Climate governance, rural livelihoods and social networks: Using the ecosystem service governance approach to analyse climate adaptation and resource conflict resolution in Kenya.

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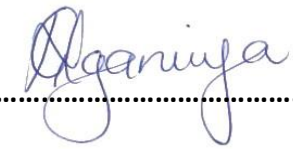
Declaration on oath

I hereby declare, on oath, that I have written the present dissertation by my own hand and have not used any other than the acknowledged resources and aids.

Place and date	Signature
Hamburg, 8th July 2014	 **…….**

ABSTRACT

No doubt impacts from climate change on natural resources threaten achievement of the Millennium Development Goals. But of more concern is the controversial "climate-conflicts nexus" theory which paints a grim future as resources become scarcer in Africa. Though some scientists believe that this popular theory is biased, there is an evident knowledge gap on successful adaptation strategies currently sustaining rural livelihoods across the Sub-Sahara. Moreover, poorly coordinated "adaptation expertise" actors in climate-vulnerable communities nurture legal pluralism and sectorial divisions that are now also projected to instigate resource conflicts at the community level. Possibility of such a scenario creates the need for efficient resource governance structures that clearly delineate actor responsibilities for enhanced site-specific conflict-sensitive adaptation. Social network analysis is emerging as the best tool for identifying actor roles and unlocking cooperation deadlocks in natural resource management. However, a methodological gap exists on how to effectively incorporate social network notions into governance frameworks for evaluating community responses to climate change and resource conflicts using actor-linkages.

To resolve this technical gap, I formulate a theoretical governance approach based on social network theory to simultaneously identify rural actors and analyse their governance activities in a multi-resource sector community. The objective is to investigate; *with whom* does a rural natural resource user *do what*? *How*? If, not possible, then *why not*? With a specific focus on climate adaptation and resource conflict resolution issues. My innovative framework - *ecosystem service governance (ESG) approach* - builds further the Ecosystem Approach and also incorporates monetary valuation of ecosystem services. To test functionality of the ESG approach, I implement it on the social network of Loitoktok in Kenya. My focus is on key ecosystem services that are economically important namely, food production, wildlife, water and medicinal plants in the district. Application of ESG requires empirical information that consists of both relational and resource attributes data gathered using structured questionnaires, expert interviews, and group discussions. Secondary data is obtained from official resource records and documents from different government agencies.

Findings reveal a significant relationship between actor linkages and adaptation performance in the agriculture, wildlife and water sectors. Whereby, high inter-actor

connections in the agriculture and wildlife sectors result in many diverse adaptation measures, poor linkage in the water sector lowers collaborative adaptation activity while the medicinal plants sector has no actor interlinkage and which promotes individual-effort adaptation practises. Secondly, dense connectivity among resource conflict resolution actors facilitates implementation of three unique mechanisms that enhance cohesion in the community. Formation of actor linkages is hindered by poor coordination, low financial support and insufficient manpower. In addition, absent inter-actor linkage in the medicinal plants sector is rooted in its lack of recognition as a valid formal economic sector that hinders legislation and contributes to lack of public interest. To resolve the identified hindrances, the ESG approach has an additional feature that simulates an "optimum" resource governance structure through network weaving actions by certain brokers. The resultant hypothetical structure illuminates potential pathways for increasing adaptation performance, livelihoods diversification, carbon sequestration and culture preservation in Loitoktok.

The formulated ecosystem service governance approach effectively answers the aforementioned research questions by revealing how adaptation and resource conflict resolution are precisely being implemented at the community level. Secondly, the study proposes using the established Revolving Fund scheme (responsible for aggregating individuals into community (business) interest groups) in disseminating climate adaptation knowledge alongside economic development. Thirdly, significance of the formulated ESG approach cannot be understated in relation to the current devolution predicament in Kenya. Whereby, the newly formed County governments can utilise the ESG for identifying collaboration deadlocks in their social structures. Finally, since the ESG approach also gives a practical structural solution to enhance resource governance, then it is foreseen that subsequent objective netweaving of actor linkages at the community and County levels will enhance climate governance especially rural adaptive capacity and reduce risk of projected climate-driven resource conflicts in Kenya.

ZUSAMMENFASSUNG

Die Auswirkungen des Klimawandels auf die natürlichen Ressourcen bedrohen zweifellos das Erreichen der Millennium-Entwicklungsziele. Aber noch bedenklicher ist der umstrittene Zusammenhang zwischen Klimawandel und Konflikten, der aufgrund einer Verknappung der Ressourcen in Afrika eine düstere Zukunft erwarten lässt. Obwohl einige WissenschaftlerInnen diese Ansicht für unausgewogen halten, gibt es ein offensichtliches Forschungsdefizit in Bezug auf mögliche Anpassungsstrategien, die ländliche Lebensweise in Afrika südlich der Sahara aufrechterhalten können. Darüber hinaus fördert die mangelhafte Koordination von Akteuren im Bereich der "Anpassungsexpertise" einen rechtlichen Pluralismus und eine sektorale Aufteilung innerhalb klimasensibler Gemeinden, was in Zukunft Ressourcenkonflikte auf Gemeindeebene begünstigen könnte. Ein solches Szenario macht deutlich, dass effizientere Ressourcen-Managementstrukturen nötig sind, die den involvierten AkteurInnen klar definierte Verantwortungsbereiche in Hinblick auf ortsspezifische und konfiktsensible Anpassungsmaßnahmen zuweisen. Die Analyse sozialer Netzwerke entwickelt sich zu einem geeigneten Instrument, um die Rolle von Akteuren zu bestimmen und Kooperationsblockaden beim Management natürlicher Ressourcen zu überwinden. Es besteht jedoch eine methodische Lücke bezüglich der Frage, wie die Netzwerkstrukturen effektiv in einen Governance-Rahmen integriert werden können, um Akteursbeziehungen wirksam für die Bewertung der Anpassungsfähigkeit von Gemeinden auf den Klimawandel und existierenden Ressourcenkonflikte zu nutzen.

Um diese methodische Lücke zu füllen, habe ich einen theoretischen Governance-Ansatz erarbeitet, der auf sozialer Netzwerktheorie basiert. So können AkteurInnen zugleich in Bezug auf Klimawandel, Ressourcenkonflikte und Governanceaktivitäten in Multi-Ressourcen-Umgebungen analysiert werden. Ziel ist es zu untersuchen, *mit wem* Nutzer ländlicher natürlicher Ressourcen *was tun*, *wie* sie es tun und falls sie es nicht tun, *warum* nicht? Der Fokus soll hierbei deutlich auf Aspekten der Anpassung an den Klimawandel und der Lösung potentieller Ressourcenkonflikte liegen. Mein innovativer Ökosystem-Service-Governance-Ansatz (ESG) ist eine Weiterentwicklung des Ökosystemansatzes und ergänzt diesen durch eine monetäre Bewertung von Ökosystemdienstleistungen. Um den ESG-Ansatz zu testen, habe ich ihn auf das soziale Netzwerk von Loitoktok in Kenia angewendet, wobei ich mich auf die wirtschaftlich wichtigsten Ökosystemdienstleistungen konzentriert habe. Hierbei handelt es sich insbesondere um die Nahrungsmittelproduktion, die Tierwelt, die Trinkwassernutzung und die Heilpflanzengewinnung in dem ausgewählten Bezirk. Die benötigten empirischen Daten, die sowohl aus relationalen als auch aus ressourcenspezifischen Informationen bestehen, wurden mittels strukturierter Fragebögen, ExpertInneninterviews und Gruppendiskussionen erhoben. Die Sekundärdaten wurden aus offiziellen Statistiken und Dokumenten verschiedener Regierungsbehörden gewonnen.

Die Ergebnisse zeigen, dass es einen signifikanten Zusammenhang zwischen der Stärke der Verbindungen von AkteurInnen innerhalb eines Sektors und deren Anpassungsfähigkeit

gibt. Während starke Verbindungen zwischen den AkteurInnen innerhalb der Sektoren „Nahrungsmittelproduktion“ und „Tierwelt“ zu einer Diversifizierung der Anpassungsstrategien führen, sorgen schwache Verbindungen im Wassersektor und keinerlei Vernetzung im Heilpflanzensektor für geringere Anpassungsaktivitäten; hier steht die Entwicklung individueller Anpassungsstrategien im Vordergrund. Außerdem ermöglicht eine enge Verbindung zwischen den an der Lösung von Ressourcenkonflikten beteiligten AkteurInnen die Entwicklung von drei Mechanismen, die den Zusammenhalt der Gemeinde verbessern: Die Ausprägung der Akteurs-Verbindungen kann durch mangelhafte Koordination, geringe finanzielle Unterstützung und fehlende Arbeitskraft gehemmt werden. Die Abwesenheit von Akteurs-Verbindungen im Heilpflanzensektor lässt sich durch die geringe Anerkennung als formaler Wirtschaftssektor erklären, was zu einer fehlenden Rechtsgrundlage und geringem öffentlichen Interesse führt. Um derartige Hindernisse zu beseitigen, verfügt der ESG-Ansatz über die Möglichkeit, mithilfe von Vermittlern Vernetzungsstrukturen zu schaffen, die ein "optimales" Ressourcengovernance simuliert. Anhand der resultierenden hypothetischen Strukturen können mögliche Pfade einer verbesserten Anpassungsfähigkeit, einer Diversifizierung von Lebensgrundlagen, der Kohlenstoffspeicherung und der Bewahrung der Kultur in Loitoktok aufgezeigt werden.

Mit dem entwickelten Ökosystem-Service-Governance-Ansatz können effektiv die eingangs gestellten Forschungsfragen beantwortet werden, indem aufgezeigt wird, wie Maßnahmen zur Anpassung und Lösung von Ressourcenkonflikten auf Gemeindeebene konkret implementiert werden. Zweitens zeigt diese Arbeit, dass es möglich ist, die etablierte Struktur der umlaufenden Fördermittel (Revolving Funds), die Individuen in gemeinschaftlich organisierte Interessengruppen zusammenfasst, für die Verbreitung von Wissen über Klimaanpassung zu nutzen, wie auch von wirtschaftlicher Entwicklung. Drittens sollte der Beitrag des ESG-Ansatzes zum Umgang mit der aktuellen dysfunktionalen Dezentralisierung in Kenia nicht unterschätzt werden, denn die neu entstandenen Regierungen von Landkreisen können mit Hilfe des ESG-Ansatzes Kooperationsprobleme innerhalb ihrer sozialen Netzwerke aufdecken. Da der ESG-Ansatz schließlich eine praktische Lösung für eine verbesserte Struktur des Ressourcen-Governance eröffnet, ist absehbar, dass die folgende Vernetzung von Akteurs-Verbindungen auf Gemeinde- und Landkreisebene die Anpassungsfähigkeit und Klima-Governance im ländlichen Raum stärkt, und klimainduzierte Ressourcenkonflikte in Kenia verringert.

THESIS DICTUM

We owe it to ourselves and to the next generation
to conserve the environment so that we can bequeath our children,
a sustainable world that benefits all.

~Wangari Maathai ~
2004 Nobel Peace Prize Laureate

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~ ASANTE SANA ~

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AMCEN	African Ministerial Conference on the Environment
ASAL	Arid and Semiarid Land
CBD	Convention on Biological Diversity
CCCU	Climate Change Coordination Unit
CCS	Climate Change Secretariat
DAO	District Agricultural Office
DKWS	District Kenya Wildlife Service
DLO	District Livestock Office
DSDO	District Social Development Office
ECA	Economic Commission for Africa
ERD	European Report on Development
ESG	Ecosystem Service Governance
ICPAK	Intergovernmental Panel on Climate Prediction and Adaptation, Kenya
IPCC	International Panel on Climate Change
NCCAP	National Climate Change Adaptation Plan
NCCRS	National Climate Change Response Strategy
NGO	Non-governmental Organisation
SCB	Scale-Crossing Brokers
SNA	Social Network Analysis
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Program
WBGU	Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (German Advisory Council on Global Change)
WEF	Women Enterprise Fund
WRMA	Water Resource Management Authority
WRUA	Water Resource Users Association
YEDF	Youth Enterprise Development Fund

CHAPTER 1: INTRODUCTION

1.1. Background

Ecosystem services act as an economic lifeline to about three quarters of the poor worldwide (Irwin et al., 2007). In Kenya, this link between ecosystem services and economic growth is clearly seen through, subsistence food production that enhances food security (Okello & D'amour, 2008), tourism based on the rich wildlife (Manyara & Jones, 2007), water that sustains all economic and ecological processes and herbal medicinal culture that existed before the arrival of orthodox medicine (OM) in Kenya (Bussmann et al., 2006; World Health Organization, 2002). Consequently, when communities degrade their ecosystems, they not only limit the ecosystem's potential as a source of environmental income, but the negative impacts also have domino effects on health, living standards, poverty and crime rates at the community level (WRI et al., 2005).

Apart from habitat degradation, impacts from climate change are also *projected* to exacerbate the loss of biodiversity (Wangai et al., 2013) and negate economic growth in developing countries (UNFCCC, 2007). In Kenya, climate change studies *confirm* changes in precipitation (Altmann et al., 2002) and temperature fluctuations (Cooper et al., 2013) that have instigated water insecurity (Schewe et al., 2013), lowered agricultural productivity (Ngaruiya, 2014) and reduced tourism earnings (Kibara et al., 2012).

In addition, since 2007, increased global interest in the climate-security nexus has contributed to securitization of climate policy in the international community (Brauch, 2009; Brzoska, 2009; Scheffran, 2009). This development is aptly described by WBGU (2008) that states "impacts from climate change could draw deeper lines of division and exacerbate existing 'ecosystem service' crises that could potentially intensify resource conflicts in developing nations". Similarly, the European Commission, indicate that "climate change acts as a threat multiplier, worsening existing tensions in countries and regions which are already fragile and conflict-prone, and if not mitigated, the negative impacts may wipe out years of development efforts and endanger achievement of the Millennium Development Goals" (EU, 2008). These statements not only emerge from the fear that sub-Saharan resolution mechanisms maybe overwhelmed with additional climate-induced conflicts (Yanda & Bronkhorst, 2011). But, also from a poor understanding of rural resource conflict resolution mechanisms that were radically altered by colonisation (Cheka, 2008).

Management of ecosystem services has evolved from simple village based systems to national resource governance schemes that advocate for a participatory method involving the indigenous community, government agencies and third party actors such as donors or non-governmental organisations (Pearce et al., 2003). Furthermore, many governments around the world have, for the last 30 years, pursued a neo-liberal agenda that, amongst other things, has devolved responsibilities from national government agencies to local agencies and communities that foster individuals' entrepreneurial capacities (Lockwood, 2010). But these localised management schemes continue to fail to minimize biodiversity loss due to capacity deficits in many sub-Saharan countries (Honey, 1999; Lockwood, 2010). In addition, this participatory practice has encouraged proliferation of actors currently offering diverse "adaptation expertise" to rural communities (Madzwamuse, 2010) and complicating further local ecosystem services governance.

1.2. Problem definition

Shortcomings in resource governance originate from power problems such as legal pluralism (Meinzen-Dick & Pradhan, 2002), poor coordination (Ernstson et al., 2010) and sectorial divisions (Madzwamuse, 2010). These shortcomings are now also predicted to be "gestating" grounds for future resource conflicts among "climate vulnerable" communities (Brooks et al., 2011). This is partly because indigenous actors and structures might not be able to access and transmit accurate, relevant and timely information for adapting their livelihoods to climate change, despite the perceived abundance of climate governance actors.

To solve such a governance dilemma, the community is advised to first identify its stakeholders and structural hindrances, then collaboratively induce or position stakeholders to foster sustainable resource use (WRI et al., 2005) and prevent competition over resources from turning into a violent conflict (Adano et al., 2012; Young, 2011). However, such an approach can only be implemented using social network analysis notions that are useful for evaluating social relationships and unlocking deadlocks in resource governance scenarios (Bodin & Prell, 2011).

1.3. Rationale for the study

Three factors are considered as key knowledge gaps that subsequently justify this study.

First, few publications exist on application of social network analysis on climate governance, particularly those that relate natural resource issues to the rural community. This knowledge gap also means that there are even fewer practical methodological frameworks based on social network theory for analysing natural resource management problems (Bodin & Prell, 2011).

Secondly, the popular climate-resource conflicts nexus theory is perceived to be fuelled by the lack of substantial information on implemented adaptation strategies in developing countries (Müller, 2013). However, I presume that adaptation activities are present at the grassroots and that collaborative action is being used to implement these activities.

Thirdly, few studies have documented the social governance structures that resolve conflicts at the grassroots (Hyden et al., 2005). This is a critical aspect of governance considering that current unpredictable climatic conditions introduce additional socioecological linkages that complicate the conflict dialogue in Africa (Carius, 2009).

