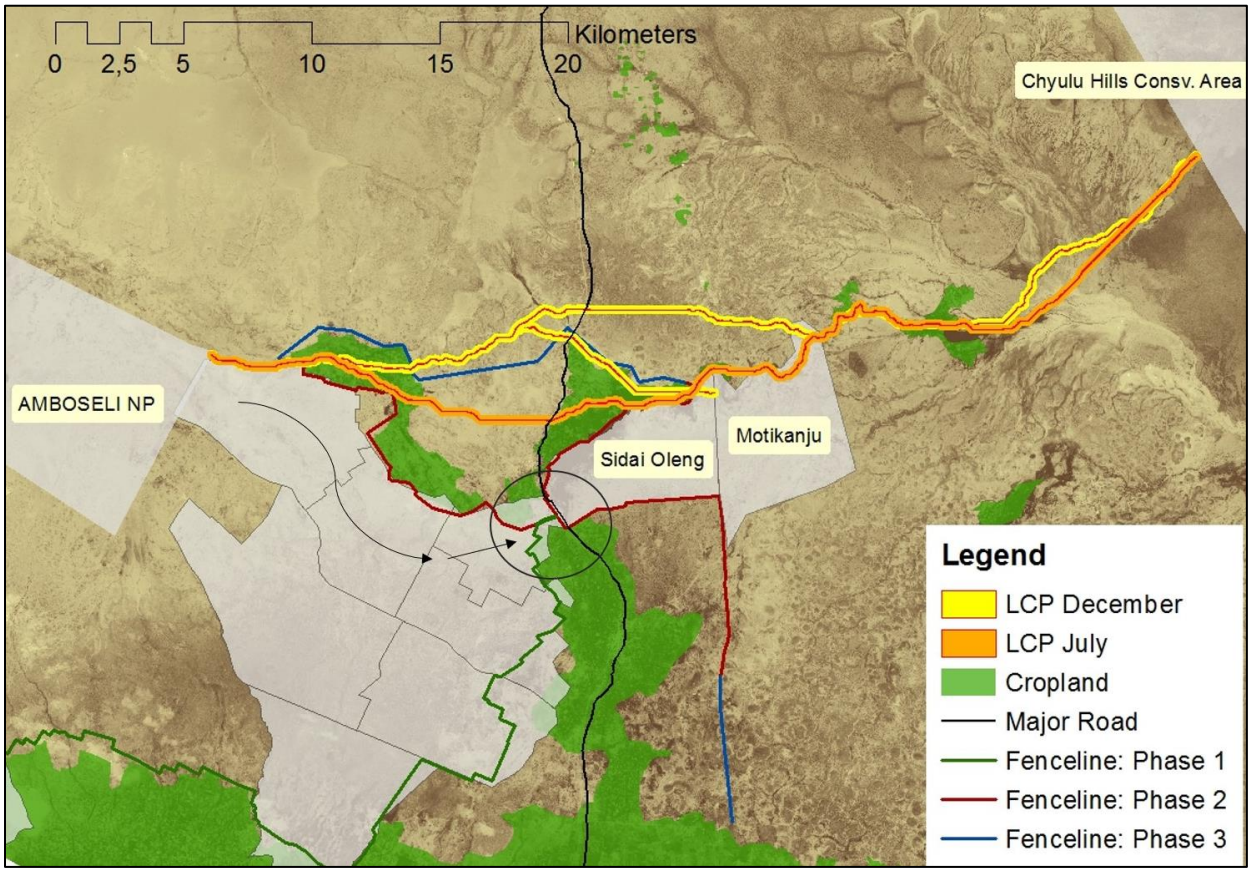
Map 10: Least-Cost Paths obtained for December



Map 11: Least-Cost Paths obtained for July

4.2.2.2 Analysis of identified Routes

Route 1: Amboseli – Motikanju – Tsavo West



Map 12: Least-Cost Paths between Amboseli NP and Chyulu Hills Conservation Area. Arrows indicate elephant movements, which can pass through a corridor of 50 m width to Sidai Oleng (circle). Data Source: Annex I

The area around Kimana town on the eastern border of Amboseli NP is probably the most critical in the area. Kimana Group Ranch had been subdivided and today, land is hold by individual land owners. Most of the fertile land around swamps and wetlands is partly fenced off and used for agricultural production. Human-elephant conflicts are the highest in this area, since elephants are highly attracted by the rich forage resources provided through farming. Main cultivated crops include maize (*Zea mays*), onions (*Allium cepa*), tomatoes (*Lycopersicon esculentum*) and beans (*Vigna faba*) (Kioko et al., 2008). Irrigated agriculture around Kimana wetland increased from 69.97 km² in 1980 to over 438.17 km² in 2013, making agriculture to the greatest causes for land-use changes. Human-wildlife conflicts are described to be most intense around farming land (KWS, 1994 cited in Okello, 2005) and crop raiding is described as the main problem between humans and elephants in the area (Nyamosyo et al., 2014). Fences were constructed for the first time in 2000 (Kimana and Namelok fences). Though fences have failed (Kioko et al., 2008) due to weak community management (Okello et al., 2008; Goss 2017, pers. comm., July 10th). Today, they are broken down and in bad condition. Nevertheless, well- functioning electric fences are costly but an effective tool to protect farmland from crop-raiding elephants. Currently, the fences shown around Kimana (Map 12) are incomplete and only phase 1 is already implemented. Phase 2 and 3 are still theoretical but planned to be constructed by Big Life Foundation and KWS. Because prior constructed fences failed when responsibility for maintenance was handed over to the community, this time responsibility for fences will permanently stay in hands of the named organisations. Through current and proposed fences, elephants can pass through a tiny 50 km wide corridor towards Sidai Oleng Sanctuary (Goss 2017, pers. comm., July 10th; Okello and Amour, 2008), as illustrated on map 12 (circle). However, the tiny corridor is challenging to find for the elephants, as it is the situation right now. When other fences are finally constructed and well managed, they would act as permanent barriers, channeling elephants in a certain direction towards Motikanju. Currently private farmers are setting up their own fences around each little *shamba*[2], without taking care of blocking any wildlife corridor. However, fences are

[2] *Shamba*, (in East Africa) describes a cultivated plot of ground; a farm or plantation (Source: https://en.oxforddictionaries.com/definition/shamba)

controversial mitigation strategies. Although conflicts can be minimised, constructed fences stimulated agricultural productivity within them (Okello, 2011) and people in areas without fences are increasingly demanding the same protection and investment to make their land secure. Electric fences are an effective tool when aiming to reduce negative interference between humans and wildlife. However, it maintenance must be ensured. Fencing was described as a final approach, if nothing else works (Goss 2017, pers. comm., July 10th).

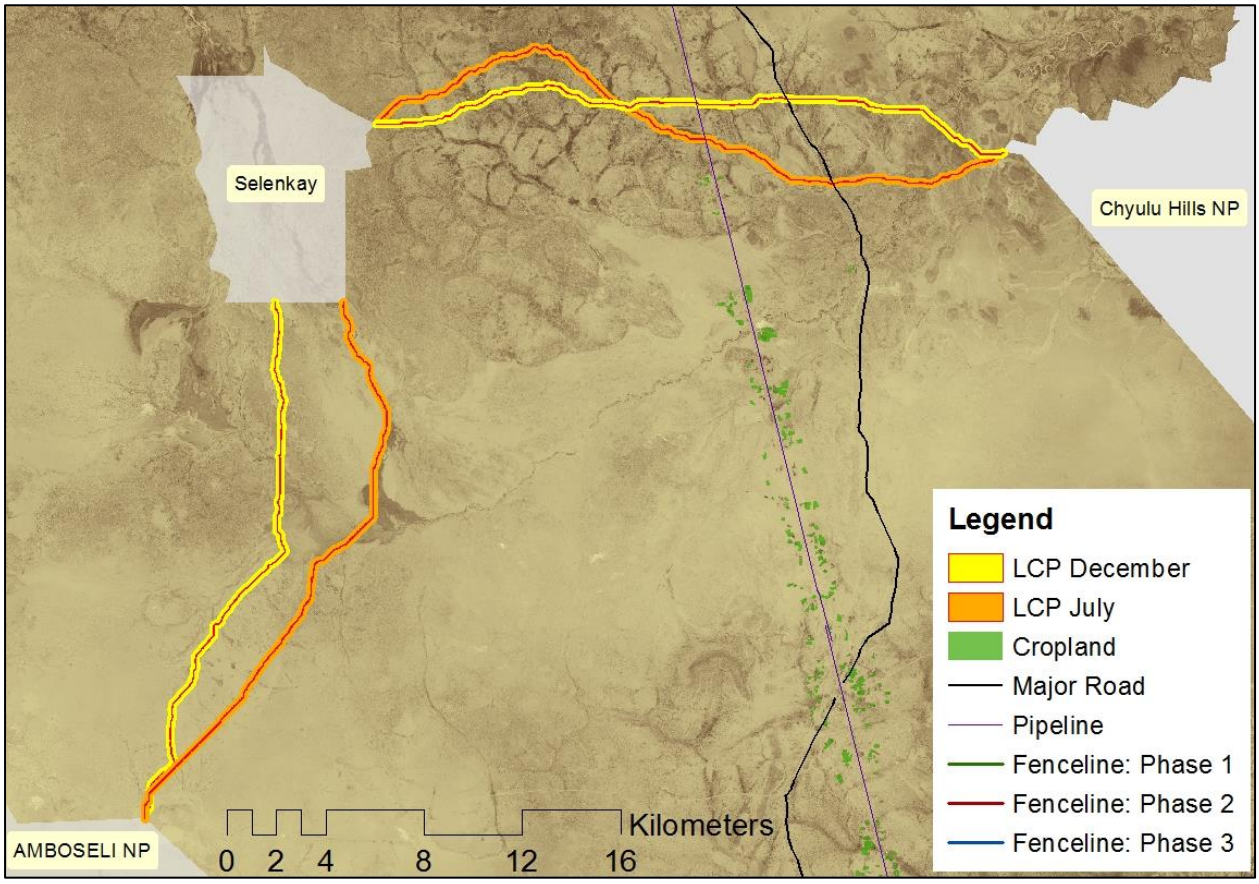
Other threats resulting from farming is the tremendous pressure on natural water resources, which is said to be highest around Kimana town, where agriculture is mainly for commercial purposes rather than subsistence (Okello, 2011). Most of the agriculture is dependent on irrigation and therefore associated with high usage amounts.

The tarmac road running towards Loitokitok must be crossed on any route from Amboseli NP towards Chyulu Hills or Tsavo West. Increasing traffic affects all wildlife species who might be scared by noises. I was informed that road accidents occur frequently with different wildlife species involved.

Route 2: Amboseli- Selenkay- Chyulu Hills/ Tsavo West

Selenkay is a well- established conservancy area, laying about 16 km north of Amboseli NP from its northern boundary. The conservancy area was created back in 1997 and covers an area of approximately 53 km² (Gamewatchers Safaris Ltd, 2015). The land is leased from local Maasai people to offer an alternative to farming activities. Surrounding Maasai communities profit from employment, improved ecosystem services and active involvement in conservation and tourism. Moreover, ownership is continued by local title deed holders. During the start of the conservancy, elephants were almost not passing through that area anymore, but the conservancy claims a significant increase in wildlife numbers, including elephants, which today have returned after 20 years of absence (Brar 2017, pers. comm., July 27th). Today, the conservancy gives refuge for a great variety of species, who use the area as an

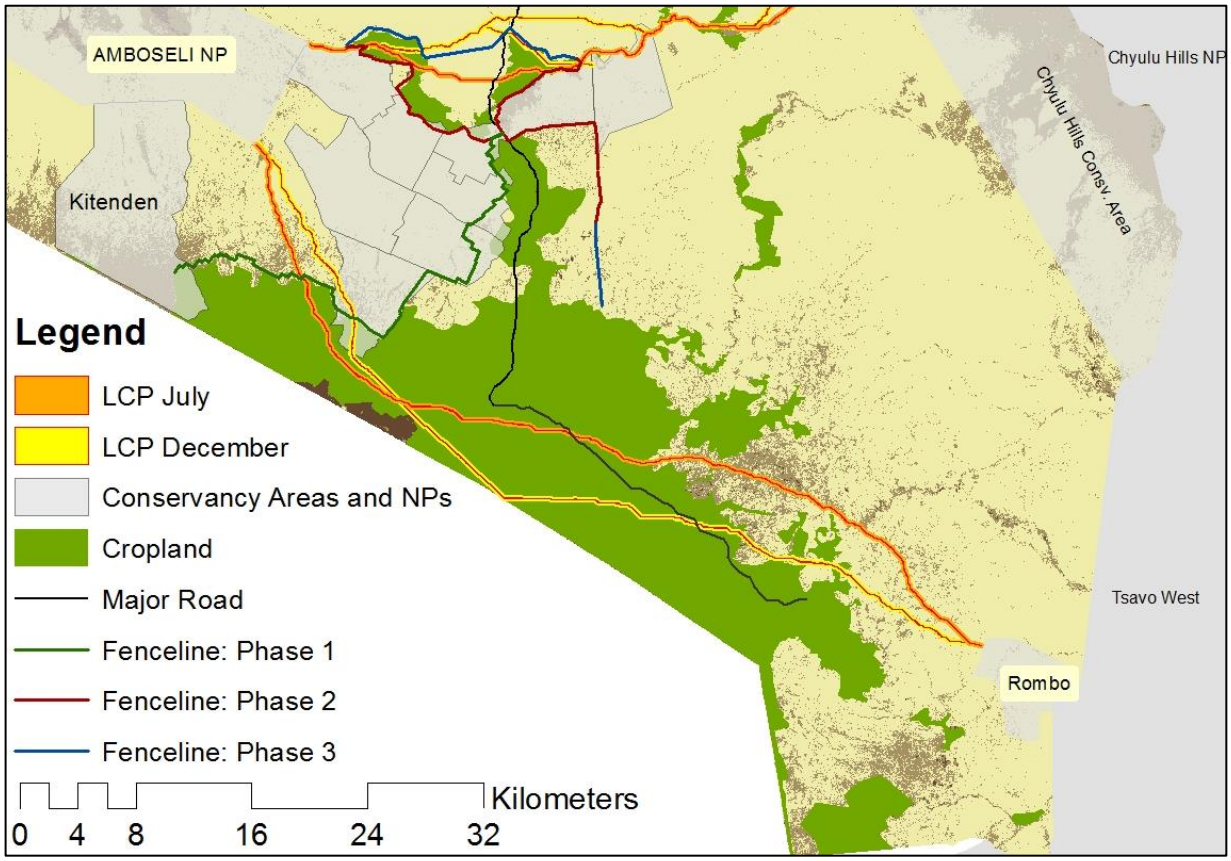
important stepping stone between the Amboseli and Chyulu Hills. Olgulului/ Ololarashi GR consists of primarily semi-arid to arid pastoral land where agriculture is hardly possible. Nevertheless, around the water pipeline farming activities might increase and block this route in future, which would inevitably lead to increased human-elephant conflicts, as crops are in general an easily accessible source of forage for the elephants. This uncontrolled development can hardly be prevented and implications to protect farmland and settlements from wildlife may include the controlled construction of electric fence. Just as around Kimana, the tarmac road running through Mbirikani GR to Loitokitok presents a threat to all crossing wildlife species.



Map 13: Least-Cost Paths between Amboseli- Selenkay- Chyulu Hills NP. Data Source: Annex I

Route 3: Amboseli - Rombo

Agricultural plots around slopes of Mt Kilimanjaro represent rich forage possibilities for elephants. Planned fences would lead animals towards Tanzania through the Kitenden corridor. Currently, the area is highly used for agricultural production, coupled with all the negative consequences such as land degradation, high water uses and pollution. The outcome of the LCPA in this case is highly impacted by the boundary of the study area. Moreover, the location of Rombo, as a proposed conservancy area, was estimated.



Map 14: Least-Cost Paths between Amboseli NP and Tsavo West/ Rombo Conservancy Area. Data Source Annex I

4.2.2.3 SWOT-Analysis

Connectivity between Amboseli, Chyulu and Tsavo West National Park is characterized by increasing fragmentation through settlements, industrial developments and increasing farming activities. Following summarized strengths, weaknesses, opportunities and threats for long-term connectivity in the region in relation to identified routes.

Strengths:

- Clearly defined route leading elephants through a tiny corridor towards Sidai Oleng and subsequently to Motikanju.
- Selenkay Conservancy presents a safe refuge area for wildlife. It is a well-managed conservancy area in cooperation with surrounding Maasai communities.
- Two other conservancy areas, namely Mailua (located between Amboseli NP and Namangahill) and Ole Narika (located between Amboseli NP and Selenkay), are proposed and in the planning process of implementation (KWCA, 2016).

Weaknesses:

- Tarmac road with increasing traffic is a dangerous source for conflicts such as roads accidents.
- Contentious land ownership and insecure land-tenure situations lead to privatization, land sales and increasing subdivisions. With subdivision processes, Maasai people are no longer able to continue with their pastoral lifestyle whereby they depend on large areas of land.
- The implementation of planned fences around Kimana will take more time and planned completion date is unknown.

Opportunities:

- Willingness and interest of communities to participate in conservation and wildlife tourism activities.
- The new WCMA (2013) encourages local communities to participate in wildlife management and to make use of it.
- Planned conservancy areas present tourism opportunities, resulting in direct benefits for local communities.

Threats:

- Weak land-use planning and land-use practices non-compatible with wildlife conservation are described as a main problem in the Kajiado County Land Policy (Government of Kajiado, 2014). Uncontrolled infrastructure and tourism development sets further pressure on scarce resources and agricultural expansion, particularly around waterbodies. Along the water pipeline running through Mbirikani GR upcoming farming activities are threating the ecosystem and blocking dispersal areas. Water pollution was also recognized as a problem through high amounts of chemical fertilizer due to farming activities.
- Climate change is one of the major threats affecting the ecosystem. A decline in rainfall by 36% has been reported since 1922 in the forests of Mt Kilimanjaro, which are feeding the springs of the wetlands in Amboseli NP (Hemp, 2005 cited in Sarkar, 2006; Okello et al., 2016a). Increased deforestation and transformation of forests into cropland or deforestation for charcoal production are unsustainable and result in reduced rainfall. Reduced rainfall around Mt Kilimanjaro would affect the whole region and might even dry up wetlands on the Kenyan side, which increases the pressure on resources such as water and pasture (Okello et al., 2014). Riverine vegetation often cleared for firewood or charcoal production (Okello, 2011). Water cycle changes and prior permanent rivers were turned into seasonal streams (Okello, 2011). Changes in the hydrological cycles due to deforestation in water catchment area of Mt Kilimanjaro changes the water flow of rivers (Okello, 2011).

- Human population increase due to migration into the area and higher birth rates and a shift from nomadic to sedentary lifestyle put further pressure on scarce resources. Moreover, an increase in livestock density is described, which increases severity of droughts (Brar 2017, pers. comm., July 27th; Gordon et al., 2017; Western and Nightingale, 2004). Besides the natural resources, space is limited in the ecosystem and the area becomes more and more fragmented, blocking wildlife from dispersing between the parks (Okello et al., 2014).
- Lack of clear policies and unclear responsibilities leading to poor implementation of strategies and uncontrolled land-use developments (Gordon et al., 2017; Nyamosyo et al., 2014).

5 Discussion

In a rapidly changing environment with an increasing population density, National Parks often become isolated areas, being blocked from one another. This threatens not only biodiversity conservation, but also increases potential of human-wildlife conflicts since direct encounters between animals and humans are more likely to happen. However, it is neither possible to secure wildlife movements by preventing the whole area from being blocked and prohibitions of human developments, nor it is sustainable to fence wildlife off in designated areas and parks. A clear identification of wildlife migration routes can minimise conflicts by purposely keeping certain routes open for the animals. It is therefore necessary to define routes that are most likely to be used by the animals and to put appropriate mechanism into place aiming to prevent the identified routes from being blocked. This study outlines specific connectivity paths based on a least-cost path analysis with the African elephant as a keystone species.

The specific circumstances in the Amboseli-Tsavo Ecosystem have led to a complex body of stakeholders, relationships and dependencies between one another. To facilitate any implementation strategy, it is necessary to outline the different conservation ideas and strategies of the various actors in the region. In the following section the outcomes of the social analysis are discussed. The second part analyses the findings of the geo-spatial part.

5.1 Stakeholder Analysis

The stakeholder analysis aimed to identify different perceptions about conservation management and to outline relationships between actors.

5.1.1 Management Ideas and Perception about Wildlife Conservation

Threats and Challenges

Organisations and Group Ranch members identified similar threats and challenges in the ecosystem. Developing sustainable livelihoods is one of them. Education was by all parties considered as the entrance fee for multiplied opportunities and an improved living situation. People demand education and work trainings to be capable to take responsibility and to have higher employment opportunities. Most of the participants never obtained formal education, hence job opportunities besides livestock keeping are limited. Provision of education and school bursaries during the last decades are one of the reasons why communities became increasingly sedentary. A trend that will most likely increase in future. Pastoralism has been described as most suitable for the human-wildlife co-existence. Wildlife and the pastoral landscape is the backbone of biodiversity conservation and tourism industry, but highly threatened by sedentary land-use changes and increasing human-wildlife conflicts. In the face of conservation, land subdivision would be detrimental and increasing fragmentation and agricultural development would put even more pressure on land, increasing the scarcity of resources. However, institutions and organisations can only advise but have no direct impact on decisions. Currently, it seems leaders have decided against subdivision. Former Kimana GR is often described as a negative example illustrating land loss for Maasai communities. Large scale farming is mainly done by outsiders who gain high profits from it. This land use change occurring all around Amboseli, has been described as one of the greatest challenges for the ecosystem (Okello, 2012). However, policies promote cultivation and farming, support irrigation investments, financing for land subdivision to establish farms (Gitahi & Fitzgerald, 2010).

Compensation and benefits

Mentioned benefits such as school bursaries and infrastructure development are insufficient and should be independent from wildlife conservation since they are basic needs. However, revenues from wildlife would not reach the county level (County Government of Kajiado, 2014). Nyamosyo et al. (2014) interviewed people around Kimana wetland about their economic benefits from wildlife. 82% outline that they would not receive any direct cash benefits but only indirect benefits such as school bursaries, construction of school among others. However, direct benefits are received from irrigated farming activities, land sale or renting (Nyamosyo et al., 2014).

The majority of the Group Ranch members noted that wildlife is rather a liability than an asset, which has been documented by other studies in prior years (Okello, 2011), but hasn't changed until today. Land owners have no legal right for claiming benefits resulting from wildlife using their land (Kameri- Mbote, 2005). The creation of benefits for people who protect wildlife is an important aspect in the whole conservation context. The increasing conflicts intensify negative perceptions about wildlife. In addition to a certain degree of exclusion in revenue and benefit sharing, communities in the dispersal areas of wildlife bear the risk of confrontation with animals. It is important to highlight that "one incidence can be one too many" (Okello et al., 2014, pp. 471). This not only in terms of attitudes towards wildlife but also for ethical reasons. However, people feel less valued due the inadequate and late compensation payments in case of any accidents. People expect KWS to act immediately and react in understandably and supportive way as also outlined by Okello et al. (2014). In fact, it is the government paying compensation and not KWS. This is confusing for subjects, since they claim KWS for not compensating adequately and timely resulting in untrustworthy relationships.