In summary, the main goal of this study is to formulate a single functional approach based on social network theory to simultaneously analyse climate change and resource conflicts actors and governance activities. The guiding question is "*with whom* does a resource user *do what*? *How*? If, not possible, then *why not*?" This statement will guide me as I examine actor linkages in climate adaptation and resource conflict resolution activities that are implemented either individually or collaboratively in a typical rural community. Furthermore, identification of hindrances and suggested solutions might increase efficiency of rural cross-sector adaptation. The interconnected questions generate the motivation for this study, which aims to contribute to the growing field of social network analysis.

For my case study, I choose Loitoktok district to represent the "best case" scenario of ecosystem-service based social network analysis in Kenya. This is because it is cited as one of the rural areas with high collaborative actors in its key economic sectors of agriculture (Okello & D'amour, 2008), tourism (Okello et al., 2011) and water (Grossmann, 2008). Also, its dominant inhabitants – Maasai - are recognized for their deep knowledge in herbal

medicinal practise with products that are popularly traded in many rural markets (Bussmann et al., 2006).

1.4. Research objectives

In this study, concepts of social network theory are used to examine rural adaptation and conflict resolution in the food production, medicinal plants, wildlife and water sectors of Loitoktok to answer the aforementioned research question(s). This process involves the following specific tasks:

1. To identify challenges in climate governance at the rural community level.
2. To formulate a single functional approach that incorporates social network notions with economic valuation of ecosystem services, climate adaptation and conflict resolution strategies.
3. To use this approach to analyse how real-life actor linkages influence climate adaptation activities and resource conflict resolution in a rural community.
4. To determine strengths and weaknesses of the formulated ecosystem service governance approach.
5. To simulate an optimum resource governance structure through network weaving using the Loitoktok actors.

These questions all merge to sequentially inform the key objective that seeks to clarify interactions between rural actors in order to establish a baseline for comparative network studies with other rural communities. The outputs will contribute to better resource governance with benefits – economic, social and ecological - to the rural community and subsequently improve the national climate adaptation status.

1.5. Structure of thesis

Thematically this thesis fits within the regional studies domain. To satisfy the interdisciplinary requirements of the research matter, it combines human geography approaches with perspectives from different disciplines including; agricultural sciences, ecology, peace and security studies, conflict management, political sciences, economics and sociology.

This thesis comprises of information and results already developed into four peer-reviewed journal articles, one book chapter and two more manuscripts under the review

process in various journals (Appendix1). Figure 1.1 gives an illustration of the research framework while a more detailed description of each chapter is presented below.

Chapter 2 begins by presenting existing literature on specific climate change impacts on food production, medicinal plants, wildlife population and water resources as key economic ecosystem services in Kenya. It illustrates the link between climate change impacts, land tenure change and increased resource conflicts in a representative rural area in Kenya. Then, it describes the recommended adaptation strategy to deal with negative climate change impacts. I introduce the role of social relational approach in streamlining governance actors and their actions in the society. Then, extend the discussion further by clarifying social network analysis and the key concepts selected towards answering the research questions. The objective of this chapter is to highlight climate and resource governance[1] challenges that are addressed by this thesis.

The geographical context in which the research is conducted is given in chapter 3. It describes in detail the three key themes of this research in relation to Kenya. These aspects are climate governance, resource conflict resolution mechanisms and social structure. The chapter also describes the study area of Loitoktok district in terms of location, geography, habitat profile and socioeconomics and also gives the reasons behind its selection as a representative of a typical rural community in Kenya.

Chapter 4 then describes formulation of the novel Ecosystem Service Governance (ESG) approach to address identified resource governance challenges. This approach incorporates two notions namely monetary valuation of ecosystem services and social network indices into traditional ecosystem management to create a single functional structure for analysing resource governance performance. The chapter also discusses predicted outcomes of the approach.

Methods used to collect data are described in chapter 5, which include semi-structured questionnaires, expert interviews and group discussions as well as official documentation that provides secondary data for valuation. Chapter 6 subsequently discusses the techniques used to analyse the data collected, which include monetary valuation techniques

[1] Ernstson et al., (2010) defined governance as the structures and processes by which collective action among a diversity of social actors (state, private, and civil society) is coordinated towards upholding certain publicly held values and resources. Governance takes place through diverse institutions defined as “an enduring collection of formal laws and informal rules, norms, customs, codes of conduct, and organized practices that shape and govern human interaction” (IDRC, 2009).

of ecosystem services and respondent choices. It also presents the equations used to obtain networks cohesion and structural holes values from network data that are subsequently used to illustrate the Loitoktok community.

Chapter 7 systematically describes the results guided by the ecosystem service governance approach structure. Findings confirm that the community has adapted through diverse activities after experiencing negative drought impacts in 2009. The chapter also includes economic valuation results which are seen as important factors when assessing adaptation performance. The social network analysis proves to be beneficial in connecting actors in adaptation knowledge to adaptation activities in the community. In addition, network analysis exposes the cohesive collaborative social structure responsible for resolving rural resource conflicts. Subsequently, the community network is illustrated for a clearer understanding of the governance structure responsible for knowledge dissemination in Loitoktok.

The results are discussed in chapter 8. First the ecosystem service governance approach is critiqued in its evaluation of governance activities and flow of adaptation knowledge in Loitoktok. Second, I describe the implications of using social network analysis to evaluate governance in a rural setting. Third, the chapter discusses key actors in adaptation knowledge dissemination that has fuelled local growth in adaptive capacity. Fourth, I discuss the role of actor linkages in developing site-specific collaborations in rural resource conflict resolution. A comprehensive assessment is given on the strengths and weaknesses of ESG for future refinement. Consequently, I design an *optimum* resource governance structure using network weaving to reveal avenues through which identified brokers can create new linkages to boost climate adaptation and sustainable development at Loitoktok.

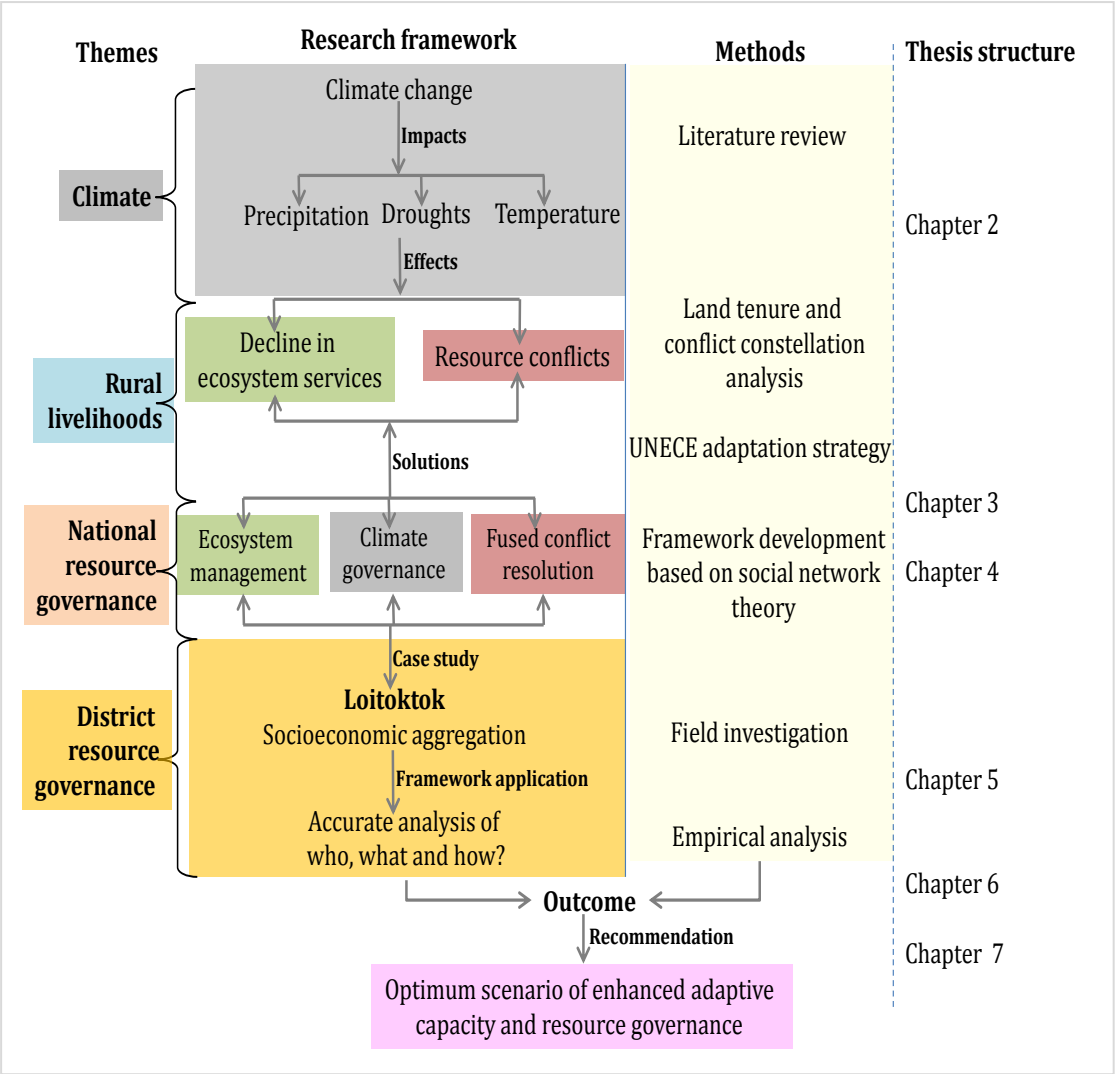


Figure 1.1: Research framework and the methods for this thesis. Source: The author.

The last section summarises key findings of the study towards guiding resource policy formulation on ecosystem service governance alongside climate adaptation. It also presents the outlook that includes future research areas using ESG. Thereafter, specific actions by Kenyan stakeholders are recommended regarding the Revolving Fund and County governments. The thesis concludes with the main implications of ESG on resource governance in rural communities.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction to chapter

Governing the commons is a dynamic process because of the need to maintain supply of ecosystem services despite the constantly changing environmental and societal circumstances. This chapter discusses these changing circumstances and their relation to resource governance. It begins with a brief description of documented impacts of climate change on key economic ecosystem services for the rural community. Then, I discuss the specific relationship between climate change, land tenure, poor adaptive capacity and resource conflicts to clarify why rural Kenyan communities are termed as "climate vulnerable". Subsequently, I present the recommended UNECE 5-pillar adaptation strategy for sustainable development under variable climate conditions. Thereafter, an emerging stepping stone for disentangling governance challenges - social relational theory - is described together with three mathematical indices of social network analysis selected for this study. The chapter ends with the knowledge gaps to be addressed in this study. Sections of this chapter form the background of four articles in which I have contributed 80% of the paper's content.

2.2. Climate change and ecosystem services

The ability to capitalise on and improve access to the wealth contained in natural resources offers significant opportunities to developing countries to overcome poverty (ERD, 2012). However, the issue of climate change is arguably the greatest emerging threat to global biodiversity and functioning of local ecosystems (IPCC, 2007). Fundamentally, global warming occurs because human activity has overwhelmed the ability of the atmosphere, oceans, soil and forests – the major natural sinks – to absorb carbon dioxide and other green-house gases (GhGs) (ERD, 2012). According to the IPCC (2007:2) greenhouse gases have increased from 280 ppm (parts per million) in the atmosphere in the year 1750 to 379 ppm in 2005. The projected increase until the year 2100 for six scenarios (SRES[2] B1, AIT, B2, A1B, A2 and A1FI) is according to the Synthesis Report of the IPCC's

[2] SRES refers to the Special Report on Emissions Scenarios by IPCC and comprise of four scenario families (A1, A2, B1 and B2) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. The A1 storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and

(2007c:45) Fourth Assessment Report (AR4) "about 600, 700, 850, 1250 and 1550 ppm, respectively". This projected increase is far above the natural variation in temperature changes that has been measured for the changes in climate for the past ten millennia (Brauch, 2009).

Climate change, in spite of being a global phenomenon, actually has localised impacts, which are specific for each region, with areas relying heavily on the environment and its ecosystem services tending to be more sensitive to climate stress (Scheffran, 2011). While climate change scenarios for Africa vary and are uncertain, the most popularized prediction says there will progressively be drier conditions with more erratic rainfall (Benjaminsen et al., 2012; Müller, 2013; Muller, 2007). Similarly, though many African grassroots people do not understand the science of climate change, they have clear observations on decreasing rainfall, increasing air temperature, increasing sunshine intensity and seasonal changes in rainfall patterns (Boon & Ahenkhan, 2013).

In Kenya, evidence of climate change is supported by several research findings that state:

a) From the early 1960s, there has been increasing temperature trends that depict a general warming with time in inland areas (Altmann et al., 2002; Government of Kenya, 2010).
b) There are neutral to slightly decreasing trends in the annual rainfall series in most areas (Government of Kenya, 2010). But there is also an general increasing trend in rainfall events of September to the February period suggesting a tendency for the "short rains" season to be extending into the normally hot and dry period of January and February over most areas (Government of Kenya, 2010).
c) Diminishing glaciers of Mt. Kilimanjaro (specifically on Kibo) that have shrunk by about 85% from 12.06 km^2 in 1912 to 1.85 km^2 in 2007 (Thompson et al., 2009),

more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), non-fossil energy resources (A1T) and a balance across all sources (A1B). B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.B2 describes a world with intermediate population and economic growth, emphasising local solutions to economic, social, and environmental sustainability. A2 describes a very heterogeneous world with high population growth, slow economic development and slow technological change (IPCC, 2007).

d) Intensified drought cycles in the 21st century (IPCC, 2007; Schilling et al., 2014). Whereby the drought cycle has changed from ten years to five years and now occurs nearly every two years i.e. 1984, 1992, 2001/2002, 2006, 2009 and 2011.

Subsequent effects on different components of climate change (e.g. temperature, hydrology, atmospheric composition) affect multiple levels of biological organisation. Of high concern is that many rural areas in Africa are characterised by communities subsisting on income generated from simple livelihoods based on food crops, fuel, fibre, fresh water, and genetic resources obtained from natural ecosystems. These natural resources are termed ecosystem services[3] and specifically denote beneficial attributes obtained from natural ecosystems that enhance human well-being (De Groot et al., 2006; Ehrlich & Ehrlich, 1992). Thus, projections indicate that productivity of many ecosystems is likely to be hindered in this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (e.g. land-use change, pollution, fragmentation of natural systems, overexploitation of resources) (IPCC, 2001, 2007).

In this study, I narrow my focus on four ecosystem services that I deem to be fundamental pillars to economic survival of rural communities. The documented impacts of climate change (particularly drought) on these ecosystem services are discussed below.

2.2.1. Impacts on food production (crops and livestock)[4]

Africa is highly vulnerable to climate change on account of its large rural population that remains highly dependent on rain-fed subsistence agriculture for food, its natural resource-based economy and constraints on internal trade (AMCEN, 2011). According to Abdou et al., (2010), climate change will lead to a 50% drop in agricultural production in Africa by 2030 via affecting rainfall, temperature and water availability in vulnerable areas. More explicitly, climate change will affect crop yields through frequent drought episodes, increased plant

[3] The services can be clustered into four groups: 1) supporting services such as pollination, nutrient cycling, productivity or biodiversity maintenance; 2) provisioning services such as food, fuel, fibre or fresh water; 3) less obvious, regulating services such as climate regulation, flood protection or carbon sequestration and, 4) cultural services such as spiritual, aesthetic, recreational, educational or cultural benefits (IPCC, 2007; Millennium Ecosystem Assessment, 2005). This study specifically focuses on provisioning ecosystem services i.e. food production, medicinal plants, wildlife and water resources, that are mainly used for income generation at the grassroots.

[4] This section forms the background of a journal article. Ngaruiya G. W. Does reactive adaptation exist? Using the ecosystem service governance approach to evaluate post-drought rural food security in Kenya. *Natural Resources*, **5,** pp. 392-407 (special issue on resource security).

diseases, maturing period change and shifts in crop climates. It will also affect livestock production though change in quantity and quality of fodder, heat stress, livestock diseases, water availability and loss of indigenous genetic biodiversity (World Bank, 2013). These consequences also have adverse effects on net farm revenues of crop and livestock farming systems to significantly upset economic growth, and worsen food insecurity (EU, 2008).

2.2.2. Impacts on medicinal plants[5]

Medicinal plants are herbs, herbal materials, herbal preparations and finished herbal products that contain active pharmaceutical ingredients from parts of plants or combinations from other plant materials (World Health Organization, 2002). These ecosystem services will suffer the same fate as other plants through the reduction in water supply, sudden weather events and unpredictable climate conditions that may cause a shift in plant geographical locations in terms of latitudes or altitudes or even extinction of some medicinal plant species (Hawkins et al., 2008). The vulnerability of this resource is further exacerbated by the depletion of forest and land cover through rapid increases in population and demand for human settlements (Government of Kenya, 2010).

2.2.3. Impacts on wildlife[6]

Climate change impacts have aggravated water insecurity that decreases pasture for herbivorous species and subsequently reduce prey availability which affects entire food webs and reduces biodiversity in protected areas (Wangai et al., 2013). In addition, the increase in temperatures has been blamed for the increased incidence of vector-borne diseases that affect wildlife diversity and population (El Vilaly et al., 2013). Moreover, in severe drought periods, animals that do not migrate or have high resilience, succumb to death in National parks and game reserves (Wangai et al., 2013; WTO & UNEP, 2008). Changes in climatic conditions have also enabled proliferation of invasive species in rangelands that block animal movement, inhibit full use of wildlife habitat and lower regeneration of indigenous plant species (Shitanda et al., 2014).

[5] This section forms the background of a journal article undergoing review. Ngaruiya G. W. Reweaving stakeholder networks: Enhancing climate adaptation and culture promotion using medicinal plants in Kenya. *Ecosystem Services* (accepted).

[6] This section forms the background of a journal article. Ngaruiya G. W. Using social network theory to analyse climate change adaptation and human-wildlife conflict resolution in the Amboseli wildlife tourism sector. To be submitted to the *Journal of Sustainable Tourism*.

2.2.4. Impacts on water security[7]

Climate change influences virtually every element of the global hydrological cycle through changes in precipitation, evaporation and snowmelt. These threaten global and regional water security through impacts like; drought and accelerated glacier retreat in trends not previously experienced (Adger et al., 2007; WBGU, 2008). Already many African countries experience physical water scarcity (state of having less than 1,000 m3 per capita per annum) or suffer water stress (state with less than 1,700 m3 per capita per annum) (Adger et al., 2007; Ngigi, 2009; WBGU, 2008). By 2020, between 75 and 250 million people are projected to be exposed to increased water stress due to climate change (IPCC, 2007). The recurrent drought episodes (Altmann et al. 2002) have dried up many water bodies and become the driving force behind migratory movements of people especially in the arid and semi-arid regions of Kenya. Impacts of natural disasters such as floods, landslides and wind storms destroy the water infrastructure and disrupt water supply in urban centres (Government of Kenya 2009). Besides, the water crisis in Kenya is further exacerbated by water-related health problems (Government of Kenya, 2009b), particularly diarrhoea and cholera in heavily populated informal settlements.

Increase of these negative impacts suggest that when ecosystems are degraded, it limits their potential as a source of environmental income and also initiates a domino effect on health, living standards, poverty (Lecocq & Shalizi, 2007). Furthermore, impacts from climate change such as droughts and sea level rise threaten to reverse the gains of development and achievement of the Millennium Development Goals (UNEP, 2011).

While policy-oriented studies indicate that land, soil degradation and water scarcity are related to resource conflicts (WBGU, 2008; EU, 2008), results from empirical conflict studies highlight mixed links between climate change impacts and other inherent societal challenges (political, institutional and cultural) facing rural communities (e.g. Buhaug, 2010; Theisen et al., 2011). Given below is a discussion on the relationship between climate change and resource conflicts.

[7] This section forms the background of a book chapter. Ngaruiya G. W., J. Scheffran & L. Lang. (2014) Social Networks in Water Governance and Climate Adaptation in Kenya. In Handbook of Sustainable Water Management by W. Leal F. and V. Sumer (Editors) in Cambridge University Press.

2.3. Climate change and resource conflicts

A resource conflict is defined as a situation whereby two or more parties (individuals or groups) have or perceive to have, a) incompatible livelihood goals and interests, or b) are in direct resource competition with each other and act upon these differences (UNEP, 2009, 2011). In the ecosystem management context, four interrelated effects of environmental degradation – reduced agricultural production, economic decline, population displacement, and disruption of social relations – may contribute to various forms of violence and conflict (Homer-Dixon, 1991; Scheffran, 2009). Similarly, the European Commission (2008) posits "climate change will fuel existing conflicts over depleting resources, especially where access to those resources is politicised".

Along this line of thought, many quantitative studies predict a significant increase in armed conflicts in sub-Saharan African by 2030 compared to the 1980 to 2000 period (Burke et al., 2009; Lobell et al., 2008). For example, the Stern Review (2006) stated, ''Climate-related shocks have sparked violent conflict in the past, and conflict is a serious risk in areas such as West Africa, the Nile Basin and Central Asia'' (Scheffran & Battaglini, 2011). Such strong allegations that draw a fine link between global climate change and conflict are primarily based on several violent land-use conflicts in the Sahel such as the border conflict between Senegal and Mauritania in 1989, the Darfur conflict, and recent clashes between ethnic groups in northern Nigeria (Benjaminsen et al., 2012; Ossenbrügge, 2009).

The climate and conflicts debate also draws from social capital which is defined as resources embedded in a social structure that are accessed and/or mobilized in purposive actions (Lin, 1999). Whereby, the mobilization can either facilitate cooperation among community members or generate resource conflicts with harmful outcomes for non-included groups in the society (Dudley, 2004). Two perspectives have been fronted to describe the precise relationship between the heterogeneity of an area and the area's vulnerability to internal societal conflict involving violence. Montalvo & Reynal-Querol (2005) hold the view that certain form of population heterogeneity (ethnic, linguistic, cultural or religious) increase vulnerability to conflict. But, WBGU (2008) infers that existence of multiple ethnic and religious fractions lowers the risk of conflict, but which can be instrumentalized for political reasons. The common point of these two perspectives is that social capital can sometimes be coercive, and generate homophily that perpetuates resource conflicts which are mistakenly branded as ethnic wars or political rivalries

(Newman & Dale, 2005). Hence, social structure becomes an important aspect to consider when analysing rural resource conflicts.

However, the discourse on climate and security is quite controversial (Solow, 2013) because of the constant misdiagnosis of African conflicts that ignores the political nature of land resources and related issues (Aapengnuo, 2010). In addition, four main points have been forwarded to disprove this controversial school of thought:

a) The literature and methodology are accused of having roots in neo-Malthusian notions of the 'carrying capacity' of a country where population growth or shrinking resources will eventually lead to conflict (Brown & Crawford, 2009). The example given to disprove this notion is that highly developed economies experience less conflict over resources even as demand increases.

b) The contradictory results concerning the possible relationship between climate trends and the risks of violent conflict are partly because of the choices of conflict measures and modelling design (O'Loughlin et al., 2012; Theisen et al., 2011). Whereby, some quantitative analysis of climate and subnational conflict data reveals a non-significant relationship between scarcity and conflict (Buhaug, 2010; Theisen et al., 2011).

c) When political ecology is used to question the climate change –conflict nexus, the research agenda is redirected towards the uniqueness of local-level power dynamics and emphasis is placed on place-specific experiences that are each rooted in particular historical trajectories that cannot be easily quantified (O'Loughlin et al., 2012). For example, Benjaminsen et al., (2012) found that land-use conflicts in the delta region are shaped by political and economic contexts rather than climate variability.

d) African history also negates this generalised climate- conflict debate because most ethnic groups coexist peacefully with high degrees of mixing through interethnic marriage, economic partnerships, and shared values in Africa (Aapengnuo, 2010). Thus the prevalent worst-case scenario that tends to assume the worst of people; that they will fight rather than cooperate over scarce resources, underestimates African populations' capacities to adapt to different conditions and to manage conflicts (Brown & Crawford, 2009).

Despite the controversy, clearly several factors account for conflict in Africa: remote sources, immediate causes, and factors that exacerbate conflict (Brown & Crawford, 2009). The *remote* sources include the colonial heritage of authoritarian governance and artificial boundaries; conditions of widespread extreme poverty, and scarcity of basic necessities of life. *Immediate* causes include competition for land, oil or other natural resources; support for internal conflicts by outside actors, government policy and resource misallocations. *Factors that exacerbate* conflict can include arms imports, pressures of refugees or internally displaced persons and food insecurity (OSSA, 2005). Thus, realistic analysis of the climate-conflict nexus must be done in the context of political, social, economic, and geographic considerations, variables that are often ignored as key controls (Theisen et al., 2011). This has been demonstrated by O'Loughlin et al., (2012) who found that temperature variations data for East Africa from 1991 to 2009 do not conform to findings that *imply* warming increases conflicts as stated by Burke et al., (2009).

Though a systematic and integrated analysis of the climate-security link is still missing (Scheffran, 2009), human societies fundamentally depend on certain environmental conditions. Thus, climate change *may*[8] increase resource conflicts in sub-Saharan Africa (Lobell et al., 2008) among resource-dependent rural communities with low adaptive capacity (AMCEN, 2011; Haldén, 2007; WRI et al., 2005). Hence, there is need to breakdown the complexities in rural resource conflicts and identify intricate site-specific aspects that either support or impede holistic ecosystem management under unpredictable climatic conditions. This is because understanding the complexity of interactions between climate stress factors, their human and societal impacts and responses is crucial to assess the implications for security and conflict on the possible causal linkages (Scheffran & Battaglini, 2011; Solow, 2013). Although current conflict studies pay attention to the vulnerability of natural and social systems to climate impacts (Scheffran & Battaglini, 2011), there are few documented studies on the social governance structures that resolve conflicts at the grassroots (Hyden et al., 2005). This aspect gives credence to this study which envisions the "domino" effect of climate change in triggering numerous conflicts over resources.

[8] Studies show that resource conflict triggers are extensive and range from political manipulations (hate speech to election fraud) to religious defence of important cultural or religious sites to social injustices (land grabbing).

Figure 2.1 illustrates possible paths to conflicts induced by climate change in a typical rural village scenario in Kenya. These paths are termed as conflict constellations which are divided into four, namely - water stress, food insecurity, drought as a natural disaster and migration issues (WBGU, 2008). Whereby, cumulative impacts from climate change on key rural livelihood activities – agriculture and wildlife tourism - subsequently decrease (or cause failed) harvests and also increase farm raids by wildlife from neighbouring protected lands. Subsequent loss of income in rain-dependent communities lowers the spending power and increases local poverty levels. Affected households are thus left with land as their only asset and which is viewed as an additional source of income especially for rural households experiencing poor harvests and livestock productivity in Kenya (Ntiati, 2002).

Subdivision of land disrupts the cultural norms and trusts of indigenous host communities through exposure to dissimilar immigrant norms and attitudes. On one hand, introduced norms could be beneficial like reduction of female genital mutilation. On the contrary, immigrants are perceived as threats who reduce "power" and influence of tribal chieftains, elites or local politicians. Such divisive thinking is grounded on the parochialism of communities in conceding the rights and interests of other communities (Western, 1994). On the extreme, if civic education is not foremost in the community then such a fragile "host vs. immigrant" situation creates fertile grounds for mobilizing citizens along ethnic[9] or cultural lines by politicians vying for elective posts by promising "equal" resource allocation[10]. This a common occurrence in Kenya during the election period, where "dark" social capital financed by the elites, awakens as militias, vigilantes and gang groups locally referred to as *Mungiki, Taliban, Sungusungu, Kamatusa* and many more regional gangs, to principally protect elite political ambitions.

Subsequently, people may retreat to their ethnic cocoons and agitate for social respite from the government. Such a "domino" effect clearly demonstrates the link between climate change impacts and resource conflict whereby a decrease in ecosystem services production leads to increased rural poverty that gradually draws ever-deeper lines of

[9] To make the discussion clearer, I use Gilley's (2004) definition of ethnicity to mean that part of a person's identity which is drawn from one or more "markers" like race, religion, shared history, region, social symbols or language. It is distinct from that part of a person's identity that comes from personal moral doctrine, economic status, civic affiliations or personal history (Gilley, 2004).

[10] Investigations into ethnic related resource conflicts reveal elites at the core who invoke ethnic ideology among tribesmen in the hope of establishing a "reliable" base of support to fight for what is purely personal and/ or political interests' (Oyugi, 2002).

division in social relations and trigger resource conflicts (WBGU, 2008). In the absence of structured transparent resolution programs, then these conflicts become cyclic and dependent on dominant political actors within the community.

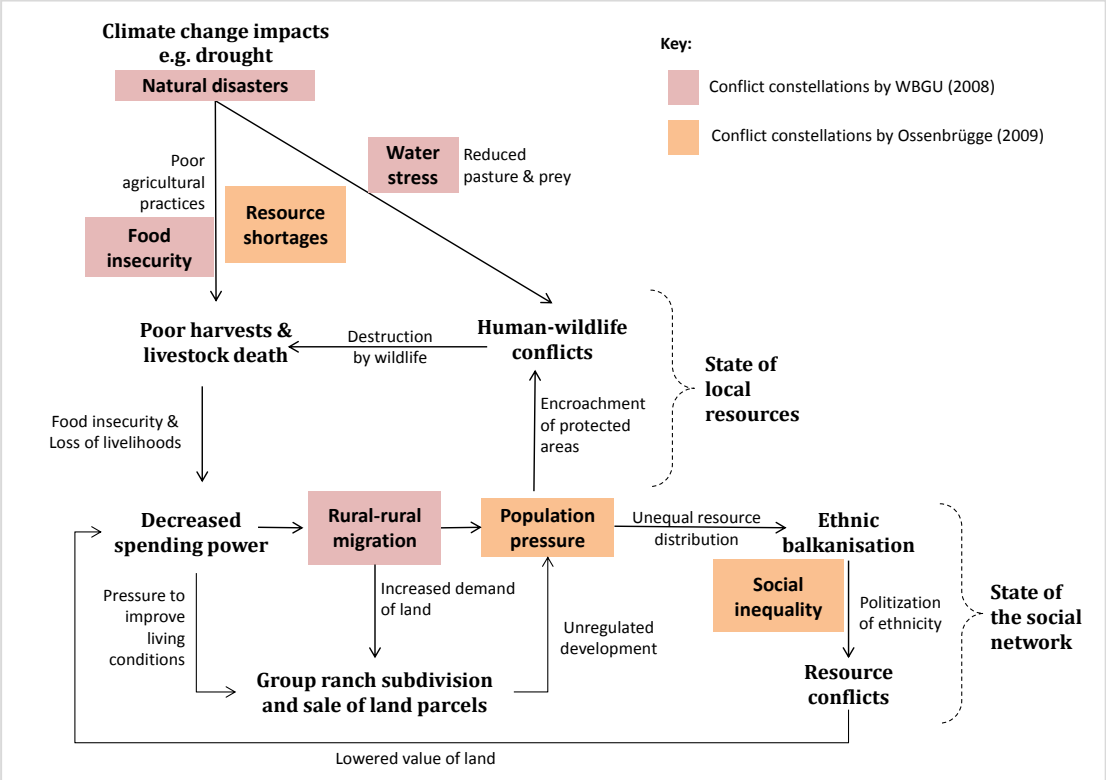


Figure 2.1: Conflict constellations in relation to climate change and rural land tenure. Source: The author**.**

The above illustration also supports results by University of Milan that confirmed existence of three complex conflict constellations in Kenya, namely: a) resource shortages due to increasing demand by high population growth ; b) resource supply shortage due to changes in geo- and bio-ecological systems; c) social inequality in terms of income inequality and property rights (Ossenbrügge, 2009).

Fortunately, there are universally agreed measures to successfully tackle climate change, prevent further decline of ecosystem services and build positive social capital.
These are:

a) Mitigation measures seek to reduce carbon levels in the atmosphere (IPCC, 2007).

b) Adaptation measures involve making adjustments in social and environmental processes in response to or in anticipation of climate change, to reduce potential damages or to realize new opportunities (Adger et al., 2007; Brooks & Adger, 2005).

Since this study is based on rural adaptation, only adaptation measures are chosen for further discussion.

2.4. Adaptation to climate change

Numerous definitions of adaptation are found in climate change literature but which are mostly variations on a common theme (IPCC, 2001; Smit & Wandel, 2006). The fundamental adaptation strategies are;

1. *Reactive adaptation* refers to specific changes by an individual that are informed by direct negative climatic experience and which cause resources to be targeted to known risks to alleviate negative impacts once they have occurred. For example, farmers are already adapting to actual changes in precipitation by changing the types of crops planted and the sowing time (UNEP, 2007).
2. *Autonomous adaptation* is a constant implementation of existing knowledge and technology in response to experienced climate changes by households and communities acting on their own without public interventions.
3. *Planned adaptation* is a deliberate public policy decision to increase the adaptive capacity of a country, community or ecosystem towards adjusting to climate variability and extremes; to moderate potential damages; to take advantage of opportunities; or to cope with the consequences (IPCC, 2001; World Bank, 2010). For example, agricultural extension officers are promoting area-specific hybrid maize seeds that are drought and pest resistant to Kenyan farmers.

Differences between above selected adaptation schemes are minimal, whereby reactive adaptation differs from autonomous adaptation because it is a conscious specific deliberated or aided response and it also differs from planned adaptation as the decision may not be based on a government policy directive. Moreover, based on their timing, adaptations can be anticipatory or reactive, and depending on their degree of spontaneity they can be autonomous or planned (Smit & Wandel, 2006).