A high need for an effective compensation scheme, that reflects the real costs of wildlife in the dispersal areas, was recognized by all stakeholders. Compensation of destructed property is only part of the new WCMA (2013), but hasn't been part of the prior compensation scheme. It is therefore crucial to put the newly elaborated compensation scheme as soon as possible into effect. People bear the costs of

conservation and it is their social right to be adequately compensated (Okello et al., 2014).

One conservancy area and tourism operator (Gamewatchers Safaris) proposes an alternative way. Rather than compensating for death or injured livestock, they recommend paying for living lions, elephants or other wildlife. This would rather give positive incentives than negatives, such as leaving weak livestock unprotected in order to receive financial compensation. Paying for living wildlife rather than dead livestock requires a monitoring scheme and active participation by all GR members.

Competition for Resources

Because land is shared with wildlife, humans and wildlife compete for resources such as water and pasture (Okello, 2005). Some would argue, that poor grazing in the area is a communally pool resource problem created by humans themselves and that scarcity and drought is mainly created by mismanagement of livestock. A year of insufficient rainfall then pushes pastoralists into a disaster and intensifies the problem. Land has been described as below optimum productivity regardless of rainfall (Goss 2017, pers. comm., July 27th). However, many other factors such as farming around important swamps exclude livestock and wildlife from those area resulting in increased pressure on other areas. Reason for poor conditions about grazing areas differ among Group Ranch members and statements given by key informants. Whereas Group Ranch members argue climate change and poor rainfall as main reasons, other stakeholders emphasize mismanagement and overstocking of livestock herds as the key factors leading to degradation. Group Ranch members see less need for effective grazing schemes than NGOs or other actors. At the same time, they argued not to know how to improve the situation. Either way, the limited rainfall increases this problematic situation tremendously. Involved organisations recommend sophisticated grazing scheme to effectively make use of the scarce resources such as forage. Key informants argue that the only reason why grazing is still good in National Parks, is because it is gazette as protected area and grazing inside is not allowed. Loosening the law and allowing resource use at any time would lead to uncontrolled grazing and hence

resulting in overgrazed areas losing its potential to regenerate by itself. At the same time, it is important to provide information about appropriate livestock numbers and breeds. An increase in composition of animals and number of livestock challenging the grazing capacity in the ecosystem was described by various key informants (Brar 2017, pers. comm., July 27th). Access and availability of resources, in particularly grazing, water and space mitigates or enhances conflict situations (Okello, 2014). It is hence important to provide water, improved resource management through rotating grazing systems in conservancy areas and to control the development of human structures in certain areas.

Conservancy Areas

Community sanctuaries and conservancies guarantee access to resources such as water and pasture. However, to establish conservation as a compatible livelihood strategy is one of the greatest challenges. Community conservation areas as supported by the new WCMA (2013) could be an option but are difficult to maintain and the question how they will be financed and rentable is not answered yet. Participatory conservation approaches are identified as the key to successful conservation. A more decentralized structure between stakeholders is needed to achieve long-term goals in conservation (Crona and Bodin, 2006).

Tourism potential in the study area has been described both as an opportunity (Okello et al., 2003) and exhausted (Goss 2017, pers. comm., July 27th), who states:

> *"All of the obvious tourism in Amboseli has been done […] you need really sharp thinking and professional, responsible professionals. […] if you get the right tourism product, that would do well I think, but then you need a real professional tour operator. You can't just put up a tent and go, you need real professionals and that takes investments."* (Jeremy Goss, Big Life Foundation)

Even though the new Wildlife Act facilitated the establishment of a privately or communally owned conservancy area, the benefits of such a conservancy are not obvious. By doing so communities would indeed actively participate in conservation which might change their attitude towards wildlife. However, it is very difficult to gain sufficient income through tourism through such a conservancy. Other income possibilities should therefore be considered such as financial incentives following the PES-Model (paying for ecosystem services), as for instance described by Bulte et al. (2008).

Conservation in Kenya highly dependents on donor funding and therefore not sustainable in long-term. KWS and CWCCC are representing governmental bodies of conservation, but ware limited in their action by the financial resources given by the government. Implementing community based projects to ensure active community participation is therefore difficult. Projects often depend on external funding and would not continue to operate without this assistance (Mburu, 2004). An example of this is Sidai Oleng, former Kimana sanctuary, which is now funded by an international developer, who is leasing the land for conservation purposes. Through conversation with the management, I was informed, that it is not unusual to have less than ten visitors per month (Satoti 2017, pers. comm., July 18th). Conservancies are one option provided within the new Wildlife Act to engage local communities into wildlife management. However, the act does not explicitly outline how benefits will then arise (Warigia & Buzzard, n.d.). Land leasing has been described as an effective tool in wildlife conservation, providing various benefit to landowners who would use the land otherwise. However, economically speaking, rates for leasing are often very small and described to be too little (e.g. Maasai Mara). High market prices make it difficult for conservationist to lease land to an appropriate rate (Gitahi, Fitzgerald 2010). Okello et al. (2003) describe diversification opportunities in the tourism market and the importance to foster possible partnerships between Sanctuaries and National Parks rather than competition. Alternative activities could include walking bush safaris, bird watching or camel and horse safaris. The market should increasingly target younger generations and backpackers (Okello et al., 2003).

Although increasing human-wildlife conflicts have been identified as a great problem by all stakeholders, different solutions are suggested to solve the conflicts. Whereas directly affected Group Ranch members wish wildlife to live in designates areas only and to construct clear boundaries such as electric fences; stakeholders with more influence such as conservation organisations or KWS aim to keep wildlife moving freely in between the National Parks. A study by Okech (2011) states that 62% of the community members want wildlife to range freely on their lands. However, traditional tolerance for wildlife seems to slowly fade among Maasai communities, with an increasing wish to clearly separate humans and wildlife. Negative perceptions on wildlife are prevalent, as also described by Okello et al. (2014). These negative perceptions and frustration about free ranging wildlife is rooted in inadequate compensation in case of damages or losses, insufficient benefits resulting from tourism and low participation opportunities and involvement in wildlife related activities. Participants showed interest in conservation participation, in particularly, if it comes along with economic benefits through employment opportunities or other received benefits (Okello, 2011). Interviews with Group Ranch members show the sensitivity of land tenure. People fear that land is going to be taken away, since wildlife is given higher priority than themselves. This is one of the reason why people support subdivision, another example to illustrate the importance for changing attitudes towards wildlife conservation.

5.1.2 Relationships

It is clear, that main responsibilities lay in hands of only a few. According to the law, all wildlife belongs to the state, resulting in strong control over all wildlife management activities by the responsible authority KWS (Kameri-Mbote, 2005). The most affected people, Maasai communities living in between the National Parks, have always been directly affected by the different conservation approaches that have been implemented since the 1960s. Conservation is predominantly associated with restrictions and regulatory mechanisms people must follow. Living with wildlife has

become more than a burden than an asset (Okello, 2011). Underlying structures and relationships between the various levels are complex and slow down appropriate management implementations. For communities, responsibilities are often unclear. Most of the interviewed individuals feel disappointed and left alone by the government. The majority of questioned Group Ranch members have never heard of CWCCC and KWS was described as an untrustworthy management body. KWS has a certain unit called Problem Animal Control (PAC), which could employ more people focusing only on human-wildlife conflicts (Okello et al., 2014). This would mitigate the impression that KWS does not care about elephants harming people, but only the other way around (Okello et al., 2014).

Group Ranch committees were recognized as an intermediary authority with high influences. A report by the CDC and DFID (2002) describes management problems, particularly in accountability and internal management conflicts in Group Ranch Associations and committees, resulting in e.g. mismanagement of funds by ATGRCA. Although, it has been reported that the association has solved their main problems and are back to follow their objectives (CDC & DFID, 2002), mistrust against it is still present. Important stakeholders in any activity include community elders and leaders and members of the elected Group Ranch committees in charge of explaining new projects and initiatives. Lack of transparency and corruption within Group Ranch leadership was told during interviews, as well as described by other researchers (Okello et al., 2003; Okello, 2011). In total, the system has been described as highly corrupt on various levels. For instance, Group Ranch committees have often been in power for many years, postponing elections year after year, which leads to a lot of frustration among communities.

At the same time, people would appreciate to take part in conservation and management, taking over responsibilities. Kameri-Mbote (2005) highlights the need of the state to withdraw its rights and control over wildlife resources and hand responsibility over to communities. The need for community participation is recognized by responsible authorities. In particularly the elaboration of the new WMCA (2013) and the implementation of CWCCC, responsibilities are shifted towards communities and aims to actively involve people in conservation. Yet, the act has not been fully

implemented, for example in terms of compensation and an effective realization of the proposed payment scheme. Moreover, people need support in getting involved and implementing wildlife favoring conservation approaches. During a community meeting in Lamu, Kenya, with CWCCC Lamu, KWS and ICRAF, the new Wildlife Act and rights and responsibilities coming along with it were discussed with community members. Members communicated their mistrust, discontent and fears regarding living closely with wildlife. Responses and experiences represented in the workshop-report are reflecting the outcome of my household interviews and, moreover, demonstrate the recognition by responsible stakeholders to improve perceptions of communities on wildlife as a first step to successfully conservation management (Mutwiri, 2016). The new WMCA (2013) aims to shift more responsibility towards the communities and encourage their active participation based on a legal framework.

Any kind of corridor or additional land set aside for wildlife conservation must equally benefit people. Fear of losing land to wildlife as happened in history is still present and has been also described by Okello et al. (2003) and Okello (2011). A research around Mt Kilimanjaro in Tanzania and a wildlife corridor implementation through the forest experienced mistrust among the pastoral Maasai, who feared losing their land and access to resources. Under clearly defined agreements such as permission for traditional gathering of firewood, building poles and grazing and livestock, the people agreed on the corridor. Farming however, was banned in the defined wildlife corridor (Newmark, 2015).

5.1.3 Limitations and Challenges of Stakeholder Analysis

Key Informants Interviews

Only a limited number of stakeholders could be interviewed. Improving the 4R's method, I highly recommend undertaking a participatory approach as described by Reed et al. (2009). In the frame of the research it was not possible to do so, but would have had highlighted all relationships more accurately. Information on the stakeholders was mainly collected through semi-structured interviews and field observations. The

stakeholders had no active involvement in constructing the interest-influence matrix which might resulted in an incomplete illustration of the complex dynamics and relationships between all actors. It might reflect a personal perception on the stakeholders. Described relationships are based on perceptions received from participants who are not involved in wildlife conservation or in constant exchange with responsible stakeholders such as NGOs. It is assumed, that relationships would change in that case. Another option would be to do a participatory approach within a focus group or by individual stakeholders during interviews. Prioritization might marginalize certain groups. Snow-ball sampling, as I did, is based on availability of contacted stakeholders on social networks of first individuals. Some stakeholders might have been omitted or recognized too late and as consequence not all were taken into consideration.

Relationships towards the Group Ranch Association were not discussed. They were barely mentioned in the interviews and therefore only assumed.

According to the law, KWS and landowners are the two major bodies responsible for wildlife. Besides the listed organisations, there are many other parties involved in the Amboseli ecosystem and holding any interest, such as various governmental ministries and agencies responsible for water, livestock, agriculture, land-use planning and provincial and district administration. Moreover, the tourism industry, various conservation and community-based development organisations are involved.

Interviews with Group Ranch members

During the household interviews the following challenges came up and are likely to have influenced the research output. First, it was difficult to establish a representative sample of households because they are scattered in remote areas where they are difficult to reach. Far distances between participants would increase travel time, short distances or participating neighbors might be influenced by each other. However, for conducted interviews in Rombo Group Ranch, all *bomas* where located close to each other and sometimes even in walking distance.