This study combines the terms "adaptation and coping" measures because they are closely related (Mortimore et al., 2009). For clarity, coping, is considered a temporary reactive response, to actually experienced climate variability or stress, such as rainfall variability or drought, whose aim it is to restore a previous state and is rather of short duration. While adaptation is associated with longer time scales and points at adjustments as fundamental changes of the systems practices, processes or structures to changes in mean conditions (Smit & Wandel, 2006). Coping mechanisms are an important factor in adaptation (Remling, 2011). If for example, reoccurring stress forces people to constantly apply coping mechanisms, these might develop into durable adaptation strategies (Eriksen & Kelly, 2007).

There are huge uncertainties concerning scenarios of future climate change in Africa which make it difficult to predict local-level outcomes (AMCEN, 2011). Furthermore, there is a risk in implementing adaptation measures relying solely on present climate projections. This is because ill-suited adaptation could lead to maladaptation[11] if climate change impacts turn out to be different from the forecasted ones (Remling, 2011). Secondly, a "one-size-fits-all" adaptation option that lacks contextual information from grassroots will not be an effective long-term solution.

But it is a fact that importance of adaptation in Africa cannot be belittled because there is often significant overlap between good adaptation and good development (Dixit et al., 2012). For instance, a reduction of drought risks to farmers and pastoralists in Kenya could support increased food security for the entire country as well as boost food exports. In other words, adaptation underpins success in development as the climate changes, as well as development success can also facilitate adaptation (Spearman et al., 2011).

According to UNECE (2009) a successful adaptation strategy should be based on five pillars that address all stages of climate change impacts and associated natural disasters progression at the community level. These pillars are discussed below.

1. Prevention measures are long-term actions taken to avert negative effects of climate variability on ecosystem services. For example, implementation of water-efficient

[11] Maladaptation denotes inappropriate responses to climate change, which instead of reducing vulnerability may inadvertently lead to increased vulnerability in the long term (IPCC, 2001; Remling, 2011).

technology, wetland restoration/protection, afforestation which also help to prevent landslides and land degradation.

2. Measures to improve resilience aim to reduce negative effects of climate change on ecosystem services and natural environment by enhancing the capacity of natural, economic and social systems to adapt to the impacts of future climate change. Such as crops that are less water demanding or are salt-resistant, reintroduction of indigenous breeds, water harvesting.
3. Preparation measures decrease negative effects of extreme events on ecosystem services. These include; accurate weather forecasts, early warning systems, emergency planning, raising awareness, water storage, water demand management and technological developments.
4. Response measures alleviate direct effects of extreme events. These include; evacuation, establishing safe drinking water and sanitation facilities inside or outside affected areas during extreme events. In Kenya, these actions are mainly done by non-governmental organizations like Red Cross in coordination with government agencies during droughts or floods.
5. Recovery measures seek to restore (but not necessarily back to the original state) economic, societal and natural systems after an extreme event. These include reconstruction of infrastructure especially water pipes following floods or landslides and introduction of insurance packages to act as a risk transfer mechanism.

If the five adaptation measures are incorporated into a single resource governance[12] plan then adapting to climate variability will make economic sense because development priorities such as infrastructure quality and settlement plans will be included.

But how does a person living in a rural village access such structured adaptation knowledge to sustain their livelihoods or learn about alternative income generating activities? Critics are already sounding warnings about high risk of increased conflict trends in Africa (Schilling et al., 2012). Obviously, conflict resolution can help to reduce the conflict tension and stabilize the interaction by involving actors to learn and adjust their actions

[12] Resource governance is defined as the interaction of various laws (statutory, customary, formal and informal), institutions and processes to make and implement decisions affecting natural resources and natural resource users and to hold decision-makers, implementers and natural resource users accountable (Moore, Greiber, & Baig, 2010).

until an agreement is reached (Scheffran, 2009). However, regular eruption of climate-related resource conflicts is likely to overwhelm rural conflict resolution mechanisms and reinforce the trend towards general instability and insecurity that already exists in many societies and regions (WBGU, 2008). This increases the urgency for effective and efficient transfer of adaption knowledge from research entities, academicians, cultural leaders to resource uses to reduce risk of escalated resource conflicts.

However, adaptation knowledge transfer is not such an easy process. In my view, three factors explicate why Kenyan rural communities are not accessing this vital information.

1. Handmer et al., (1999) posit that poorer regions and countries will have difficulty in adapting to climate change, since they lack comprehensive technical and financial ability, despite the adaptation financing opportunities from developed countries as agreed in Conference of the Parties to the United National Framework Convention on Climate Change (AMCEN, 2011). The main reason for this inability is that African governments are faced with other major developmental issues such as conflict, diseases and poverty that require direct engagement by the state. Besides, when projects to build adaptive capacity are implemented, results are undermined by weak coordination as a result of conflicting, overlapping mandates and dysfunctional arrangements in inter-agency integration at the grassroots (Madzwamuse, 2010).
2. Adaptation is not just a technical process but also a political process, because power relations need to be adjusted for individuals and groups to achieve discrete interests to maintain their own livelihoods (Eriksen & Lind, 2009). However, preference for "foreign" non-governmental organisations (NGOs) with disparate interests in formulating the African adaptation agenda has resulted in poor representation and subsequent poor understanding of the grassroots in the climate discourse, yet they are the most affected group (Adger et al., 2007; Hellmuth et al., 2007; Madzwamuse, 2010). But the quest for effective adaptation demands that selection of adaptation options must be based on the knowledge of local conditions framing the impact.
3. Marginalisation of African customary law in climate change policy-making at both national and international levels is also a key factor in the low adaptive capacity (AMCEN, 2011). This emanates from dominance of international non-governmental organisations (NGO) in climate agendas of many developing nations (Madzwamuse, 2010). Secondly, despite the high significance of indigenous knowledge in the

Kenyan society, the education systems also neglect indigenous knowledge in their curricula due to the strong negative undertone given to cultural practises by former colonial governments (Sindiga et al., 1990). It is now emerging that examining local perceptions provides important complementary knowledge to climate science and can enable the formulation of effective adaptation strategies (Remling, 2011).

Moreover, there has been no satisfactory explanation as to why despite the large amounts of global funds invested in adaptation measures; there is little evidence that the "climate vulnerable" poor are aware of managing climate risks that affect their development (Brooks et al., 2011; Madzwamuse, 2010; Smit & Wandel, 2006). Climate vulnerability[13] is highly related to adaptation deficit that refers to "countries or communities that are underprepared for climate change because of a complete lack, insufficient frequency or poor content of communication about climate uncertainty, and therefore do not rationally allocate or utilise resources sustainably to adapt to climate change events" (Moser, 2009; World Bank, 2010). Vulnerability can be broken down into three factors[14]: (i) exposure to climate change, (ii) sensitivity to climate change, and (iii) adaptive capacity[15] (IPCC, 2007). On the extreme, such communities may practise maladaptation that inadvertently increases vulnerability to climatic stimuli (Agrawal et al., 2008; IPCC, 2001).

Another concept which is often interlinked with vulnerability is "resilience". Resilience is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to still remain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004). Vulnerability and resilience are large research fields by their own right thus; I restrict my focus to adaptation and adaptive capacity issues.

Adaptive capacity is context-specific and varies from country to country, from community to community, among social groups and individuals, and over time. It varies not only in terms of its **value** but also according to its **nature**. The scales of adaptive capacity are not independent or separate: the capacity of a household to cope with climate risks depends to some degree on the enabling environment of the community, and the adaptive capacity of the community is reflective of the resources and processes of the region (Smit &

[13] Vulnerability is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change" (IPCC, 2007).
[14] The first two factors have been addressed briefly in the previous sections.
[15] Adaptive capacity is the ability to design and implement effective adaptation strategies or to react to negative climatic stresses (Brooks & Adger, 2005).

Wandel, 2006). For example, impoverished climate-vulnerable communities will be forced to continue exploiting diminishing natural resources increasing local poverty levels and negating economic growth (Emerton & Mogaka, 1996). Thus, understanding the context in which an adaptation intervention takes place requires practitioners to explore a site-specific relationship between the development status of the intervention's beneficiaries and their vulnerability to climate change (Spearman et al., 2011).

Though natural resources usually seem like the obvious cause, conflict may also be triggered by the absence of good institutions[16] and external interference (Adano et al., 2012). The former plays a major role on the continued eruption of conflicts at the grassroots since institutions shape the human–environment interaction and become critical in preventing competition over resources from turning into a violent conflict (Adano et al., 2012; Young, 2011). Non-climate factors (such as poverty, governance, conflict management, regional diplomacy and so on) also largely determine whether and how climate change moves from being a development challenge to presenting a security threat (Brown & Crawford, 2009). As stated by Scheffran (2009) "whether societies are able to cope with the impacts and restrain the risks of climate change depends on their responses and abilities to solve associated problems". There is therefore an urgent need to evaluate the transfer process of adaptation knowledge from research institutions to resource users at the grassroots.

Lin (1999) aptly stated that "Convergence of social resources and social capital studies complements and strengthens development of a social theory that focuses on the instrumental utility of accessed and mobilized resources embedded in social networks". From the given background, it is clear that proper analysis of climate adaptation and conflict resolution demands a clear contextual inquiry into rural actor linkages. Hence, the reason why I choose social relational theory to facilitate clear understanding of how adaptation knowledge dissemination is implemented at the grassroots.

[16] Institutions are defined as "an enduring collection of formal laws and informal rules, norms, customs, codes of conduct, and organized practices that shape and govern human interaction" (IDRC, 2009).

2.5. Social relational theory

Ecologists note that little attention within the climate change literature has been devoted to addressing social and cultural limits to adaptation (AMCEN, 2011; IPCC, 2007). This *knowledge gap* gives relevance to my integration of social relational theory concepts into climate, resource and conflict governance. For a long time, people had a deterministic view of social relations and assumed that they were mysteriously pre-given and are the source, rather than the outcome, of behavioural conformity of shared viewpoints (Saunders, 2007). However, scientific inquiries into achieving sustainable resource utilisation have established the link between social and natural sciences in a growing field of study known as relational sociology. Relational sociology (social relational) is founded on the theory that human action unfolds through, and, as part of, relations among actors and not by independent self-contained interacting individuals (Ramirez-Sanchez, 2007). This theory explains why sometimes ecosystem management is characterised by ineffective institutional arrangements midst multiple actors competing for resource use because it argues that though human action is organized through categorical affiliations, it is motivated by the structure of social relations in which actors are embedded (Bodin & Prell, 2011; Ramirez-Sanchez, 2007).

Evidently, potential for adaptation and alleviation of adaptation deficit lies on social structures, institutional capacity, knowledge and education, access to infrastructure and financial resources (World Bank, 2010). Additionally, Agrawal & Gibson (1999) argue that communities and their interactions with their natural resources could be better understood if greater attention was given to "the multiple actors with multiple interests that make up communities, the processes through which these actors interrelate, and, especially, the institutional arrangements that structure their interactions". These two schools of thought boost suitability of the social relational approach because it specialises in investigating how patterns of social relations among actors within a system enable and constrain actors and processes in the phenomenon of social embedding (Bodin & Prell, 2011).

As earlier mentioned - local options for adaptation strongly depend on and are constrained by the specific socio-economic, cultural and geographical context and are contingent on the assets available to people in order to make adaptive choices (Remling, 2011). Thus an underlying assumption in the social relational approach is that social structures influence the actions of individuals just as the actions can influence social

structures. For clarity, social structure is understood as patterns of relations (i.e. networks) between social units or actors (i.e., individuals, organizations or countries) (Prell, 2012). Such an approach then may help to describe and explain the local constraints and opportunities that social structures impose on individual action (Marsden, 1990).

It is worth noting that the actor-network theory may also be a potential avenue to look into actor linkages. However it is an advanced theory as it is concerned with investigating the social and the technical taken together or, putting it another way, with the creation and maintenance of coextensive networks of human and nonhuman elements which, in the case of information technology, include people, organizations, software, computer and communications hardware, and infrastructure standards (Walsham, 1997). Thus the social relational approach was chosen for this study because a) it allows a systematic assessment of the extent to which different ideologies impact upon relations in a more convincing manner (Saunders, 2007) and b) it allows for quantitative social network analysis only based on actor linkages unlike other relational approaches under the social sciences domain (Bodin & Prell, 2011).

2.6. Social Network Analysis

One of the best-developed sociological methods for studying social relations is organised under the social network analysis (SNA) umbrella (Wasserman & Faust, 1994). Social network analysis focuses on "relationships between actors and on the patterns and implication of these relations" in the transfer or flow of resources (Bodin & Prell, 2011). The fundamentals are given by four principles, namely: independence of actors; presence of relations or ties in the transfer of resources; the constraining and/or enabling of individual actors by networks; and the generation of long-lasting ties and networks by social structures (Williams & Durrance, 2008).

But in a real-life network:

a) Every node is not tied to every other node. This is because maintenance of resources (expressive action) tends to take place between homophilous ties (two people who are alike in some way) (Williams & Durrance, 2008). Whereas acquisition of better resources (instrumental action) tends to take place between heterophilous ties and is intended for change of individual status.

b) Adaptations are not isolated from other decisions, but occur in the context of demographic, cultural and economic change as well as transformations in information technologies, global governance, social conventions and the globalising flows of capital and labour (Adger et al., 2005). It can therefore be difficult to separate climate change adaptation decisions or actions from actions triggered by other social or economic events.

Consequently, a social network perspective gives new leverage for answering standard social and behavioural science research questions by giving definition to aspects of political, economic or social structural environment (Wasserman & Faust, 1994). This is because networks have a cognitive dimension that involves information transmission and learning processes which can be studied to identify knowledge transfer obstacles. Also, governance networks are related to public purposes such as the collective management of natural resources and which distinguishes them from other kinds of networks. This fact makes it easy to delineate actors according to their respective resources for streamlining governance.

The fundamental difference of a network perspective from standard social science research is that, rather than focus on attributes of autonomous individual units; it views characteristics of the social units as arising out of structural or relational processes (Wasserman & Faust, 1994). Secondly, using social network analysis offers valuable tools for mapping and analysing social structures to provide information about the underlying structure for more stable interactions (Carlsson & Sandström, 2008). Governance networks are created, encouraged, or maintained by certain central steering actors like the government or community (Newig et al., 2010). Therefore, it **becomes easier to evaluate mandates of each central actor versus the governance outcomes**. This is done through illustration of the network as a graph that consists of nodes (actors) joined by lines (relations) (Prell et al., 2010). The actor-linkage sociogram[17] eases identification of trends, outliers, transitions, systematic errors, implausible configurations and other types of patterns (Hennig et al., 2012).

[17] Sociograms or sociographs or digraphs are instances of standard representations for graphs in which actors are represented by point-like graphical objects and their relations by line-like graphical objects (Hennig et al., 2012).

Social network analysis is guided by formal theory organised in mathematical terms and grounded in the systematic analysis of empirical data (Bodin & Prell, 2011). This relational data consists of at least one structural variable measured for a set of actors (Hennig et al., 2012; Wasserman & Faust, 1994). Several structural variables are used in social network analysis, but key interest to this study is how social networks facilitate identification of central stakeholders responsible for adaptation knowledge dissemination and how these actors link various parts of network together. Therefore, three following concepts of social network were selected to quantify patterns of interactions and indicate level of synergy among rural community actors.

2.6.1. Network cohesion

Network cohesion is also called network closure (Bodin & Prell, 2011) or centralized integration (Burt, 2000). It is basically understood as the extent to which actors are interconnected via some kind of social tie (Bodin & Prell, 2011). Cohesion is calculated using the number of links and the distance between actors in a given network (Wasserman & Faust, 1994). Cohesion is an important concept in social sciences and stems from early thinkers such as Tönnies (1887) whose discussion of "Gemeinschaft" emphasized the relational belonging of community members. In reality, high network closure is evidenced by networks that are well-integrated indicating rapid flow of diverse information, while low network closure removes all possibility for new ideas and innovations in a community network (Carlsson & Sandström, 2008; Krebs & Holley, 2004).

Two measures are used conjointly to get the notion of cohesion, and these are density and centralisation.

2.6.1.1. Density

The density of a network is the proportion of possible ties (links) that are actually present in the network. It is also used to indicate the level of homophily in the network (Wasserman & Faust, 1994). Homophily is a situation where similar actors are attracted to one another, choose to interact and have higher mutual understanding between them. But explaining density straight from network analysis is not simple because typically large networks tend to have lower density levels simply because the potential number of ties is so

large making it impractical for actors to maintain a large number of ties (Bodin & Prell, 2011). In addition, a high proportion of ties does not automatically imply a cohesive network because the ties could be flowing via a single actor (Prell, 2012). These two obstacles are solved by calculating the degree centrality values of the network.

2.6.1.2. Centralization

Degree centralization measures the extent to which one actor in a network holds all of the ties in that network (Bodin & Prell, 2011). It is a direct measure of an actor's level of involvement or activity in the network (Prell, 2012). Centrality values reveal the most prominent actor who is assumed to be a major channel for information as they are seen to be connected to many others and subsequently have potential to spread new information quickly across the network e.g. chief, village elder (Prell et al., 2010).

Practically, a network with high density and high centralisation would be less cohesive than one with the same density but a lower centralisation score (Bodin & Prell, 2011).

2.6.2. Structural holes (heterogeneity)

Structural holes are "empty spaces in social structure" (Burt 2011) that exist between two actors when either party is unaware of value available if they were to coordinate on some point. They occur whenever an actor (a) has a relationship with someone who is connected to a separate cluster of actors and (b) has no other direct or indirect connections with the people in that cluster (Ehrlich & Carboni, 2005). There are various ways of measuring structural holes including, bridge counts, constraint values, hierarchy, and ego betweenness. Since the study's objective is based on analysing information flow and actors with highest influence in the community, then ego betweenness is chosen as it examines the extent to which an actor is between other actors in the network (Everett & Borgatti, 2005). This because interactions between two nonadjacent actors might depend on other actors in the set of actors, especially the actors who lie on the path between the two (Wasserman & Faust, 1994). Networks with high structural holes may be deemed to be poor for information diffusion between actors and between different sets of actors (Carlsson & Sandström, 2008). Conversely, few structural holes infer a well-connected network with

high information flow that could be beneficial for increasing adaptive capacity and community resilience.

2.6.3. Brokerage

If an actor rests between many others (seals many structural holes), then they have the ability to "broker" information to other actors and thereby influence the level of collective knowledge in the community. Brokers are also referred to as network weavers (Krebs & Holley, 2004), scale-crossing brokers (Ernstson et al., 2010) or network entrepreneurs (Burt, 2000). These actors not only influence the quantity of knowledge but also enhance the quality of knowledge circulating because they are able to connect diverse stakeholders to solve a common resource problem (Ehrlich & Carboni, 2005). Simply put, structural holes give competitive advantage to actors whose relationships span the holes since they have the ability to create connections between disconnected actors in a network. Networks that are comprised of many brokers are considered rich in social capital[18], rich in opportunities and therefore, better performing (Carlsson & Sandström, 2008). Thus, deliberate brokerage in a community can implement adaptive strategies that minimize security risks and mitigate conflicts by strengthening institutions, economic wealth, energy systems and other critical infrastructures. But if done unrestrainedly, brokerage can foster institutional incoherence and cause organisation chaos or manifest in errors such as resources allocated to conflicting goals and units in the same organisation but are competing against one another (Burt, 2011).

Application of brokerage results has been hypothesised by Krebs & Holley (2004) under the term - network weaving- which refers to the deliberate creation of linkages between actors in a social network. The main objective of network weaving (netweaving) is to influence a small number of well-connected nodes for better outcomes rather than the traditional strategy of accessing the top person or calling on random players in the policy network i.e. "*If you know the network, you can focus your influence*".

In conclusion, the general hypothesis is that although network heterogeneity facilitates access to different types of ecological knowledge, network closure promotes the ability to set, maintain, and monitor common management rules (Sandström & Rova, 2010). Overall,

[18] Social capital is described as a collection of resources and interactions that coordinates people towards achieving mutual benefits in a specific area (Bourdieu, 1986; Putnam, 1993).

application of SNA obliges resource managers to understand how actors are connected to each other; influence each other's behaviour, and how their interactions influence the overall network structure (Hennig et al., 2012). Subsequently, this field has grown into a sub-discipline in resource governance known as network governance that attempts to integrate different actors and their respective expertise in solving sustainability problems (Newig et al., 2010). However, there still remains a methodological gap in terms of governance structures based on social network theory to assess multi-level interaction across various organizations (public, private, civic) and actors (informal and formal) and provide ways of strengthening resource governance.

2.7. Identified knowledge gaps

Following this complex review of climate change and resource conflicts literature within the resource governance agenda, it is clear that examination of social structures can offer many new insights (Crona & Hubacek, 2010) relevant for ecosystem services management. Thus, I endeavour to *first formulate* a practical methodological framework based on social network theory as my contribution to the climate change and resource conflicts discourse. Secondly, I will use this framework to analyse an actual rural social network and comprehensively address three main knowledge gaps identified in this thesis.

1. *We cannot continue to assume that adaptation is not happening in Kenya.*

   Many studies referenced in this chapter (Adano et al., 2012; Burke et al., 2009; Handmer et al., 1999; Lobell et al., 2008) presume that rural communities lack ability to adapt and have the highest potential of resorting to violence. This is without doubt a major debate in the resource governance discourse passé, but Müller (2013) indicates that published works on African adaptation activity (though present) is very limited, especially from rural regions. He further emphasises that minimal circulation of local adaptation efforts is the fuel for the unrealistic increased resource-conflicts discourse founded on the ideology "production systems are too rigid and will not change against prevailing climate stress" in Africa.

   Moreover, indigenous communities had their own small- scale methods to conserve their ecosystem services but these methods have been side-lined by

international non-governmental organisations (NGO) who tend to promote disparate interests that negatively affect performance of local adaptation programs in developing nations (Madzwamuse, 2010). Since adaptive capacity is measured by the extent to which adaptation knowledge translates into viable activities, then network analysis insights can analyse social structures for adaptation activities to document actions that may be more beneficial to the country than *imported* adaptation knowledge.

2. *Determine specific roles of actors on rural adaptation performance and resource conflict resolution*

   Poor coordination among grassroots actors is blamed for the low adaptation information reaching the grassroots levels. Few case studies exist on actor linkages and social governance structures versus adaptation performance and resource conflict resolution in the sub-Saharan region (AMCEN, 2011; Hyden et al., 2005; IPCC, 2007). This is an important governance aspect to consider because high influx of adaptation funds have increased actors seeking to be enjoined to rural resource governance networks (Madzwamuse, 2010) and conflict resolution mechanisms have evolved following colonial influence. Hence, there is need for rural resource governance structures to identify these additional actors and their activities for effective knowledge transfer to build resilience and cohesion in the community. However, identifying diverse stakeholders from an entire heterogeneous multi-sector community is not such a straightforward process (Prell et al., 2010). But it now seems that incorporating social network analysis may solve this challenge in rural governance and promote effective communication for resolving conflicts and develop shared views through deliberative[19] processes (Newig et al., 2010).

3. *Legal pluralism and sectorial divisions*

[19] Deliberation refers to a genuine exchange of ideas and arguments, regardless of societal power asymmetries which produce more creative "emergent" ideas and solutions, as compared to a situation in which actors are reasoning by themselves (Newig et al., 2010).

Kenya adopted a new constitution in 2010 which introduced devolution of governance down to the county level. As a result natural resource management fully moved from central government to County governments hosting their own sub-ministries committees. Thus, there is need to investigate how coordination problems like legal pluralism and sectorial divisions can be resolved at the grassroots now that the County assembly has the power to formulate its own policies and regulations concerning resource management.

In particular, this study focuses on challenges associated with particular economic ecosystem services. For example, wildlife tourism sectors in developing countries (like Kenya) are generally termed as risky due to their questionable development strategies that are weak in sustainability agendas (Lepp & Gibson, 2003). Secondly, there is no national management policy for medicinal plants, despite the high reliance on medicinal plants by rural communities in Kenya. Thus there is need to evaluate and recommend feasible actions to stabilise ecosystem services supply and economic growth under prevailing climate change.

These three knowledge gaps give relevance to this study and highlight its expected contribution in revealing unutilised brokerage positions for improving learning and coordination of activities for maintenance of ecosystem services in the social-ecological landscape (Crona & Hubacek, 2010). The anticipated results from this research are: practical resource governance framework, successful rural adaptation stories; clarification of actor responsibilities in rural resource governance and proposals of new policies that enhance adaptation, into the climate-conflicts discourse in Kenya and other similar African countries.

Implications of this thesis:

Climate change confronts humanity with multiple security risks and major challenges to its problem-solving capacities (Scheffran, 2009). This chapter sequentially describes challenges facing rural resource governance from impacts of climate change on ecosystem services to societal dynamics that are exhibited as conflicts over scarce resources. Fortunately, adaptation to climate change is considered a pressing global development issue based on the establishment of the “Adaptation Fund” to finance concrete adaptation

projects and programmes in developing countries which are Parties to the Kyoto Protocol (Government of Kenya, 2010; UNFCCC, 2007). But the challenge is how to increase transfer of adaptation knowledge to lower vulnerability and enhance resilience at the grassroots.

My suggestion is to integrate a new sub-discipline – social network analysis – into resource governance to evaluate and resolve challenges in rural climate governance for holistic natural resource management. Whereby, indices of network closure and heterogeneity are used to evaluate information quality and actors responsible for information dissemination within a rural community. Subsequent network weaving through brokers may enhance adaptation knowledge transmission across a rural community network. This chapter contributes information to the climate adaptation, livelihoods and social networks discourse.

CHAPTER 3: GEOGRAPHICAL CONTEXT OF STUDY

3.1. Introduction to chapter

Kenya is part of the Horn of Africa region; it borders Tanzania in the South, Uganda in the West, Sudan and Ethiopia in the North, and finally, Somalia in the East. Kenya's physical geography has several notable features. The environmental diversity is high, ranging from the Indian Ocean in the East to Lake Victoria in the West, from arid dry lands in Turkana's North to the great plains of the Mara in the South. The topography is lowest in the coastal plains and slowly rises towards the Kenyan highlands in the West. Kenya's highest point, Mount Kenya, lies in the eastern section of the Rift Valley (Remling, 2011).

Kenya is often described as holding a key role in Eastern Africa in reference to democracy and human rights and takes the lead in numerous regional processes (Remling, 2011). In particular, it is a regional driving force in terms of economic development despite the fact that around 80% of the country comprises of arid or semi-arid lands, where pastoral farming is the dominant livelihood (Mortimore et al., 2009). As expected, climate change impacts dampen national economic growth expectations because Kenya's national development agenda is centred on natural resources exploitation (Downing et al., 2009; Mutimba et al., 2010). Thus the challenge currently facing Kenya is how to achieve sustainability– environmental, economic, and social development – in such unpredictable climatic conditions.

Therefore, this chapter continues the discussion by providing contextual in-depth information about Kenya concerning - climate governance, resource conflict resolution and rural social structure. It also gives information on the study site of Loitoktok and presents the reasons why it was selected as a prime representative of rural community in Kenya.

3.2. Climate governance in Kenya

Climate governance refers to all the purposeful mechanisms and measures aimed at steering social systems toward preventing, mitigating, or adapting to the risks posed by climate change (Jagers & Stripple, 2003). It is concerned about the extent to which countries have influence in deciding how climate-related decisions are made and implemented from the national level down to the grassroots especially in vulnerable sub-Saharan countries (Madzwamuse, 2010; Mutimba et al., 2010).

In Kenya, two government Ministries spearhead climate change activities, namely the Ministry of Environment and Mineral Resources (MEMR) and the Ministry of Forestry and Wildlife (MoFW)[20] from 2007. Subsequently, the Climate Change Secretariat (CCS) was established under the MEMR to initiate and coordinate climate change related activities. The CCS consists of 25 members from key ministries as well as from universities, the private sector and local authorities (Schilling & Remling, 2011). Another parallel institution known as the Climate Change Coordination Unit (CCCU) was established in 2008 under the Office of the Prime Minister [21] of Kenya with support from the Danish embassy in Nairobi. On one hand the CCCU increased pressure on the Ministry of Environment and Mineral Resources (MEMR) to make climate change a priority. But on the other hand the overlapping purposes of the CCCU and the Climate Change Secretariat led to disagreements concerning issues of competence, leadership and the distribution of financial resources (Schilling & Remling, 2011).

In 2010 the Government of Kenya launched its first climate change strategy labelled as the National Climate Change Response Strategy (NCCRS) with a set vision of "a prosperous and climate change resilient Kenya" (Government of Kenya, 2010; Mutimba et al., 2010). The strategy recognises the threat climate change poses to sustainable development and advocates the need to integrate climate information into national government policy (Government of Kenya, 2010). It covers six objectives in a broad spectrum of climate change issues, namely:

1. Evidence and impacts of climate change
2. Response, adaptation and mitigation interventions
3. Communication, education and awareness
4. Vulnerability assessments
5. Research, technology development and transfer
6. Policy, legislation and the institutional framework

Already, the terms of reference for a 5-year action plan (2013-2017) contained in the National Climate Change Action Plan (NCCAP) that stipulates how the NCCRS will be implemented was launched in 2013. But doubt is increasing on implementation efficiency

[20] These two ministries were merged in 2013.
[21] This office ceased to exist after dissolution of the coalition government in April 2013.

despite the proliferation of actors promoting different agendas at the grassroots and also across administrative boundaries.

a) Majority of resource ministries are not yet familiar with the NCCRS, (leave alone the NCCAP) in terms of their role in its delivery (Norrington-Davies & Thornton, 2011).
b) Climate change "desks" have been established in each ministry but these are yet to impact much on climate awareness at the community level (Madzwamuse, 2010; Mutimba et al., 2010).
c) The viability of NCCRS is also being questioned on its comprehensiveness and technical accuracy as a national investment framework (Madzwamuse, 2010; Mutimba et al., 2010).
d) A lack of cooperation and harmonisation exists not only among governmental bodies, but also between the government, the private sector and the civil society hindering utilisation of all competences and perspectives available in the sector (Remling, 2011).

Remling (2011) also found that Kenyan farmers and agriculturalists, whose livelihoods were identified as being particularly susceptible to climate change, have responded *autonomously* to the new situation, with policies and government support remaining negligible. Consequently, the low visibility of the state in local adaptation strategies becomes a valid concern (as previously mentioned) due to the ability of climate change impacts to instigate resource conflicts among people solely dependent on ecosystem services. This situation justifies the subsequent discussion which analyses Kenyan resource-conflicts resolution mechanism because it has undergone drastic changes over the last century. This is important because the role of conflict resolution within the adaptation agenda cannot be ignored. This analysis will also clarify why institutional incoherence exists between "developed countries" climate governance and grassroots resource governance systems.

3.3. Evolution of resource conflict resolution mechanisms in Kenya[22]

Management of conflicts before colonization was guided by indigenous governance institutions that established consensual decision-making arrangements at the African grassroots (ECA, 2007). This administrative role was later transferred to chieftaincies created by colonial governments that imposed hierarchical rule on its subjects (Osaghae, 1989). After independence, the chieftaincy position was maintained despite fundamental restructuring of socioeconomic systems by African political entities (ECA, 2007). This maintenance became a controversial issue by some who were concerned with rapid growth and transformation of African economies. The late Tom Mboya quoted in Osaghae (1989) stated "Chieftaincy impedes the pace of development as it reduces the relevance of the State in the area of social services". Proponents of the chieftaincy stratagem highlighted differences between the two systems that were clearly seen especially during conflict resolution. For example, colonial (modern) legal system operates on the basis of an adversarial approach while the traditional decision-making systems function on the basis of consensual decision-making and reconciliation arrangements (ECA, 2007; IDRC, 2009; IIDEA, 2011). Thus to remedy the situation and increase positive perception of the government by the masses, post-colonial governments opted to incorporate indigenous knowledge into local administration regulations. This action elevated grassroots chiefs making them custodians of customary law and communal assets, with a responsibility to dispense justice, resolve conflicts and enforce contracts (ECA, 2005).

Where access to renewable natural resources essential to rural livelihoods is highly contested; improving cooperation in resource management is an important element for increasing climate resilience[23] and conflict prevention (Ratner et al., 2013). Researchers now advocate that the most effective way to solve rural climate-driven resource conflicts is to incorporate indigenous knowledge with the formal conflict resolution system. This is because indigenous institutions guide how people negotiate access to resources and help reduce (though not avoid altogether) negative effects of conflict or drought (Eriksen & Lind,

[22] This section has been developed into a journal article. Ngaruiya G. W. & J. Scheffran. Intricacies of resource conflict resolution under advancing climate change in rural Kenya. To be submitted to *Conflict resolution*. I have contributed about 85% of the content.

[23] Resilience is defined as the as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2001).

2009). Such integration is important because local people know each other better, have more rapport and sense of belonging that creates opportunities for cooperation and collective action[24] in managing natural resources on a self-ruling and self-sufficient basis.

The aforementioned integration between formal and traditional institutions creates flexible systems known as "Adaptive comanagement" that are tailored to specific locations and situations, and are supported by (and work) with various organizations at different levels (Folke et al., 2005). These systems involve a diversity of actors from security arrangements, conflict resolution and asset management sectors who collaboratively strengthen local adaptive capacity and reduce predicted conflict cases grassroots (Donnelly-Roark et al., 2001; Mowo et al., 2013).