The participating group in Olgulului Group Ranch were all met at the local school for group meeting. After a short introduction, subjects started to fill the questionnaires

with assistance of me and my colleague. I realized that the questionnaires were too difficult and some of participants didn't understand all questions. It was obvious that similar answers were given by participants sitting next to each other, who had the opportunity to talk and discuss. Participants also helped each other by understanding problems, which influenced the replies. However, at this point it was too late to change the structure for this survey method. Participants expected something in return for their time which was communicated before the meeting. The disadvantage of this clearly was the limitation in the number of participants I could allow. Nevertheless, the advantage was that people were taking the survey very serious, some of them coming in their best clothes and they really took their time in filling the questionnaires on their best behalf. I recognized that participants may provide false information thinking that would be the best way to satisfy and please me as the researcher.

Participants from both groups appreciated to be involved in a research. However, I felt there was also a little bit of hope that through their participation and my specific research their situation might change. White people are recognized differently, and interview replies are influenced by that. People were always very open and happy to see me. However, I was always seen as the one with money and I was told by colleagues that people may have high expectations and their replies are influenced by my occurrence. People tend to say more negative things, hoping their bad living situations might change because a white person will somehow help. Participants were prior informed about the purpose of my research and that I was a student. However, they might still have acted differently than they would have among Kenyan researchers. Aiming to minimise this effect, interviews were conducted in cooperation with a local development organisation and with assistance of local teachers who know the Maasai culture very well, speak the language and are aware about certain rules or how to ask cultural sensitive questions. For the second group the survey method was changed from questionnaires to personal interviews because of language barriers. Interviews then took longer than originally expected and I realized not the participants, but my assistants got exhausted after the first interviews. The personal interviews included several similar questions with different phrases to check on consistence of answers.

Although rewording questions is a good option to obtain a clear picture, it takes a lot of time. Time invested to prepare my assistants for the interviews was too short and should have been more intense. I had to trust them fully, because I did not have any influence on how they asked or translated the questions and in how far they gave response examples, which might would have influenced the replies by the participants.

5.2 Geo- Spatial Analysis

5.2.1 Landscape Connectivity in Amboseli-Tsavo Ecosystem

Elephants disperse between Amboseli, Tsavo West and Chyulu Hills. Transboundary movements towards Tanzania through the Kitenden corridor were highlighted by Gordon et al. (2017) and Osipova et al. (in review). The identified travel routes resemble with the outcome of Osipova et al. who used a least-cost path analysis and circuit theory with empirical data to identify main migration routes between the National Parks. Besides cross border movements to Tanzania, Osipova et al. highlight the importance of Kimana corridor, which was used most frequently by the collared elephant individuals they used for their study. The Amboseli elephant population is likely to extent to the Chyulu Hills and Tsavo West (Moss et al., 2011). Other studies suggest that elephant populations from northern Tanzania are the same as in southern Kenya (Western 2007; Kikoti, 2009). A ranging report by ATE (2014) identifies minor migration corridors between Amboseli NP and Selenkay, as well as a major corridor towards Sidai Oleng. Little information is available regarding movements from Sidai Oleng, Motikanju towards Chyulu Hills.

The government of Kenya and other stakeholders in the region are aware of the increasing fragmentation in the landscape and the threat it opposes towards free ranging animals. As part of the vision 2030, the government recently released a report about “securing wildlife dispersal areas and migratory corridors" aiming to collectively work on the issue of connectivity (Gordon et al., 2017). The report indicates wildlife movements between the parks based on empirical movement data and categorizes linkages depending on how threatened they are, ranging from none, low, moderate,

high to being completely blocked. The Amboseli-Kitenden-Kilimanjaro connection, as well as the Amboseli-Kimana-Tsavo route were rated as highly threatened by subdivision and irrigated agriculture. The Kimana-Elerai-Kilimanjaro route was also evaluated as highly threatened for the same reasons, as well as the movement corridor between Amboseli-Chyulu-Tsavo. Amboseli-Mailua-Namanga Hill is affected by degradation and sedentarization, but was rated as moderately threatened. The Amboseli-Selenkay-Mbirikani route remains still open and current threats are described as "low" (Gordon et al., 2017). Increasing settlements and farming activities around the water pipeline were described to threaten dispersal movements between Amboseli, Mbirikani and Chyulu Hills (Goss 2017, pers. comm., July 27th; Western, 2007). Recommended solutions include to keep parts open allowing undisturbed movements north and south of Mbirikani. Well managed grazing areas serving as grass banks dry seasons should be established (Western, 2007).

The slightly different paths in the output between the seasons are caused by changes in forage and water distribution. During dry season, when seasonal water resources have dried up, elephants remain in the park or must share boreholes and wells with Maasai livestock outside of the park (ATE, 2014). During dry season conflicts therefore increase through animals searching for water in homesteads (Kosei et al., 2017).

The three routes were analysed aiming to assess their current and future connectivity potential in the landscape, as illustrated in Table 11. Existing conservancy areas such as Selenkay or Elerai are well established and indicate strong interests in community participation and wildlife conservation, as well as high potential influence by responsible actors. Conservancies serve as crucial stepping stones between the parks. Sidai Oleng and Motikanju are protected land areas, however, with less community participation and other activities, leaving space for improvement. The land area between Motikanju and Chyulu Hills is mainly free of settlements and agriculture. It offers great potential to serve as linkage corridor between the parks. To maintain connectivity between Amboseli and Sidai Oleng, proposed well-functioning and maintained fences are a crucial step to channel wildlife to safer areas. The illustrated tarmac road indicates a potential threat for all routes, with traffic that is most likely to

increase in future. Road underpasses might be a feasible solution in near future to minimise the number of road accidents. The third connectivity route from Amboseli towards Rombo along the Tanzanian border appears to be most challenging because of high agricultural production. Moreover, conservation requires transboundary strategies with more parties involved. However, Kitenden corridor and Elerai conservancy are promising stepping stones with strong responsible actors.

Table 11: Status of current and future connectivity in the ecosystem based on selected features (HEC = human-elephant conflict)

	Stakeholder interest & influence	**Conservation Areas**		**Threats**			**HEC**	**Connectivity Potential**	
		existend	planned	farming	traffic	settlements		current	future
Route 1 Amboseli-Selenkay-Chyulu Hills	good	Selenkay	Ole Narika	low	moderate	moderate	medium	good	okay
Route 2 Amboseli-Sidai Oleng-Tsavo West	good	Sidai Oleng/ Motikanju	-	high	moderate	high	high	poor	okay
Route 3 Amboseli-Rombo	good	Elerai	Rombo	high	moderate	high	high	okay	poor

Number and exact locations of human-wildlife conflicts including human-elephant conflicts (HEC) are well documented by KWS and other organisations, but in was not possible to get insight information. Potential for human-elephant conflict was therefore only assumed.

The Amboseli Ecosystem Management Plan proposes a zoning of the area into high use (tourism zone), exclusive use (existing and proposed conservation areas) and low use zones (not specified), as a solution to the named problems (KWS, 2008a). The zoning has been done and can be find in the management plan. The follow-up plan, which is not yet available will further explain zoning strategies and the current process. The County Government of Kajiado proposes fencing off protected areas, enforcement of

the WCMA (2013) and education and awareness as strategies to solve the human-wildlife conflicts. Immediate objectives are to "demarcate and conserve all the wildlife migratory corridors by 2017" (County Government of Kajiado, 2014, pp. 36). However, strategies are nor further explained. According to Gordon et al. (2017) and CWCCC (Mwato 2017, pers. comm., August 22nd), implementation of conservancy areas along migratory corridors is planned, including Ole Narika between Amboseli NP and Selenkay and Rombo. Long-term connectivity in the ecosystem highly depends on current and future conservation mechanism. In this context, Goswami et al. (2017) highlights the interplay between the maintenance of connectivity on a landscape level and mitigation strategies for human-elephant conflict. Implementing barriers such as fences to mitigate human-wildlife conflict might be counterproductive in terms of connectivity. Fences around individual agricultural plots have a different impact on connectivity than if larger areas are being fenced off, but the same impact on reducing conflict situations. Through pro-active spatial planning elephants can be encouraged to use identified paths of least resistance (Goswami et al., 2017), resulting in less conflict situations.

5.2.2 Limitations of the Geo-Spatial Analysis

Analytical Hierarchy Process (AHP)

Expert opinion was used to select and weight factors to develop the cost-surface used for the least cost analysis. AHP is a clearly defined method, compiling expert opinions. However, opinions are often based on own experiences and might be incomplete (Wade et al., 2015). Therefore, results might be influenced by experts' previous research and make it difficult to objectively evaluate performance. However, this method is recommended when empirical data are missing (Zeller et al., 2012). Consulted experts were provided with a predefined matrix with selected factors to do a pairwise comparison. They were given the option to add or cut out any factor. By doing so I obtained valuable insights and field experiences. However, the method also led to different numbers of factors being compared among each other, which

subsequently resulted in difficulties in the weight calculation. The problem was solved by using average values in case of a missing factor. Resulted weights were converted into percentage values. To avoid equal values, weights were either rounded up or down, not following mathematical rounding rules. Thereby, it was possible to clearly illustrate differences in the cost-surface.

It is noteworthy that preferred habit characteristics might differ from the characteristics of a preferred migration route. However, in the analysis I followed the approach of Newmark (1993, pp. 500) who defines a wildlife corridor as "habitat that permits the movement of organisms between ecological isolates."

Remote Sensing and Analytical Workflow

Shapefiles used for the least-cost path analysis were gathered from the World Resources Institute (WRI) or kindly provided by NGOs. However, differentiating water bodies into permanent and seasonal water layers were challenging and differentiation was based on limited information.

Although, layers obtained from NGOs are accurate, they are often limited to a small area of interest based on the focus area of the organisation. Whereas open source data are often inaccurate and don't show satisfying results. However, it was out of my scope to obtain reliable water data for both dry and wet season including all water bodies accessible for wildlife. This relates in particularly to boreholes, dams and springs, which are sometimes fenced off for human consumption only and sometimes also accessible for wildlife. An approach of detecting open surface water bodies through radar satellite imagery produced only limited results, which were finally considered to be less accurate than open source shapefile layers. The reason for the most accurate results of the open source shapefile layers in comparison to Sentinel-1 water classification is that with the Sentinel-1 radar imagery only larger areas of standing water can be detected and wetlands could not be included. Another reason for an insufficient output might be the sensitivity of radar signals towards surface movements resulting from winds. Moreover, water bodies are difficult to detect under shadow or forest canopies (Nguyen, 2015; Čotar et al., 2016). This explains why the output doesn't show riverine vegetation. Another reason can be the high amount of sandy soils that are easily

confused with water bodies and leading to an overestimation of it in the area (Martinis, 2017).

To obtain the vegetation cover of the area, two methods were used. First, a K-Means cluster analysis was performed and second, the NDVI index was calculated using the same satellite imagery. The NDVI is widely used to estimate the amount of green biomass in a landscape. When comparing K-means classification output with the NDVI, it was decided to use the NDVI since it showed most accurate results for the relevant land cover type vegetation. However, the index is sensitive to soil background and atmospheric effects. Moreover, it measures only healthy green vegetation based on its reflectance (Naji, 2016), which might result in an underestimation of the amount of vegetation in a semi-arid region such as Amboseli-Tsavo, where shrubs and bushes are often dried up during dry season, but would flourish with the start of the rain. Other developed indices such as the SAVI (soil-adjusted vegetation index) were described to be more reliable and to minimise certain influences (Rondeaux et al., 1996). Naji (2016) for instance, compared the NDVI with the STVI-4 (stress related vegetation index) and concluded that the STVI-4 index performed better in relation to efficiency and accuracy, because it uses red, near- infrared and mid-infrared bands (Naji, 2016). However, Sentinel-2 only provides blue, green, red and near-infrared bands. For this reason, STVI could not be calculated for freely available Sentinel-2 data. Sensors which include also mid-infrared band do have lower spatial resolution and therefore could lead to inaccurate results. Aiming to improve the methodological approach it is recommended to improve the landcover classification and to obtain accurate data about water resources during dry and wet season.

Least-Cost Path Analysis

The least-cost approach considers that species move between landscape features by taking paths with least resistance and avoiding costly areas. The approach assumes that wildlife has a detailed knowledge about the landscape and moves around with certain intentions (Wade et al., 2015). Corridors generated with least-cost models have been criticized because the outcome highly depends on given resistance values, which are generally generated through expert opinion. It is therefore recommended to verify

results with empirical data (Osborn et al., 2003; Wade et al., 2015). Independent data such as empirical movement data should be used to assess whether the mapped output paths correlate with actual movement paths, recommended for future studies. Unfortunately, empirical data of collared elephants could not be included in this study. Least-cost path modeling does not consider the total costs of generated paths, but only calculates the resistance values for each single pixel. It is important to outline, that the outcome of a single-pixel wide paths is not representative for movements by any organism (Wade et al., 2015). However, the least-cost method still gives a relevant and robust outcome with only small input and a relatively small amount of required data (Parks et al., 2013) and hence an inexpensive method (Wade et al., 2015). Another great advantage is that different landscape characteristics and varying influences of the matrix can be considered. To improve performance of the least-cost path, an iterative approach can be considered to include the resilience of connectivity. Hereby, certain links from each pair of patches are removed and metrics recalculated until all links have been removed. This gives information about initial connectivity and its resilience, meaning in what happens in case of any changes e.g. when habitat is lost. Moreover, a sensitivity analysis can be run to visualize changes in the results if assumptions of underlying cost values were altered. For example, changing all values across the entire landscape: all agricultural areas have low cost, or all have high costs. Summarized, the least-cost path analysis is a helpful method to identify migration routes for keystone species such as the elephant. The outcome of this study shows three major connections between the National Parks and highlights current and future barriers that threaten the connectivity. This knowledge can be used to most effectively coordinate land use and spatial planning processes or to restore smaller ecosystems along migration paths (Cushman et al.,2013).

Another aspect to bear in mind when working with keystone species such as elephants, are differences in movement behavior of individuals across the ecosystem, which can vary enormously (Osipova et al., in review). Besides biotic factors, it is very important to take individual behavior of the elephants into account. Elephants have great memories on individual experiences they made, but they are also able to pass information to their family members (ATE, 2014). Polansky et al. (2015) highlight the

ability to remember spatial distribution of environmental factors such as waterholes to minimise travel distances. Kioko et al. (2006) additionally highlight the impact of the presence of humans and livestock on wildlife. Livestock and wildlife movements respond to rainfall patterns and livestock influences wildlife movement. However, due to a lack in data information, it was not possible to consider this fact in the geo-spatial analysis.

6 Recommendations

Three movement corridors for the African elephant between Amboseli NP, Chyulu Hills and Tsavo West were identified. Even though important migration routes were visualized and compared with other maps and studies (Gordon et al., 2017; Osipova et al., in review; ATE, 2014), the proper implementation of supportive conservation mechanisms is challenging. To effectively use the outcome of this study and to improve human-wildlife co-existence in Amboseli-Tsavo region in long-term, the following section summarizes important key points that should be considered:

i) *Establishment of proposed conservancy areas along identified migration routes.* High poverty rates, as around Amboseli and therefore around viable tourism resources indicate a mismanagement. Tourism profit and wildlife only benefits a small group of people. Community-owned and managed conservancy areas can be the missing link between development and biodiversity conservation in rangelands as also described by other authors (Ykhanbai et al., 2014). Wildlife conservation, which is important for the tourism sector, can simultaneously reduce poverty among the population, if done in the right way. Yet, conservancy areas must be financially viable for the people for example through additional economic incentives based on the number of wildlife sightings throughout the area. Monitoring and annual animal counting would be used e.g. once a year to calculate the payments. Bulte et al. (2008) conclude in their study that payment schemes for ecosystem services could be a promising tool in Amboseli ecosystem because it promotes

conservation and reduces poverty among local population. Besides economic benefits, conservancy areas should include an elaborated grazing scheme based on a rotating grazing system, as it is also the case in most of the current conservancies. This improves access to resources and hence, security among the members. It is important to ensure that conservation initiatives are at least as beneficial as other land uses such as agriculture or industrial uses. Additional payments for example by tourism enterprises can be a powerful instrument as for outlined by Nelson et al. (2010) in an example from Tanzania, where surrounding communities were compensated by tourism companies.

ii) *Enacting the new Wildlife Act 2013.* There is a clear lack of efficient compensation identified by all stakeholders. The new compensation scheme and proposed payments must be enacted as soon as possible. The process of being compensated must be guaranteed, adequately and in time. According to the Act, destruction, damage or injuries by a given list of animals is provided. However, predators such as lions (*Panthera leo*) and hyenas (*Crocuta crocuta*) are described to follow migration herbivores who are profiting any wildlife corridor. Grazing livestock are then often victims of the carnivores (Okello, 2011). Besides damage and injury or killing of livestock, transmission of diseases from dispersal wildlife to livestock affect Maasai economically (Okello, 2011) and should be part of any compensation scheme.

iii) *Employment and elaborating alternative livelihoods* besides pastoralism and farming are one of the greatest challenges as identified by all key informants. Conservation of wildlife must a competing livelihood opportunity. Since illegal killings and poaching is one of the main threats elephants are facing in Kenya and migration corridors would give a certain threat to the animals. However, increased security through patrols and guards can increase employment while at the same time fostering participation in conservation.

iv) *Extensive educational programs, awareness campaigns and capacity building* for local communities throughout the whole ecosystem must be elaborated. Facilitated access to research information about wildlife should be provided to local communities. This could for instance be achieved through social media, radio or television programs. Awareness campaigns must come along with required benefits needed to accept wildlife and to improve perception on conservation initiatives. A radio program called Wildlife Conservation Radio Program with similar goals was launched within a Community Outreach Project in Zambia (Game Rangers International, 2013). The program includes a live-phone for questions and answers, or for example prizes awarded in certain programs. Another related program is run around Tsavo NP, called Radio Tsavo which is a local radio station. With their approach they are aiming to "to bridge the gap between whole groups of people and wildlife by engaging the communities to participate in conservation." (Amara Conservation, 2015). Radio Tsavo aims to improve communication between different stakeholder groups. Broadcast should be in Kiswahili, Maasai and English to reach all potential listens. Amara covers various topics such as conservation, health or environmental protection and announcements, weekly programs offered by local NGO's. Training programs to enhance skills in radio journalism, technical skills etc. Moreover, people get together in towns to watch the news in the local restaurants which are all equipped with one or more televisions. Radio is an effective tool to share information among rural areas. An extension of Radio Tsavo around Amboseli could be an effective strategy to inform communities while at the same time offering employment and participation in conservation.

7 Conclusion

Unlike Tsavo West and Tsavo East National Park, Amboseli is too small to bear the current number of elephants and therefore depend on surrounding dispersal areas (Bulte et al., 2006; Okello and Amour, 2008; Kipkeu et al., 2014). Moreover, high elephant populations are likely to exceed the capacity of insularised ecosystems, leading to negative impacts on the habitat and vegetation (Okello et al., 2014; Western et al., 2009; Western, 2007). For long-term conservation purposes, it is therefore crucial to obtain connectivity to other parks.

This thesis highlights important migration routes for the African elephant *Loxodonta africana* as a keystone species in the Amboseli-Tsavo Ecosystem. Aiming to prevent identified travel paths from being blocked through upcoming farming activities, emerging industrialization or other land uses, identified routes are analysed and certain threats and opportunities presented. The study has employed qualitative methods, particularly semi-structured interviews, to complete its geo-spatial analysis and to make appropriate comments on the current and future state of management in the ecosystem. The in-depth interviews with Group Ranch members revealed the personal feelings of individuals towards wildlife conservation and their attitude towards other stakeholders.

Insights from key informants show a common interest in participatory conservation, a way towards shared responsibility and increased benefit sharing with local communities. The new Wildlife Act (2013) is an important step shifting responsibilities towards communities and must be further developed and refined to secure a safe environment for both humans and wildlife. Yet, it is still a long way to go and should be set as a priority. Maasai communities might not continue living as pastoral nomads for the next hundreds of years. However, development does not necessarily exclude wildlife from human-populated areas. Yet, co-existence must be well planned. Without a coordinated, well-thought management and land-use plan, time will eventually run short. Elaborating alternative livelihoods and changing the negative perceptions of

local communities towards wildlife and other stakeholders were identified as main steps to take in the process. The identified routes can help in land-use planning. Keeping them open by putting appropriate mechanisms into place can ensure connectivity between the National Parks. Connectivity potential of all of paths is threatened, but can be preserved. Further interviews with Group Ranch members along identified paths are recommended aiming to analysis the willingness to support this landscape connectivity approach.

8 References

Amara Conservation (2015): Community Wildlife Conservation [online]. Available at http://amaraconservation.org/community-and-wildlife-conservation-by-jacob-dadi [Accessed 3rd of December 2017].

Amboseli Baboon Research Project and University of Notre Dame (2017). Protocols and Data Downloads [online]. Available at: http://amboselibaboons.nd.edu/downloads/ [Accessed 30th of November 2017].

Amboseli Trust for Elephants [ATE] (2014): Elephant Corridors and Ranging Report.

Beier, P.; Majka, D.; Jenness, J. (2006): Conceptual steps for designing wildlife corridors.

Beier, P.; Majka, D.; Spencer, W. (2008): Forks in the road: choices in procedures for designing wildland linkages. In *Conservation biology: the journal of the Society for Conservation Biology* 22 (4), pp. 836–851. DOI: 10.1111/j.1523-1739.2008.00942.x.

Bennett, A. (2003): Linkages in the Landscape. The role of corridors and connectivity in wildlife conservation. IUCN Forest Conservation Programme (Conserving Forest Ecosystems, 1).

Bulte, E.; Boone, Randall; Stringer, R.; Thornton, P. (2008): Elephants or onions? Paying for nature in Amboseli, Kenya. In *Environment and Development Economics,* 13 (03). DOI: 10.1017/S1355770X08004312.

BurnSilver, S.; Worden, J.; Boone, R. (2008): Processes of Fragmentation in the Amboseli Ecosystem, southern Kajiado District, Kenya. In K.A. Galvin et al. (eds.), *Fragmentation in Semi-Arid and Arid Landscapes: Consequences for Human and Natural Systems,* pp. 225-253.

Bhushan, N.; Kanwal, R. (2004): Strategic decision making. Applying the analytic hierarchy process. London, New York: Springer (Decision engineering).

Bunruamkaew, K. (2012): How to do AHP analysis in Excel [PowerPoint presentation]. Available at: https://wenku.baidu.com/view/8c202fde6bec0975f465e2ab.html [Accessed 8th of December 2017].

CITES (2017): Appendices I, II and III. Available at: https://cites.org/sites/default/files/eng/app/2017/E-Appendices-2017-10-04.pdf [Accessed 5th of December 2017].

Copernicus (2017): Open Access Hub. Available at: https://scihub.copernicus.eu/dhus/#/home [Accessed 27th of November 2017].

Čotar, K.; Oštir, K.; Kokalj, Ž. (2016): Radar Satellite Imagery and Automatic Detection of Water Bodies. In *Geodetski glasnik* 50 (47), pp. 5–15.

County Government of Kajiado (2013): County Integrated Development Plan 2013-2017. Available at: http://www.kajiado.go.ke/downloads/?mdocs-cat=mdocs-cat-4 [Accessed 19th of December 2017].