Migration is one of the age-old factors causing transformation of a rural community from single ethnic aggregation into a multi-ethnic society. Nevertheless, there is need to identify other current factors that promote aggregations in the rural social structure and should be incorporated in the resource governance agenda in Kenya.

3.4. Rural social structure in Kenya[25]

Natural resources are embedded in a shared social space where complex and unequal relations are established among a wide range of social individual or group actors (Mwanika, 2010). For example, agro-export producers and farmers, ethnic minorities and government agencies work collaboratively in the case of the production of primary products in Kenya. Moreover, due to insufficient State resources, individuals are encouraged to form interest groups so as to increase the number of persons participating and benefiting from community-based development projects in developing countries. Political scientists generally divide community interest groups[26] into two categories: economic and noneconomic.

[24] Collective action is action by more than one person directed towards the achievement of a common goal or the satisfaction of a common interest (that is, a goal or interest that cannot be obtained by an individual acting on his own).

[25] This section is part of a journal article. Ngaruiya G. W. & J. Scheffran. (2013) Reducing climate adaptation deficits using revolving fund network schemes in rural areas of Kenya: Case study of Loitoktok district. *African J. Economic and Sustainable Development* **2 (4**): 347 – 362. I contributed 80% of the content.

[26] Interest groups are organizations of people who share a common interest and work together to protect and promote that interest by influencing other stakeholders within the same network (Olson, 2002; SparkNotes, 2010)

a) Economic groups, which seek some sort of financial advantage for their members, are the most common type. These groups work to win private goods with benefits that only the members of the group will enjoy (Olson, 2002).
b) Non-economic groups are interest groups that fight for social causes and influence public opinion instead of seeking material gain.

Unlike economic groups, which work for private goods, noneconomic groups seek public goods (also called collective goods), that benefit everyone in society, not just members of the group (Olson, 2002). Instead of material incentives, these groups offer their members a variety of selective incentives, including purposive benefits, (emotional), solidarity benefits (social) and informational benefits (educational). In Kenya, non-economic interest groups usually revolve around cultural-based issues that affect the well-being of a specific demography of the community.

Of interest to this study is how the Kenyan government encourages formation of rural economic interest groups through increased monetary incentives towards natural resource utilisation for improving human security[27] (Government of Kenya, 2007). The main goal is to create livelihood opportunities at the grassroots level that reduce poverty, food shortages, crime and other negative societal outcomes. This target is embodied in "Vision 2030" which is the official road-map to Kenya's development that was launched in 2008. It is based on economic, social and political pillars that aim to make Kenya an industrialized middle income economy, providing high quality of life in terms of poverty reduction, livelihood security, and improved well-being for all its citizens by the year 2030 (Government of Kenya, 2009a). Whereby,

1. The economic pillar promotes utilization of natural resources in agriculture and tourism sectors through several initiatives, including Arid and Semiarid Lands (ASAL) Development Projects, Development of Resort Cities, Premium Parks Initiative and Underutilised Parks Initiative.
2. The political pillar advocates for a democratic system that is issue-based and people-centred, results-oriented and accountable to all Kenyan citizens.

[27] Human security is a broad term that comprises of components such as economic, food, health, environment, personal, community and political security (UNEP, 2011).

3. The social pillar creates an enabling environment for livelihood promotion opportunities mainly through the Revolving Fund system that is currently responsible for aggregation of community members into interest groups.

The Revolving Fund scheme is decentralised from the national to the constituency level and operates from monies set aside by the government for the public to borrow at zero or lower interest rates than commercial banks for a business purpose and repay according to business performance. It has a two-pronged objective, to empower women as business owners and to reduce youth unemployment. Consequently, the Ministry of Gender, Children and Social Development established the Women Enterprise Fund (WEF) under section 26 & 35 of the Financial Management Act (2005) as a strategy for gender equity by improving women access to resources in 2006 and the Youth Enterprise Development Fund (YEDF) was established in 2006 under the State Corporations Act, Cap. 446 but became fully operational as a state corporation in 2007.

Submitted proposals are judged by appointed financial intermediaries such as banks, Non-Governmental Organizations (NGOs), Savings and Credit Cooperatives (SACCOs), and Micro Finance Institutions (MFIs), according to a cost and profit criteria to ensure business sustainability. The subsequent repayment ensures circulation of money that contributes to economic growth and has proved to be a success among entrepreneurs at the grassroots (African Development Bank, 2012). The entire fund transfer process results in a complex linkage system with many intermediaries across public & private sectors, urban & rural agencies, gender, age and livelihoods (Figure 3.1).

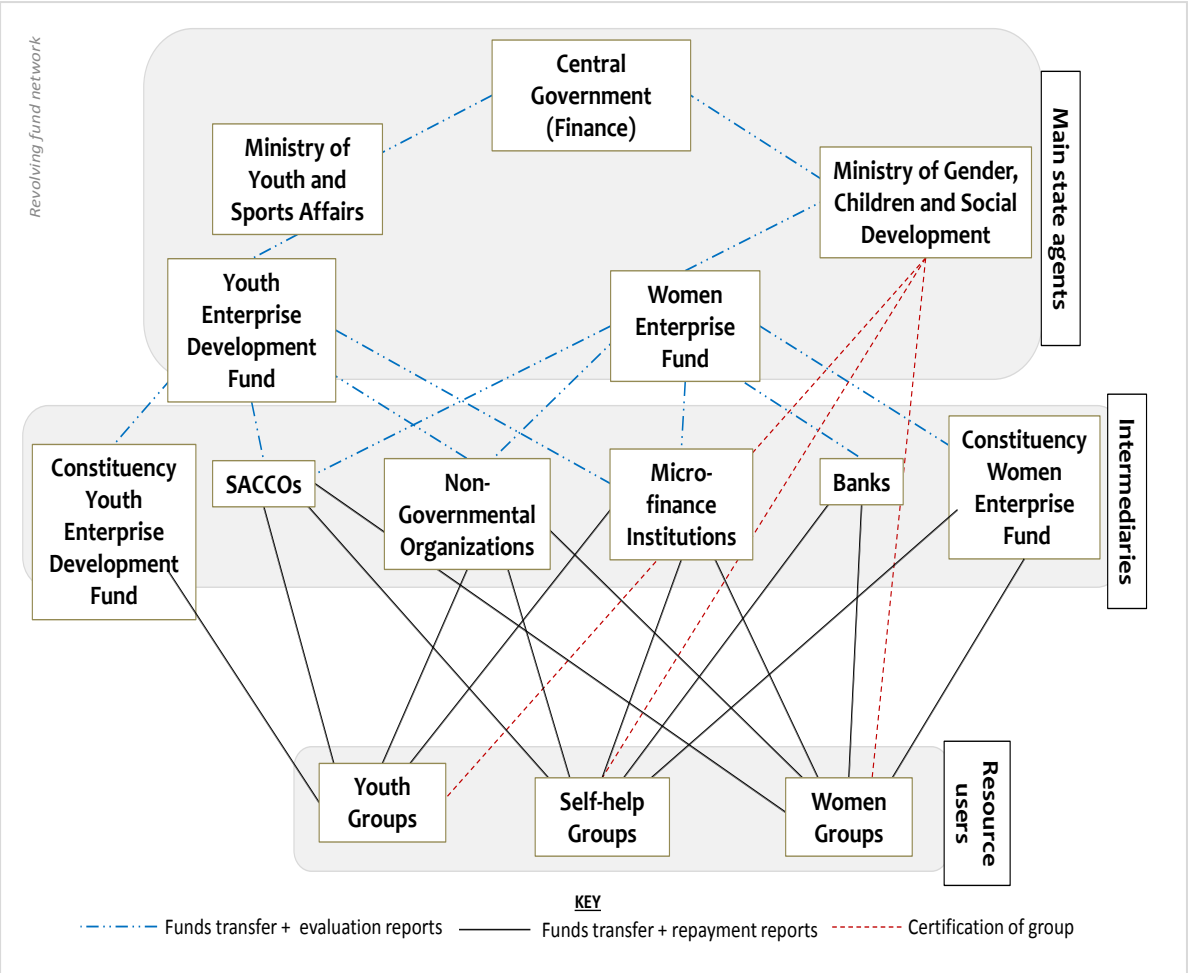


Figure 3.1: The Revolving Fund structure in Kenya. Source: The author.

Though the revolving fund business model seems successful at empowering and increasing actor linkages at the grassroots, it lacks a strong component of environmental monitoring of natural resources and transfer of climate adaptation knowledge. Therefore, the existing challenge is how to develop adequate institutional connections to help overcome identified barriers and create conditions in favour of beneficial outcomes (Ngaruiya & Scheffran, 2013).

Analysis of the general social setup becomes the first step to envisaging possible synergies among existing institutions to secure ecosystem services supply. From this chapter then **it is possible to identify the various actors** (institutions) present in rural Kenya. These institutions can be broadly classified into three categories, namely;

1. Formal institutions which are state-sponsored institutions that were mostly inherited from colonialism and constitute the written or codified rules such as the

constitution, judiciary laws, organized markets, policies and property rights (IDRC, 2009; Mowo et al., 2013).

2. Traditional institutions that are defined as a power, permission or an institution emanating from indigenous authority that draws its legitimacy, whether wholly or partially, from tribal/ethnic/cultural values of a group of people that share them (Cheka, 2008). Such traditional institutions have either centralized or decentralized governance systems. Whereby, centralized systems had kings and monarchs such as the Abyssinia (Ethiopia), Buganda (Uganda) and Ashanti (Ghana) while decentralized systems comprise of council of elders found among the Kikuyu and Maasai (Kenya), gada (age-set) system of the Oromo in Ethiopia, or the Ibo village assembly in Nigeria (ECA, 2007).
3. Informal institutions which are the patterns of interdependence and actions among individuals who build themselves into different structural configurations to collectively improve their living conditions or enhance resource exploitation. The actor linkages vary by religion, ethnic identity, mode of production and are manifested as social networks (Prell et al., 2010).

Consequently, **it also becomes easier to identify the challenges** lowering efficiency of climate governance schemes and that also increase vulnerability of rural communities in Kenya. Such an approach brings clarity in transfer of adaptation information for successful implementation of climate governance in Kenya.

THE CASE STUDY

3.5. Loitoktok district

The area of focus in Kenya is Loitoktok district in Kajiado County which is located at the southern tip of former Rift Valley province in Kenya. It covers 6,356.3km² and is situated between longitudes 36º 5’ and 37º5’ East and between latitudes 1º0’ and 3º0’ South (Government of Kenya, 2009a). It borders the Republic of Tanzania to the West from where one can view Mt. Kilimanjaro (Figure 3.2).

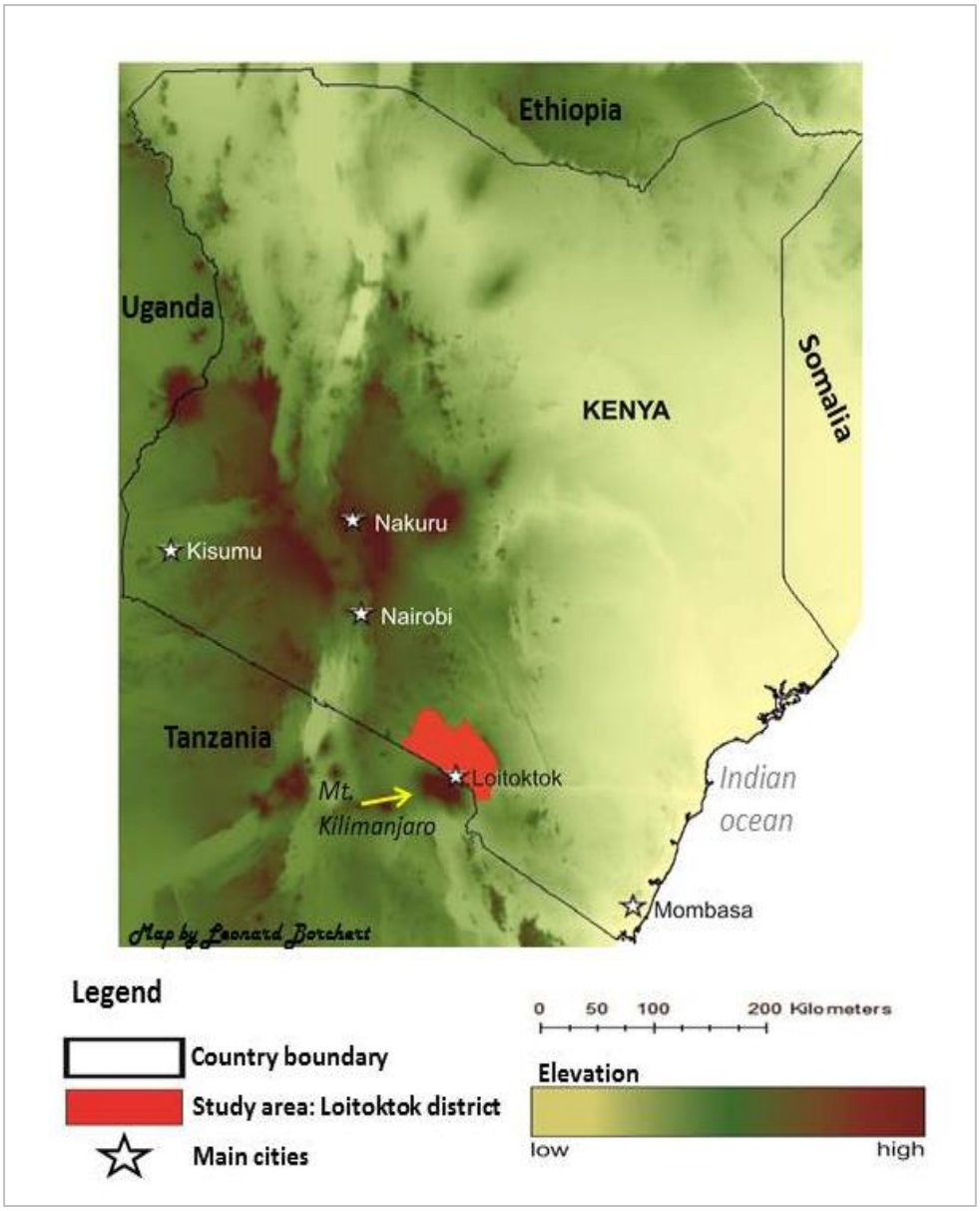


Figure 3.2: Location of the study area in Kenya and its proximity to Mt. Kilimanjaro. Source of data: GADM-Global Administrative Maps Database (http://www.gadm.org/)

In terms of government administration, it is divided into six divisions, 16 locations and 31 sub-locations (Government of Kenya, 2009a).

3.5.1. Climatic conditions[28]

There are two key rainfall seasons in the area, i.e. heavy rains in October to December and light rains from March to May. The rainfall is not equally distributed because of the presence of Mt. Kilimanjaro at the border of the district to Tanzania, which causes the lowest elevation to receive about 500 mm and the mountain slopes an average of 1250 mm (Figure 3.3).

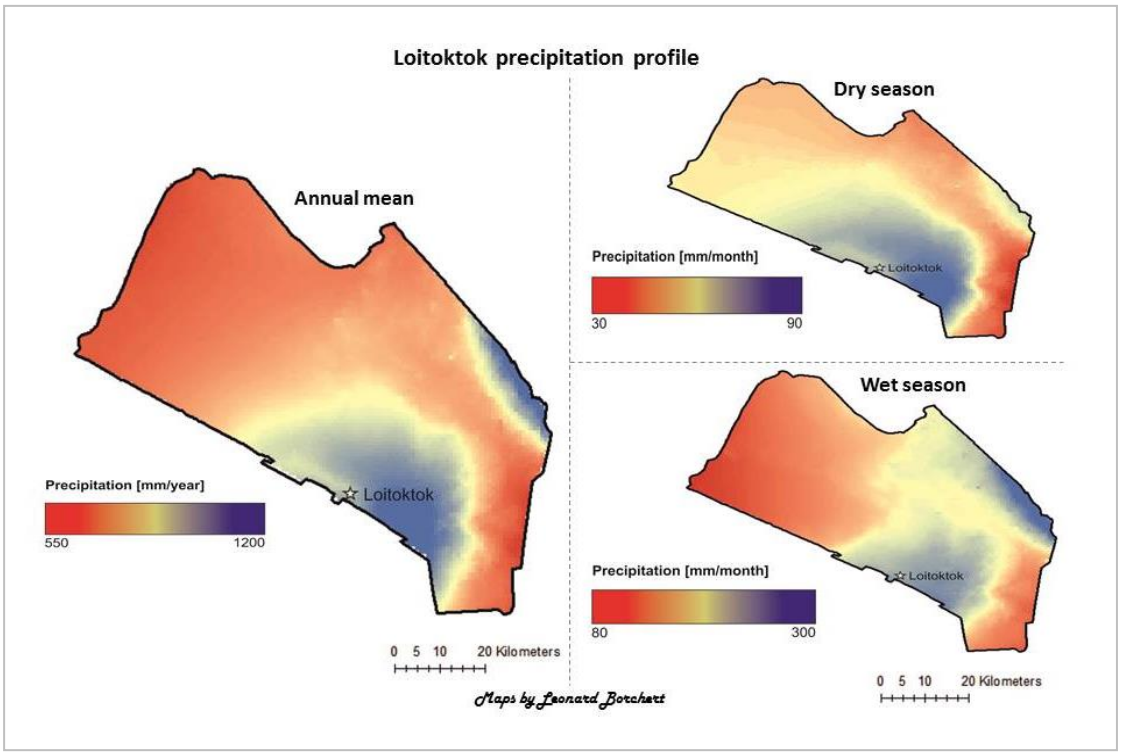


Figure 3.3: Precipitation in Loitoktok district. Source of data: WorldClim (Global climate data) (http://www.worldclim.org/)

Similarly, the temperature varies with altitude from as low as 10º C on the eastern slopes of Mt. Kilimanjaro to a mean maximum of about 30º C around Lake Amboseli (Government of Kenya, 2009a).