County Government of Kajiado (2014): Kajiado Land Policy.

Crona, B.; Bodin, Ö. (2006): What You Know is Who You Know? Communication Patterns Among Resource Users as a Prerequisite for Co-management. In *Ecology and Society* 11 (2).

Cushman, S.; Chase, M.; Griffin, C. (2010): Mapping Landscape Resistance to Identify Corridors and Barriers for Elephant Movement in Southern Africa. In Samuel A. Cushman, Falk Huettmann (Eds.): *Spatial Complexity, Informatics, and Wildlife Conservation,* pp. 349–367.

Cushman, S.; McRae, B.; Adriaensen, F.; Beier, P.; Shirley, M.; Zeller, K. (2013): Biological corridors and connectivity [Chapter 21] in *Key Topics in Conservation Biology* 2, First Edition. Edited by David W. Macdonald and Katherine J. Willis.

DFID & CDC (2002): Realising the Economic Development and Poverty Alleviation Potential of Nature in Magadi. Ol Donyo Nyoike, Ol Keri, Olkiramatian & Shompole Group Ranches.

Douglas-Hamilton, I.; Krink, T.; Vollrath, F. (2005): Movements and corridors of African elephants in relation to protected areas. In *Die Naturwissenschaften* 92 (4), pp. 158–163. DOI: 10.1007/s00114-004-0606-9.

Epps, C.; Mutayoba, B.; Gwin, L.; Brashares, J. (2011): An empirical evaluation of the African elephant as a focal species for connectivity planning in East Africa. In *Diversity and Distributions* 17 (4), pp. 603–612. DOI: 10.1111/j.1472-4642.2011.00773.x.

ESA (2017a): Sentinel- 1 SAR Overview. Available at: https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-1-sar/overview [Accessed 5th of December 2017].

ESA (2017b): Level- 2A Algorithm Overview. [online] Available at https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-2-msi/level-2a/algorithm [Accessed 27th of November 2017]

ESRI ArcGIS(2017a): How weighted overlay works. [online] Available at: http://desktop.ArcGis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/how-weighted-overlay-works.htm [Accessed 30th of November 2017]

ESRI ArcGIS (2017b): Understanding cost distance analysis. [online] Available at: http://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/understanding-cost-distance-analysis.htm [Accessed 30th of November 2017]

ESRI ArcGIS (2017c): Cost Back Link. [online] Available at: http://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/cost-back-link.htm [Accessed 30th of November 2017]

FAO (2005): Negotiation and mediation techniques for natural resource management. With assistance of Antonia Engel, Benedikt Korf, pp. 1- 236.

Fitzgerald, K. (2013): Community Payment for Ecosystem Services in the Amboseli Ecosystem: Leasing Land for Livelihoods and Wildlife. AWF Technical Paper Series.

Forkel, M. (2012): Infoblatt Klimaklassifikation. Available at: www.klett.de/alias/1012498 [Accessed 22nd of December 2017].

Gara, T.; Wang, T.; Skidmore, A.; Zengeya, F.; Ngene, S.; Murwira, A.; Ndaimani, H. (2016): Understanding the effect of landscape fragmentation and vegetation productivity on elephant habitat utilization in Amboseli ecosystem, Kenya. In *African Journal of Ecology*. DOI: 10.1111/aje.12346.

Gamerangers International (2013): News Flash #26, February. Available at http://gamerangersinternational.org/wp-content/uploads/2016/02/Newsflash-26.pdf [Accessed 21st of December 2017].

Gamewatchers Safaris Ltd (2015): [online] Available at: https://www.porini.com/about-us/responsible-tourism/ [Accessed 2nd of November 2017].

Gitahi, N.; Fitzgerald, K. (2010): Conserving Wildlife on Private Land: The Legal Framework for Landownership and New Tools for Land Conservation in Kenya.

GoK [Government of the Republic of Kenya] (1970): Land (Group Representatives) Act, CHAPTER 287, revised 2012.

GoK [Government of the Republic of Kenya] (2008): Kenya Vision 2030. The popular Version. Available online at: http://www.vision2030.go.ke/index.php/vision [Accessed 19th of December 2017].

GoK [Government of the Republic of Kenya] (2013): Kenya Gazette Supplement. Acts, 2013. The Wildlife Conservation and Management Act, 2013.

Goldman, M. (2009): Constructing Connectivity: Conservation Corridors and Conservation Politics in East African Rangelands. In *Annals of the Association of American Geographers* 99 (2), pp. 335–359.

Gordon, O.; Wargute, P.; Said, M.; Worden, J.; Davidson, Z.; Muruthi, P., et al. (2017): Wildlife Migratory Corridors and Dispersal Areas. Kenya Rangelands and Coastal Terrestrial Ecosystems.

Goswami, V.; Vasudev, D. (2017): Triage of Conservation Needs. The Juxtaposition of Conflict Mitigation and Connectivity Considerations in Heterogeneous, Human-Dominated Landscapes. In *Front. Ecol. Evol.* 4, e57872. DOI: 10.3389/fevo.2016.00144.

Ykhanbai, H.; Rishu G.; Aman S.; Moiko, S.; Beyene, C.; Roe, D.; Nelson, F.; Blomley, T.; Flintan, F. (2014): Rangelands. Conservation and "Land Grabbing" in Rangelands: Part of the Problem or Part of the Solution?

ILRI (2007): [International Livestock Research Institute]: GIS services. Available at http://192.156.137.110/gis/search.asp [Accessed June 2017].

IUCN World Commission on Protected Areas (WCPA) (2003): A Guide to: Securing Protected Areas in the Face of Global Change. Options & Guidelines.

Kameri-Mbote, P. (2005): Land Tenure, Land use and Sustainability in Kenya. Towards innovative use of property rights in wildlife management. IELRC Working Paper. International Environmental Law Research Centre.

Kenya Wildlife Conservancies Association [KWCA] (2016): State of Wildlife Conservancies in Kenya. Report 2016.

KWS [Kenya Wildlife Service] (2008a): Amboseli Ecosystem Management Plan 2008-2018, pp. 1- 192.

KWS [Kenya Wildlife Service] (2008b): Tsavo Conservation Area Management Plan 2008-2018, pp. 1- 211.

KWS [Kenya Wildlife Service] (2012): Conservation and Management Strategy for The Elephant in Kenya 2012 - 2021, pp. 1–92.

Kioko, J.; Okello, M.; Muruthi, P. (2006): Elephant numbers and distribution in the Tsavo-Amboseli ecosystem, south-western Kenya. In Pachyderm 40, pp. 65–129.

Kioko, J.; Muruthi, P.; Omondi, P.; Chiyo, P. (2008): The performance of electric fences as elephant barriers in Amboseli, Kenya. In *South African Journal of Wildlife Research* 38 (1), pp. 52–58. DOI: 10.3957/0379-4369-38.1.52.

Kipkeu, M. Mwangi, S.; Njogu, J. (2014): Community Participation in Wildlife Conservation in Amboseli Ecosystem, Kenya. In *Journal of Environmental Science, Toxicology and Food Technology*, 8 (4), pp. 68–75. DOI: 10.9790/2402-08426875.

Kosei, S.; Osuga, B.; Waweru, A. (2017): The causes of human and wildlife conflict within kajiado south sub county. In *Journal of Conflict Management* 1, pp. 23–33.

Laurence, W. (n.d.): Landscape connectivity and biological corridors. Smithsonian Tropical Research Institute, Republic of Panama.

Laws of Kenya (2010): Constitution of Kenya, Nairobi. Available at: https://www.kenyaembassy.com/pdfs/the%20constitution%20of%20kenya.pdf [Accessed 21st of December 2017].

Loarie, S.; van Aarde, R.; Pimm, S. (2009): Fences and artificial water affect African savannah elephant movement patterns. In *Biological Conservation* 142 (12), pp. 3086–3098. DOI: 10.1016/j.biocon.2009.08.008.

Maasai Wilderness Conservation Trust (MWCT): Annual Report 2016. Available at:
http://maasaiwilderness.org/2017/02/22/mwct-annual-report-2016/ [Accessed 22nd of December 2017].

Martinis, S. (2017): Improving Flood Mapping in Arid Areas using Sentinel- 1 Time Series Data. In *IEEE International Geoscience Proceedings*, pp. 193–196.

Mayers, J. (2005): Stakeholder power analysis. Available at: http://www.policy-powertools.org/Tools/Understanding/docs/stakeholder_power_tool_english.pdf [Accessed 22nd of December 2017].

Mburu, J. (2004): Wildlife Conservation and Management in Kenya: Towards a Co-management Approach.

Minang, P.; van Noordwijk, M.; Freeman, O.; Mbow, C.; Leeuw, J.; Catacutan, D. (2015): Climate-smart landscapes. Multifunctionality in practice. Nairobi Kenya: World Agroforestry Centre (ICRAF).

Moss, C.; Croze, Harvey; Lee, P. (Eds.) (2011): The Amboseli Elephants: A Long-Term Perspective on a Long-Lived Mammal. Chicago University Press.

Mutwiri, J.; Koech, G.; Shebwana, A. (2016): Opportunities for community based biodiversity conservation and management in Kenya. A manual prepared for the IGAD Biodiversity.

Mwangi, E. (2005): The transformation of property rights in Kenya's Maasiland: triggers and motivations. In CAPRi Working Paper No. 35.

Naji, T. (2016): Examination the efficiency of NDVI index by comparing with STVI-4 index to recognize the vegetation cover. In *Journal of Genetic and Environmental Resources Conservation* 4 (1), pp. 1–4.

Nelson, F.; Foley, C.; Foley, L.; Leposo, A.; Loure, E.; Peterson, D. et al. (2010): Payments for ecosystem services as a framework for community-based conservation in northern Tanzania. In *Conservation Biology: the journal of the Society for Conservation Biology* 24 (1), pp. 78–85. DOI: 10.1111/j.1523-1739.2009.01393.x.

Nelson, F. (2012): Recognition and support of ICCAs in Kenya. Recognizing and supporting territories and areas conserved by indigenous peoples and local communities. Global Overview and National Case Studies. Edited by Ashish Kothari, Colleen Corrigan, Harry Jonas, Aurélie Neumann, Holly Shrumm. ICCA Consortium, IUCN/TILCEPA, Kalpavriksh, and Natural Justice (CBD Technical Series No. 64).

Newmark, W. (1993): The Role and Design of Wildlife Corridors with Examples from Tanzania. In *Ambio* 22 (8), pp. 500–504.

Ngene, S.; Skidmore, A.; van Gils, H.; Douglas-Hamilton, I.; Omondi, P. (2009): Elephant distribution around a volcanic shield dominated by a mosaic of forest and savanna (Marsabit, Kenya). In *African Journal of Ecology* 47 (2), pp. 234–245. DOI: 10.1111/j.1365-2028.2008.01018.x.

Ngene, S.; Skidmore, A.; van Gils, H.; Muthoni, F.; Mutero, W.; Omondi, P. (2013): Zero Tolerance. Evolving Wildlife Management in Kenya. In *IJEPP* 1 (2), p. 24. DOI: 10.11648/j.ijepp.20130102.12.

Ngure, B. (n.d.): The Wildlife Conservation and Management in Kenya: Implementing the Framework Law.

Nguyen, B. (2015): Automatic detection of surface water bodies from Sentinel-1 SAR images using Valley- Emphasis method. In *Vietnam Journal of Earth Sciences* 37, pp. 328–348

Nyamosyo, S.; Kihima, B. (2014): Changing Land Use Pattern and Their Impacts on Wild Ungulates in Kimana Wetland Ecosystem, Kenya. In *International Journal of Biodiversity*.

Okech, R. (2011): Wildlife-community conflicts in conservation areas in Kenya. In *Afr. J. Conflict Res.* 10 (2). DOI: 10.4314/ajcr.v10i2.63311.

Okello, M.; Seno, O.; Wishitemi, Bobby (2003): Maasai community wildlife sanctuaries in Tsavo-Amboseli Kenya. In *Parks* 13 (1), 62-75.

Okello, M. (2005): An assessment of the large mammal component of the proposed wildlife sanctuary site in Maasai Kuku Group Ranch near Amboseli, Kenya. In *South African Journal of Wildlife Research* 35 (1), pp. 63–76.

Okello, M.; D'Amour, D. (2008): Agricultural expansion within Kimana electric fences and implications for natural resource conservation around Amboseli National Park, Kenya. In *Journal of Arid Environments* 72 (12), pp. 2179–2192. DOI: 10.1016/j.jaridenv.2008.07.008.

Okello, M. (2011): Community Opinions on Wildlife, Resource Use and Livelihood Competition in Kimana Group Ranch Near Amboseli, Kenya. In *The Open Conservation Biology Journal* 5 (1), pp. 1–12. DOI: 10.2174/1874839201105010001.

Okello, Moses M. (2012): The contraction of wildlife dispersal areas by human structures and activities in Mbirikani Group Ranch in the Amboseli Ecosystem, Kenya. In *International Journal of Biodversity Conservation* 4 (6). DOI: 10.5897/IJBC11.153.

Okello, M.; Njumbi, S.; Kiringe, J.; Isiiche, J. (2014): Prevalence and Severity of Current Human-Elephant Conflicts in Amboseli Ecosystem, Kenya. Insights from the Field and Key Informants. In *Natural Resources* 05 (09), pp. 462–477. DOI: 10.4236/nr.2014.59043.

Okello, Moses M. (2014): Economic Contribution, Challenges and Way Forward for Wildlife-Based Tourism Industry in Eastern African Countries. *In Journal of Tourism Hospitality* 03 (01). DOI: 10.4172/2167-0269.1000122.

Okello, Moses, M.; Njumbi, Stephen J.; Kiringe, John Warui (2015): Habitat use and preference by the African elephant outside of the protected area, and management implications in the Amboseli Landscape, Kenya. In *International Journal of Biodiversity Conservation.* 7 (3), pp. 211–226. DOI: 10.5897/IJBC2014.0795.

Okello, Moses M.; Kenana, Lekishon; Maliti, Hanori; Kiringe, John Warui; Kanga, Erastus; Warinwa, Fiesta et al. (2016a): Population density of elephants and other key large herbivores in the Amboseli ecosystem of Kenya in relation to droughts. In *Journal of Arid Environments* 135, pp. 64–74. DOI: 10.1016/j.jaridenv.2016.08.012.

Okello, Moses, M.; Warui Kiringe, John; J. Njumbi, Stephen; Isiche, James (2016b): Prevalence of human elephant conflicts in Amboseli ecosystem, Kenya. Current opinions of local community. In *International Journal of Biodiversity Conservation* 8 (3), pp. 60–71. DOI: 10.5897/IJBC2015.0865.

Ondicho, T. (2010): Tourism, power and politics: the challenges of Maasai involvement in tourism development. A dissertation presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy. Massey University, Palmerston North, New Zealand.

Osborn, F.; Parker, G. (2003): Linking two elephant refuges with a corridor in the communal lands of Zimbabwe. In *African Journal of Ecology* 41, pp. 68–74.

Osipova, L.; Okello, M.; Njumbi, S.; Ngene, S.; Western, D.; Hayward, M.; Balkenhol, N. (in review): Using step-selection functions to model landscape connectivity for African elephants (Loxodonta africana): accounting for variability across individuals and seasons.

Parks, S.; McKelvey, K.; Schwartz, M. (2013): Effects of weighting schemes on the identification of wildlife corridors generated with least-cost methods. In *Conservation biology: the journal of the Society for Conservation Biology* 27 (1), pp. 145–154. DOI: 10.1111/j.1523-1739.2012.01929.x.

Pittiglio, C.; Skidmore, A.; van Gils, H.; Prins, H. (2012): Identifying transit corridors for elephant using a long time-series. In *International Journal of Applied Earth Observation and Geoinformation* 14 (1), pp. 61–72. DOI: 10.1016/j.jag.2011.08.006.

Polansky, L.; Kilian, W.; Wittemyer, G. (2015): Elucidating the significance of spatial memory on movement decisions by African savannah elephants using state-space models. In *Proceedings. Biological sciences* 282 (1805). DOI: 10.1098/rspb.2014.3042.

Pulsford, I.; Lindenmayer, D.; Wyborn, C.; Lausche, B.; Worboys, G.; Vasilijević, M. and Lefroy, T. (2015) 'Connectivity conservation management', in G. L. Worboys, M. Lockwood, A. Kothari, S. Feary and I. Pulsford (eds) Protected Area Governance and Management, pp. 851–888, ANU Press, Canberra. (2015): Chapter 27 Connectivity Conservation Management. With assistance of G. L. Worboys, M. Lockwood, A. kothari, S. Feary and I. Pulsford. Protected Area Governance and Management: ANU Press, Canberra.

Reed, S.; Graves, A.; Dandy, N.; Posthumus, H.; Hubacek, K.; Morris, J. et al. (2009): Who's in and why? A typology of stakeholder analysis methods for natural resource management. In *Journal of environmental management* 90 (5), pp. 1933–1949. DOI: 10.1016/j.jenvman.2009.01.001.

Roever, C.; van Aarde, R.; Leggett, K. (2012): Functional responses in the habitat selection of a generalist mega-herbivore, the African savannah elephant. In *Ecography* 35 (11), pp. 972–982. DOI: 10.1111/j.1600-0587.2012.07359.x.

Rondeaux, G.; Steven, M.; Baret, F. (1996): Optimization of soil-adjusted vegetation indices. In *Remote Sensing of Environment* 55 (2), pp. 95–107. DOI: 10.1016/0034-4257(95)00186-7.

Saaty, T. (1990): How to make a decision: The Analytical Hierarchy Process. In *European Journal of Operational Research* 48, pp. 9–26.

Sarkar, S. (2006): Long- and Short-Term Dynamics of the Wetlands in the Amboseli Savanna Ecosystem, Kenya. In fulfillment of the thesis requirement for the degree of Doctor of Philosophy in Biology. University of Waterloo, Ontario, Canada.

Schwartz, M. (2015): Resistance-surface-based wildlife conservation connectivity modeling: Summary of efforts in the United States and guide for practitioners. USDA- United States Department of Agriculture (General Technical Report RMRS-GTR-333).

Taylor, P.; Fahrig, L.; Henein, K.; Merriam, G. (1993): Connectivity Is a Vital Element of Landscape Structure. In *OIKOS* 68:3.

USGS (2015): NDVI, the Foundation for Remote Sensing Phenology [online]. Available at: https://phenology.cr.usgs.gov/ndvi_foundation.php [Accessed 5th of November 2017].

Voelker, E.; Doyle, C.; Karakashian, J.; Policelli, F.; Masek, J. (2013): Kenya Water Resources. Using Satellite Imagery to Support Land Cover, Water, and Habitat Monitoring in Kenya's South Rift Region. NASA Development National Program. Goddard Space Flight Center.

Wade, A.; McKelvey, K.; Schwartz, M. (2015): Resistance-surface-based wildlife conservation connectivity modeling: Summary of efforts in the United States and guide for practitioners. USDA- United States Department of Agriculture (General Technical Report RMRS-GTR-333).

Wall, J.; Douglas-Hamilton, I.; Vollrath, F. (2006): Elephants avoid costly mountaineering. In *Current Biology: CB* 16 (14), R527-9. DOI: 10.1016/j.cub.2006.06.049.

Wanyonyi, E. (2012): Mobilizing Resources for Wildlife Conservation in Kenya beyond the 21st Century. In *The George Wright Forum* 29 (1), pp. 118–125.

Warigia, G.; Buzzard, B. (n.d.): Kenya's New Wildlife Laws. What impact on conservancies?

Western, D. (1989): The Ecological Role of Elephants in Africa. In *Pachyderm* (12), pp. 43–49

Western, D. (2007): The ecology and changes of the Amboseli ecosystem. Recommendations for planning and conservation. Amboseli Conservation Program at African Conservation Centre Nairobi.

Western, D.; Groom, Rosemary; Worden, Jeffrey (2009): The impact of subdivision and sedentarization of pastoral lands on wildlife in an African savanna ecosystem. In *Biological Conservation* 142 (11), pp. 2538–2546. DOI: 10.1016/j.biocon.2009.05.025

Western, D.; Nightingale; Manzolillo D.L. (2004): The Impact of Environmental Change on Vulnerability of Pastoralists to Drought: A case study of the Maasai

WRI (2007): [World Resources Institute] (2007): Kenya GIS Data. Available at: https://www.wri.org/resources/data-sets/kenya-gis-data [Accessed June 2017].

Ykhanbai, H.; Rishu G.; Singh, A.; Moiko, S.; Beyene, C.; Dilys, R.; Nelson, F.; Blomley, T. and Flintan, F. (2014): Rangelands. Conservation and "Land Grabbing" in Rangelands: Part of the Problem or Part of the Solution?

Zeller, K.; McGarigal, K.; Whiteley, A. (2012): Estimating landscape resistance to movement. A review. In *Landscape Ecology* 27 (6), pp. 777–797. DOI: 10.1007/s10980-012-9737-0

Key Informants and Expert Interviews

Brar, Mohanjeet [Programmes Manager at Gamewatchers Selenkay Conservancy], personal communication: July 27th, 2017

Fishlock, Vicki [Research Scientist at Amboseli Trust for Elephants], personal communication: June 24th, 2017

Goss, Jeremy [Conservation Project Manager at Big Life Foundation], personal communication: July 10th and July 27th, 2017

Jakinda, Samwel [Programs Manager at Neighbors Initiative Alliance], personal communication: July 9th, 2017

Millar, Craig [Security Manager at Big Life Foundation], personal communication: July 6th, 2017

Mpelele, Shadrack [Project Manager at Illaramatak le Mpusel], personal communication: July 19th, 2017

Mwato, Jackson [Chairman of CWCCC and Program Officer at ACC], personal communication: August 22th, 2017

Mwinzi, Christine [Research Scientist at KWS, Amboseli NP], personal communication: July 11th and 21st, 2017

Nyagi [Warden of KWS in Loitokitok], personal communication: July 21st, 2017

Onuko, Julius [Camp Manager at Satao Elerai], personal communication: July 18th, 2017

Olivier, Iain [Conservation and Programs Manager at MWCT], personal communication: August 16th, 2017

Satoti [Rancher at Sidai Oleng], personal communication: July 18th, 2017

Wilkie, Ryan [Research Scientist at STE], personal communication: July 6th, 2017

All pictures are own photographs and were taken during fieldwork in Amboseli-Tsavo during July and September (2017)

9 Annexes

Annex I: Environmental factors and data sources used for geo-spatial analysis

Environmental data layers			
	Name	**Data Source**	**Initial Data Resolution**
Natural	Slope	SRTM[1]	30 m
	Proximity to wetlands	WRI[2]	Vector data
	Proximity to rivers	WRI[2]	Vector data
	Waterbodies	Sentinel 1 [3] July images: 23/07/2016 December images: 23/12/2016	10 m
	NDVI	Sentinel 2 [4] July images: 23/07/2016 December images: 20/12/2016	10 m
Anthropogenic	Distance to major roads	WRI[2]	Vector data
	Distance to towns	Google Earth Satellite	Vector data
	Proximity to boreholes	WRI[2], BL[5] MWCT[6]	Vector data
	Protected Areas and Conservancies	WRI[2], BL [5]	Vector data
Artifical barriers and restricted areas	Fences	BL [5]	Vector data
	Cropland	BL [5]	Vector data
Others	Group Ranch/ Country boundaries/ Pipeline	ILRI[7]	Vector data

1- Shuttle Radar Topography Mission

2- World Resource Institute (2007): Kenya GIS Data. Available at: https://www.wri.org/resources/data-sets/kenya-gis-data [Accessed June 2017].