Ecologically, it is categorized among the arid and semi-arid districts in Kenya. The district is generally divided into; forests and woodlands (7.66km^2), parks and reserves in protected area (837km^2), arable land (4131.6km^2) and urban settlements take up 410.2km^2

[28] In-depth analysis of the vulnerability, exposure and conflict risk of Loitoktok will be published in Ide T., Schilling J., Scheffran J., Ngaruiya G. W. Kominek J. and T. Weinzierl (2014) On Exposure, Vulnerability and Violence: Spatial Distribution of Risk Factors for Climate Change and Violent Conflict across Kenya and Uganda Submitted to *Political Geography* for a special issue on climate change and conflict. I contribute about 10% of the content.

(Government of Kenya, 2009a). But this is gradually changing as changes in land tenure, overgrazing and overstocking have converted most of the woodland to marginal crop farming areas, the swamps into irrigated land and grassland to bushlands (Ntiati, 2002).

Socio-economic setup

The current population is estimated at 171,520 persons with an estimated annual population growth rate of 4.51% as per last census count (Government of Kenya, 2009a). This population growth has facilitated increase in land subdivision and fast economic growth. The Maasai from the Ilkisonko clan are generally considered as the indigenous people of Loitoktok district. They remain as the main land owners, producers of robust livestock for local and regional markets and promoters of the well-known Maasai culture in the district. In addition, immigrants have introduced diverse norms, discipline mechanisms, cultural and religious procedures into the Maasai community (Ntiati, 2002).

Construction of a tarmac highway road linking the Nairobi-Mombasa highway road and Tanzania has opened up the region and boosted economic activity in the district. This improved road network has stimulated mushrooming of 14 trading centres across the district and major urbanisation of three other satellite locations (Kimana, Mbirikani and Rombo) offering modern accommodation, trading/banking services and various “informal” livelihood activities to the Loitoktok community.

The Loitoktok formal health sector comprises of one hospital, two health centres, 12 dispensaries and seven private clinics (Government of Kenya, 2009a). According to the 2009 census, the prevalence levels in Loitoktok for common ailments such as Malaria were at 11.3%, respiratory diseases at 11%, diarrhoea diseases at 3%, pneumonia at 1.6% and eye infections at 1.5% (Government of Kenya, 2009a). There are no mobile clinics to provide regular medical services to pastoralists. In terms of interaction, the ratio of doctors to population is 1:30,000 while the ratio of nurses to population is 1:2000. These statistics act as an indicator to the local importance of traditional herbal practise in ensuring good health of the community.

At Loitoktok, the local revolving fund network is a narrowed into a triad whereby the Constituency- level YEDF and CWEF offices form the intermediary link between Equity Bank and the funded community group. Thus CYEDF and CWEF field officers as the central actors

are responsible for publicizing official program guidelines from their respective ministries; facilitate business proposal writing by interested community groups and oversee the subsequent repayment of the money (Ngaruiya & Scheffran, 2013).

3.**5.2. Economic growth and ecosystem services**

3.5.2.1. Agriculture sector

The presence of numerous springs, moderate climate and availability of affordable land from subdivision has supported a rapidly increasing diverse agro-ecosystem that has increased food security in the district (Figure 3.4). Crops are classified into subsistence crops such as maize (*Zea mays*) and beans (*Phaseolus vulgaris*) for local consumption, horticultural and fruits crops that are grown for external markets. The horticultural produce such as Karella (*Momordica charantia*), Dolichos (*Lablab purpureus*), Ravaya (*Solanum melongena*) and Okra (*Abelmoschus esculentus*) target Indian markets. Fruits include oranges (*Citrus* spp.), avocadoes (*Persea americana*), mangoes (*Mangifera indica*), bananas (*Musa* spp.) and pawpaw's (*Carica papaya*) (Ngaruiya, 2014).

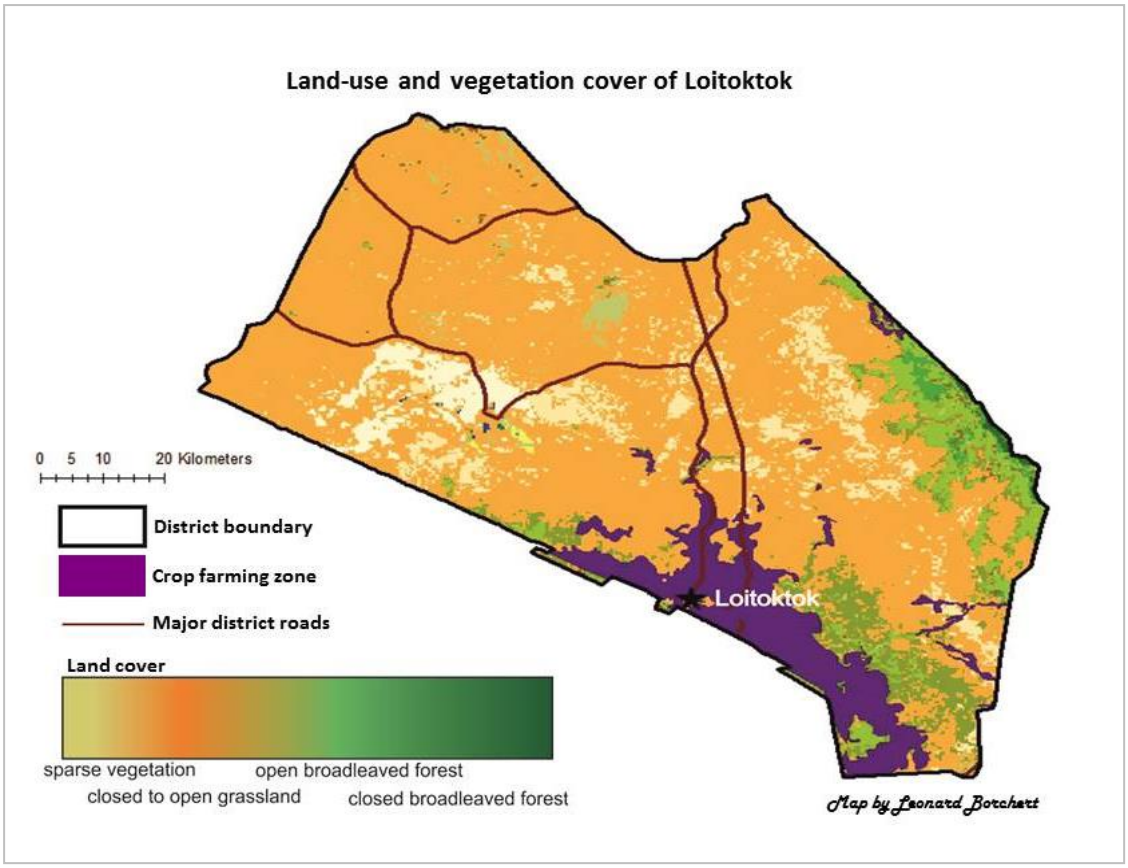


Figure 3.4: Crop farming (intensive) activity zone in Loitoktok. Source of data: GLAC (Global Land Cover 2000 project) (http://www.diva-gis.org/Data)

3.5.2.2. Medicinal plants sector

In Loitoktok, about 43 plant species are utilised for their pharmaceutical properties, whereby 20 species are harvested from communal land while protected areas provide 13 plant species to the market in Loitoktok. Scientific and common names of these plants are given in appendix 2.

3.5.2.3. Wildlife and tourism sector

Loitoktok comprises of the Amboseli ecosystem which supports a wide range of ungulates, that in turn support carnivores such as lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), hyena (*Crocuta crocuta*), jackals (*Canis* spp), civets (*Civettictis civetta*) and serval cats (*Leptailurus serval*) (Kenya Wildlife Service, 2009). Also, it is one of the 60 Important Bird Areas in Kenya. There have been over 400 bird species recorded including 40 birds of prey species in this area. It has globally threatened bird species e.g. Lesser Kestrel (*Falco naumanni*), restricted-range birds that are found only in a

very small area such as the Taveta golden weaver (*Ploceus castaneiceps*), bird species that live only in a particular vegetation type such as the Grosbeak weaver (*Amblyospiza albifrons*), and regionally threatened bird species such as Martial eagles (*Polemaetus bellicosus*) (Kenya Wildlife Service, 2009). The 2009 drought impacts on wildlife species such as Zebra (*Equus burchelli*) and wildebeest (C*onochaetes taurinus*) resulted in deaths of approximately 54% and 27% of their respective populations (Wangai et al., 2013).

The rich biodiversity was the first economically developed natural resource for tourism purposes by the colonial British government. The Amboseli national park was gazetted in 1974 after existing from early 1960's as a big (over 8,000 km^2) game reserve. It currently covers an area of 392 km^2 and is one of the highest tourism earners in absolute revenue per protected area, revenue per unit area of conservation and tourist congestion in Kenya (Okello et al., 2011). Though small in size it is supported ecologically by the neighbouring Tsavo and Chyulu National Parks as well as other smaller private conservancies and sanctuaries (Figure 3.5). Connecting Amboseli National park and Kilimanjaro forest on the Tanzanian side is a narrow strip of land, the Kitenden Corridor, which allows wildlife movement, particularly of elephants (*Loxodonta africana*), between the two protected areas (Kenya Wildlife Service, 2009). Additional factors like the Maasai culture (dances, fabrics, jewellery and homestead design) and Mt. Kilimanjaro have created a tourism industry that continues to attract investors to construct private hotels and lodges that offer employment opportunities to the community.

3.5.2.4. Water sector

The Amboseli basin receives both surface runoff and groundwater (recharged at the forest zone between 1,500 m and 3,000 m above sea level) from Mount Kilimanjaro (Grossmann, 2008). Since precipitation is not enough to support the growing agricultural sector and emerging economic development in the case area (Figure 3.5), stakeholders have constructed 9 major irrigation schemes, 20 small-scale irrigation projects, 5 water system projects, 3 community water pans, 25 boreholes, 5 urban piped water schemes and 300 shallow wells to increase local water supply (Government of Kenya 2009a). Loitoktok also supplies water through the 100 km-long old-railway pipeline that transmits 17 litres/s and the 262 km-long Noolturesh pipeline that transmits 200 litres/s to other nearby towns such as Kajiado, Machakos and Athi River (Grossmann, 2008).

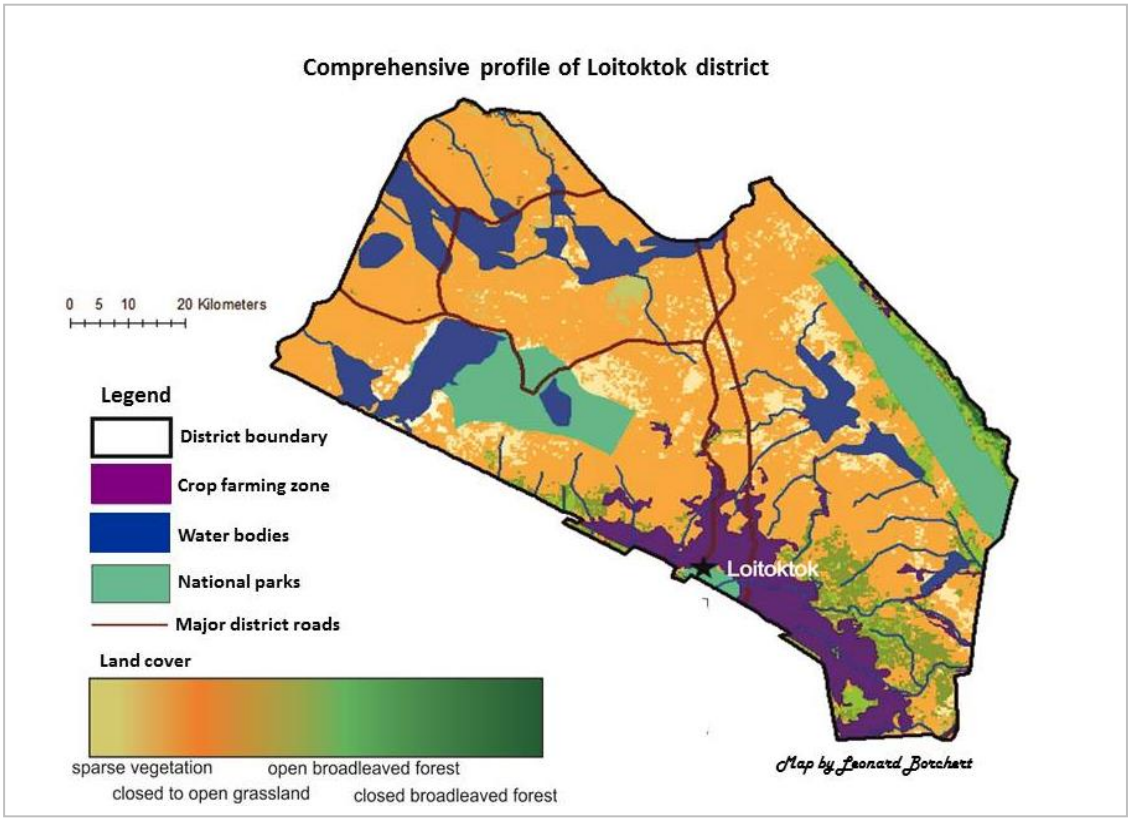


Figure 3.5: Main crop farming and wildlife tourism zones in Loitoktok. Source of data: Digital chart of the world for Inland water and GLC2000 - Global Land Cover 2000 project (http://www.diva-gis.org/gdata)

3.5.3. Evolution of Loitoktok land tenure

The district is famously described using the eleven community group ranches (labelled in Figure 3.6) that embody its rich land tenure background. Under the Kenyan adjudication program, lands that were previously under the colonial government were administered by the government but held in trust by the respective county councils. From the late 1960s these lands were later surveyed and then assigned to various registered groups of Maasai to improve management of pasture by developing facilities such as water and dips for their livestock on a communal basis (Sindiga, 1984). This was done under the land legislation of 1968 (Land Group Representatives and Land Adjudication Act) where land ownership was identified with groups and enabled conferral of land titles to these groups (Ntiati, 2002; Sindiga, 1984). The main parcels of land in Loitoktok that were allocated to groups and are still recognized are Kimana (25,120 ha), Kuku A & B (114,712 ha), Mbirikani (125,893 ha), Eselenkei (74,794 ha), Rombo (38, 365 ha) and Olgulului (147,050 ha).