3- ESA Copernicus Data Hub (2017): Available at https://cophub.copernicus.eu/ [Accessed September 2017]

4- USGS Earth Explorer (2017): Available at https://earthexplorer.usgs.gov/ [Accessed June 2017]

5- Big Life Foundation (pers. comm., 2017)

6- Maasai Wilderness Conservation Trust (pers. comm., 2017)

7- International Livestock Research Institute (2007): GIS services. Available at http://192.156.137.110/gis/search.asp [Accessed June 2017]

Annex II: Pairwise comparison matrix scheme for expert interviews to obtain weights for selected factors

Factor A	Factor weighting score									Factor B
	5 extremly strong	4 very strong	3 strong	2 marginally strong	1 Equally strong	2 marginally strong	3 strong	4 very strong	5 extremly strong	
Distribution and density of permanent water points										Distribution of roads
										Area of settlements
										Slope
										Elevation
										Vegetation
										Elevation
Distribution of roads										Area of settlements
										Slope
										Elevation
										Vegetation
Area of settlements										Slope
										Elevation
										Vegetation
Slope										Elevation
										Vegetation
Elevation										Vegetation

Additional Factor A	Factor weighting score									Factor B
	4 extremly strong	3 very strong	2 strong	1 marginally strong	0 Equally strong	1 marginally strong	2 strong	3 very strong	4 extremly strong	
										Distribution and density of permanent water points
										Distribution of roads
										Area of settlements
										Slope
										Elevation
										Vegetation

Annex III: Guiding questions used for interviews with key informants

1. What are the 4-5 key activities you do in the Amboseli-Tsavo Ecosystem?
2. What are the five main challenges you see in the whole management of Amboseli-Tsavo Ecosystem? Who do you think is the main actor responsible for the challenges you highlighted? For example, if there is human-wildlife conflict who specifically from the different actors is associated with it?
3. What kind of challenges could threaten the Amboseli-Tsavo Ecosystem in the future?
4. Who do you consider as your key partners and why?
5. What are the 3-4 issues that your organisation and Amboseli management agree/disagree on?
6. What are the 3-4 issues that your organisation and Kajiado County agree/disagree on?
7. Which of the following groups (private land owners, communal land owners, group ranches, group ranch committee, individual farmers/pastoralists) do you generally work with?
8. What are the three main challenges local communities are facing?
9. What are the three main challenges when working with communities?
10. Do you think Amboseli ecosystem management is including the concerns of the group ranch members e.g. individual farmers/pastoralists?
11. How did the number of human-wildlife conflicts change in the last 10 years?
12. What do you think are reasons for that?
13. What do you think should be done to reduce human- conflicts?
14. What is your optimum long-term solution regarding human-wildlife conflicts? How do you (as NGO) picture wildlife coexistence between human and wildlife animals in the future?
15. Do you think wildlife should range freely in group ranches?
16. If no, how would you (as NGO) like wildlife to move in the group ranches? (only restricted areas, fences etc.)
17. Do you think connectivity is a problem in this ecosystem?
18. Is there a corridor or connectivity between Amboseli NP and Tsavo West (corridor defined as a connected piece of land without interruptions by settlements or agriculture used by elephants) sufficient for elephant movements? If yes, how does it connect? If no, do you think there is a need for one?
19. Do you think there is a possibility of creating or keeping a specific passage route for wild animals? Where would you propose or keep this kind of corridor?
20. What is the main limiting factor in conservation and effectively reducing human-wildlife conflict? (financial support and money provided by the government?)
21. In how far are you (NGO) involved in the establishment of sanctuaries or conservancy areas?
22. Are you involved in selecting certain areas for the establishment of conservancy areas?
23. Have you discovered land subdivision in the group ranches? From your experience, can you say this trend is increasing or decreasing?

24. Do you see subdivision in the group ranch as a threat or an opportunity for wildlife conservation and to cope human-wildlife conflicts? Please outline shortly.
25. How do you rate the importance of an effective compensation scheme in regard to wildlife compensation?
26. What structures have been put in place by your organisation to encourage people participation in conservation?
27. What do you think needs to be done to improve the coexistence between humans and wildlife?

Annex IV: Survey scheme to gather information from group ranch members

Ranchers and Farmers perspective on wildlife movements and management practices in the Group Ranch	
Informed consent	
▪ All information collected in this survey is confidential and your name will be kept anonymous. ▪ Your participation is important for the outcome of the study. ▪ Your participation is voluntary and you can skip any question you do not wish to answer. ▪ If you are uncomfortable, you can end the interview at any time. ▪ Please feel free to ask any questions you might have. **Do you consent to provide information Yes [ ] No [ ]**	
Date	
Target household information	
Name of interviewee	
Group name and position of interviewee in the Group	

Household Information

1. How old are you?
2. What is the highest level of formal education you completed?
3. What are your main sources of income?
4. Please define your way of living (nomadic, semi-nomadic, sedentary)

Land Use and Land Tenure

1. What is your source of land for the farming you do? On which land do you graze your livestock?
2. Have you recognized subdivision of land in your group ranch?
3. Do you personally support land subdivision and individual ownership in your group ranch?
4. Please name one to three reasons why you support or do not support land subdivision in your group ranch?

5. Did the land in your group ranch and the way it is used by its members changed in the last years? If yes, what changes did you recognize?
6. Did you personally change your land use practices and what did you change?
7. What are the reasons why you changed?

Wildlife Conservation Management

1. Are you part of a communally managed conservancy area?
2. Who in your group ranch takes part in the management of the conservancy area? (e.g. Group members, NGOs, government or others) Please name them.
3. Are you part of a tourism revenue sharing program?
4. Have you been somehow benefitting from community conservation? If yes, how did you benefit?
5. Would you like to take part in community conservation?
6. If yes, how would you like to take part/ which role do you want to play in conservation?

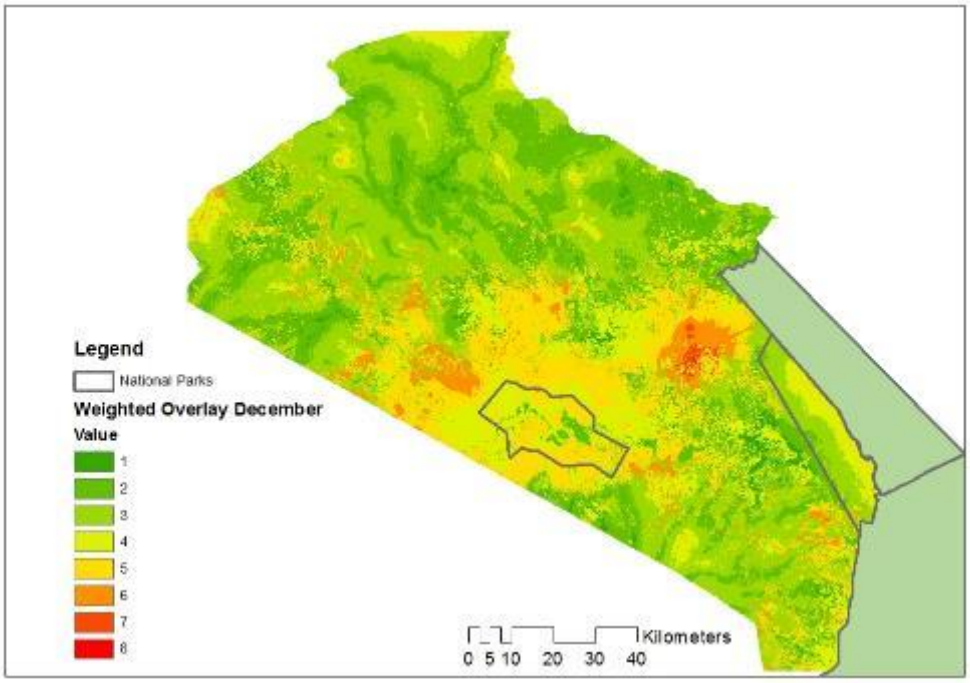
Elephant and wildlife's movement in your Group Ranch

1. Do you see elephants as an asset or a liability?
2. What are the main problems with elephants that you are facing?
3. Are you benefitting from the wildlife in your group ranch? If yes, how do you benefit?
4. Do you think wildlife should move freely in your range?
5. What is your perception towards wildlife using the same pastoral areas as livestock?
6. How do you picture wildlife coexistence between human and wildlife animals in the future?

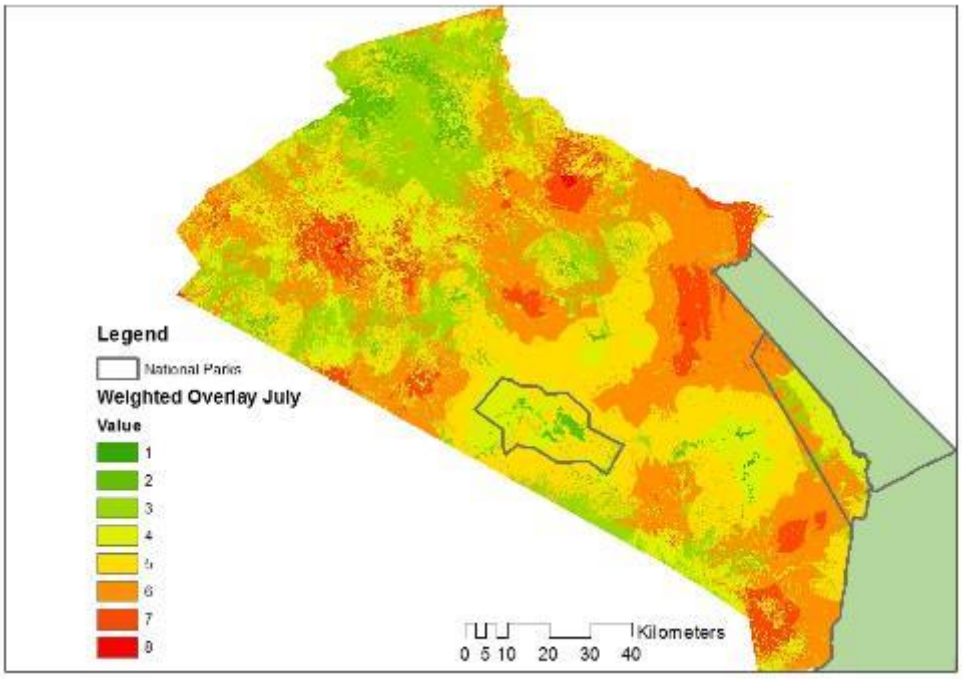
Management practices Group Ranches

1. What problems do you have in your group ranch?
2. Which institutions or groups/people are responsible for the management of the problems you are facing and how well do you feel supported by them?
3. How are members in your group ranch involved in wildlife management?
4. How do you see the management of grazing areas for livestock and wildlife in your group ranch?
5. Who is responsible for the managing of grazing areas for livestock?
6. Who do you think should manage the grazing areas?

Annex V



Map 15: Weighted overlay (cost-surface) for December



Map 16: Weighted overlay (cost-surface) for July

Declaration in lieu of oath

by

Marit Schnepf

This is to confirm my Master's Thesis was independently composed/authored by myself, using solely the referred sources and support.

I additionally assert that this thesis has not been part of another examination process.

Place and Date **Signature**

Ihr Dokument wurde erfolgreich bei Turnitin | Ephorus eingereicht, und Ihr Lehrer ITT Master (ephorus_masterthesis@itt.th-koeln.de) wurde benachrichtigt.

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