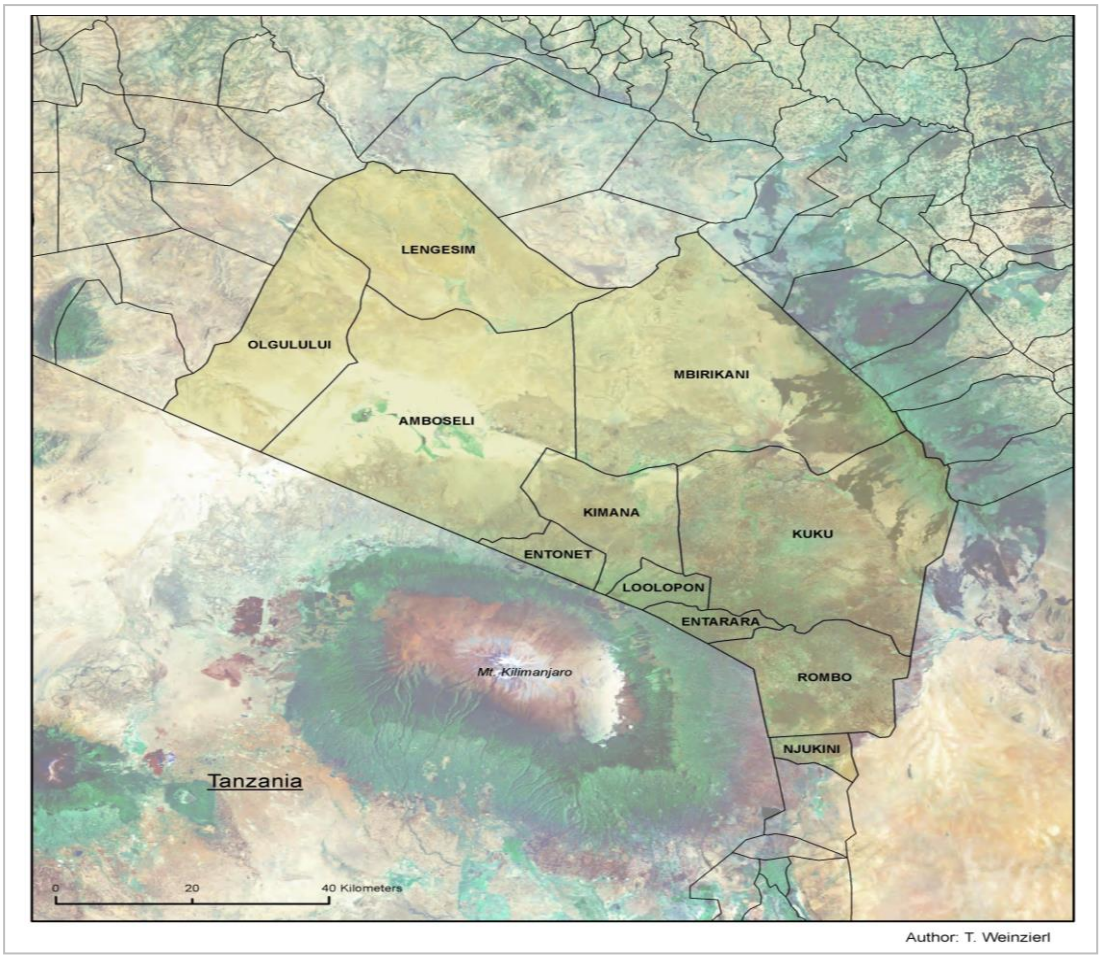


Figure 3.6: The group ranches of Loitoktok. Source of data: GADM- Global Administrative Maps Database (http://www.gadm.org/)

However, failure of the group ranch system to deliver improved livelihoods and security of tenure to the group ranch members set in motion the subdivision of group ranches. As of April 2012, Kajiado land registry records indicated that two group ranches had been fully subdivided i.e. Entarara (9,270ha) and Kimana group ranches, three more were under the subdivision process i.e. Kuku, Mbirikani and Eselenkei while land officials state that Olgulului has been partially subdivided to enable members to individually improve their livelihoods. The land subdivision has facilitated a rapid land tenure change from community to private ownership in many rural areas of Kenya. This change conforms to evolutionary theory of property rights which state that "population pressures and increased land scarcity tend to push towards a transition from communal to more individualised rights" (Chauveau et al., 2006). Moreover, subdivision is currently driven by young Maasais who are subdividing inherited land parcels into many smaller parcels and selling them regularly as a main source

of income. This view of land as a monetary source has increased local land prices to unprecedented highs and is also blamed for the deterioration of moral issues in Loitoktok.

3.5.4. Ecosystem service governance in Loitoktok

3.5.4.1. Crops and livestock

The Ministry of Agriculture (MoA) oversees the management of crop and livestock product at the district level as separate agencies i.e. District Agricultural Office (DAO) and District Livestock Office (DLO). The agriculture (crop production) office is further divided into four departments namely, crop development, soil and water management, home-economics (energy & nutrition) and agribusiness. While, the livestock office is divided into two departments namely, livestock production and veterinary services headed by a veterinary surgeon. These departments have extension officers who conduct daily field visits to farmers and pastoralists and also hold regularly field schools to demonstrate new farming techniques or products.

3.5.4.2. Medicinal plants

In Kenya, herbal medicine was outlawed by the colonial administration under the "Witchcraft Act" of 1925 but the practice continued in secret, until parts of the law were revoked with independence in 1963 (Sindiga et al., 1990). However, the negative undertone is yet to diminish and many urban ‘educated’ persons still associate herbal medicine with witchcraft to the extent that it is not part of school syllabus and even university curricula. This perception also denies the sector budgetary allocations for research and value addition to increase appeal of herbal products that are still traded mostly as powder and liquid concoctions. Moreover, the secrecy behind herbal medicine has given rise to a new crop of “herbalists” who advertise unverified cures especially for HIV, cancer and other social ills creating unprecedented demand for these herbal products.

Herbal products are traded in the weekly open-markets and several herbalists have set up clinics at various locations in the district. The open-market traders pay a small fee to the council to display their wares and conduct business - however, there is no form of registration of the herbal medicine traders, their origin, qualifications and their products.

Additionally, herbalist clinics are issued with a business license by the county council but have no registration connection to the formal health sector in Kenya.

3.5.4.3. Wildlife

The Ministry of Tourism and Trade handles tourists and hospitality stakeholder's issues while the Ministry of Environment, Water and Natural Resources manages wildlife resources through Kenya Wildlife Service (KWS). In terms of financial arrangements, the central government collects taxes on tourist expenditures and taxes from hospitality providers while all receipts by National Parks from tourism and wildlife activities go to KWS. It also collects licensing fees from tourism facilities located in protected areas and shares some park revenues with local authorities although this aspect has proved controversial (Korir et al., 2013).

An estimated 40,000 domestic and 90,000 non-resident visitors were recorded between 2004 and 2007 in Amboseli (Kenya Wildlife Service, 2009). They stay in establishments found in and around the park that cater for all classes of tourists. There are also several community based and private conservancies that support diverse tourist and conservation activities. Since the Maasai culture is synonymous with wildlife, the community is actively involved in the local tourism sector through presentation of cultural dances, sale of artefacts (curios) and in wildlife protection through the game scouts association.

3.5.4.4. Water

The main institution in-charge of water issues in Kenya is the Ministry of Water (MoW). The Water Act of 2002 set in motion decentralization in the water sector and is credited with formulation of the Water Resources Management Authority (WRMA) that is mainly responsible for water governance at the grassroots level (UNDP and SIWI 2007). In addition, Ewaso Nyiro South Development Authority (ENSDA) established in 1989 by the act of parliament chap 447 of the laws of Kenya is charged with implementation of sustainable water development within the Loitoktok drainage system.

Within the community, the Water Act also empowers individuals, water project, company or organization that impacts or benefits from a particular water resource to form a Water Resource Users Association (WRUA). This group is directly managed by WRMA

through regular training on water governance and financial support for water resource development. Other stakeholders involved in water governance at the community level include, non-governmental organizations (NGOs), interest groups such as water-sellers, and other types of civil society organizations. These peripheral actors are especially important in remote and informal settlements during emergency relief, provision of community managed water supply, and construction of local boreholes, wells or water pans (UNDP and SIWI 2007).

3.5.5. Why Loitoktok?

Loitoktok was selected as a case study because of specific factors that give it holistic representation of a typical Kenyan rural area. These factors are,

1. Evidence of environmental impacts related to climate change have been documented through changes in precipitation (Thompson et al., 2009), temperature fluctuations (Altmann et al., 2002), wildlife mortality (Wangai et al., 2013) in Loitoktok.
2. Strong and quickly expanding agricultural sector (Ngaruiya, 2014).
3. Rapid land subdivision from community group ranches into individual land parcels that are driving the high urbanisation rate and livelihood diversification (Ntiati, 2002).
4. Diverse cultures (norms, discipline mechanisms, cultural and religious procedures) introduced by immigrants with different livelihood practises apart from pastoralism of the Maasai community.
5. Its wildlife tourism sector is one of the most studied and considered as the top conservation area in Kenya (Okello et al., 2011).

As a reminder, the aim of this study is to evaluate how actor relationships influence decisions on climate adaptation and conflict resolution towards enhancing resource governance using the actual rural network of Loitoktok.

CHAPTER 4: ANALYTIC FRAMEWORK DEVELOPMENT

4.1. Introduction to chapter

Any scientific inquiry starts by identifying a gap or problem in a body of knowledge as accomplished in the two previous chapters. The challenge highlighted is to analyse social networks to identify community actors, implemented adaption and conflict resolution measures, obstacles to knowledge dissemination and propose an efficient way to boost local livelihoods and biodiversity conservation. These diverse factors can only be studied using a multi-disciplinary tool that combines analysis of both relational and resource attributes data. Though there is no such thing as "the best" institution (Ostrom, 2005), this chapter introduces the - Ecosystem Service Governance (ESG) approach – **that builds further the ecosystem approach** by integrating it with notions borrowed from monetary ecosystem services valuation and social network analysis to formulate a *comprehensive* assessment framework for ecosystem services. The approach specifically targets rural communities in Africa because of their high reliance on natural resources, low involvement in resource governance and unique social network structure. Presumably, in future this framework can be used to implement schemes such as Payment for Ecosystem Services to enhance social capital. This chapter has been developed into a journal article[29].

4.2. Background on ecosystem service governance

Ecosystem productivity depends on maintenance of ecosystem components within certain limits to avoid a system collapse (Perrings et al., 1995). However, ecosystem services do not operate in isolation but interact with each another in unpredictable ways that are further complicated by diverse external forces (Millennium Ecosystem Assessment, 2005). If the combined effect of several forces operating either in a multiplicative or exponential on ecosystem services is greater than the sum of their separate effects (defined as synergism) then effects can either be positive or negative (Millennium Ecosystem Assessment, 2005). Therefore, detailed knowledge about how society manages ecosystem services is important to prevent negative synergistic interactions that could affect human well-being.

[29] Ngaruiya G. W. Ecosystem Service Governance: A synergistic approach developed from key natural management schemes relevant in rural areas. *Ecosystem Services* journal.

Consequently, the concept of an ecosystem provides a valuable framework for analysing and acting on the linkages between people and the environment (McKenzie et al., 2010). This chapter introduces an approach that draws insights from natural resource management strategies such as climate governance, integrated conservation and development projects (ICDPs) and sustainable forest management (Pearce et al., 2003) that are implemented in a single ecosystem. Figure 4.1 illustrates how a dryland ecosystem in a rural setting is typically managed. The four sectors are managed from different levels, i.e. the climate change agenda is set at the global and national level, most resource conflicts are addressed at a transboundary (state) level, while ecosystem services initiatives are seen as a private actor scheme and local actors form community interest groups according to their culture or societal need.

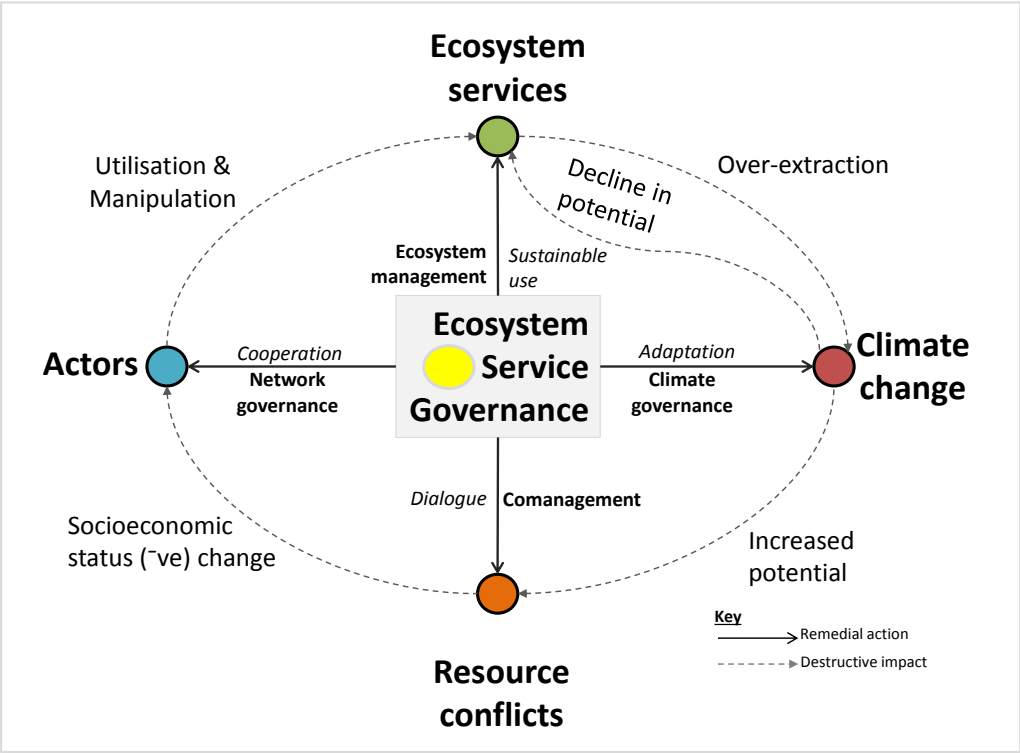


Figure 4.1: Key governance schemes implemented by diverse actors within a single a rural community. Source: The author.

Many expert-based resource management strategies previously followed a "one-size-fits-all" approach, but which gave such poor governance and biodiversity conservation returns and led to the establishment of participatory resource management approaches to promote community-based conservation in developing countries (Berkes, 2004). Yet despite

scattered successes, not one approach has so far achieved major shifts in tropical land-use trends (Brandon et al., 1998; Lockwood, 2010). Similarly, increasing studies indicate that grassroots citizens are not accessing relevant adaptation information and are not participating in judicial review to influence policy as well as project decisions affecting ecosystem resources (Irwin et al., 2007). Obviously, environmental management faces complex problems characterized by uncertain and unpredictable systems dynamics but resources managers also lack sufficient knowledge on the effects of interventions and societal conflicts about the appropriateness of interventions (Newig et al., 2010).

In my view, this lack of knowledge is a result of *institutional incoherence* which occurs when diverse institutions become incompatible or discordant with each other (IDRC, 2009; Mowo et al., 2013). Institutional incoherence may appear to be a problem at the national or regional level but rural institutions may also become incompatible and subsequently hinder adaptation knowledge dissemination within the community. Incompatibility originates in the rural community through;

1. The multidimensional character of the rural community inhibits operation of a single consistent set of rules and fosters "**legal pluralism**" defined as the coexistence of multiple types of rules each backed by a different institutional framework in a geographical area (Meinzen-Dick & Pradhan, 2002). This scenario is further complicated by the immense adaptation funding that has led to a proliferation of actors offering diverse "adaptation expertise" in rural communities (Madzwamuse, 2010).
2. **Poor coordination** in addressing scale mismatches between ecological processes on one hand, and social processes of governance on the other (Ernstson et al., 2010). This is because success depends between the scale at which knowledge is produced and the scale at which decisions have to be made (Termeer et al., 2010). For example, a community group or social network is usually concerned about local livelihoods, a national agency about planning national development, and a secretariat of an international convention about improving the state of a specific type of resource such as biodiversity, migratory species, or climate change (Irwin et al., 2007). If the three actors do not streamline their grassroots adaptation activities, then effective knowledge dissemination is hampered in the community.

3. An “us against them” attitude that creates **sectorial divisions** especially with regards to natural resource conservation. For example, international NGOs tend to dominate climate change adaptation and wildlife conservation agendas in developing countries and promote disparate interests from the grassroots (Goredema et al., 2007; Madzwamuse, 2010). This attitude explains why rural individuals and communities do not have the incentive and influence to make adaptation decisions to sustain the ecosystem services they depend on for their identity and survival (Irwin et al., 2007).

The incompatibility causes adaptation programs and resource governance schemes to be implemented separately or even ad-hoc creating sectorial silos among multiple agencies dealing with ecosystems and their services (Greiber & Schiele, 2011).

Table 4.1 further analyses strengths and weakness of the four key governance approaches implemented by resource managers to overcome diverse environmental challenges. The first approach is climate governance that deals with climate change by guiding mitigation strategies and adaptation policies to overcome impacts of climate change. The second scheme is the ecosystem management approach that seeks to emphasise people’s dependence and impact on the services provided by ecosystems by monetizing ecosystem services and incorporating these values into decisions made by governments, businesses, NGOs and individuals (McKenzie et al., 2010). Third is the widespread comanagement strategy that enables private and public actors to cooperate and share power in order to solve conflicts related to natural resource management (Carlsson & Sandström, 2008). Finally, network governance is a specialized form of comanagement that builds mutual trust and promotes reciprocal relationships to enhance cooperation and is mainly used in policy implementation (Hennig et al., 2012).

In summary, core strengths of the strategies involve: funds availability, deep ecological knowledge, grievances resolution, and policy adoption analysis. While, the central weaknesses emanate from poor grassroots participation, incomprehensible & technical ecological lingo, high bureaucracy and poor grasp of area-specific dynamics by the management strategies.

Table 4.1: Strengths and weaknesses of key rural resource governance schemes. Source: Compiled by the author.

THEORIES & CONCEPTS	STRENGTHS	WEAKNESS
Climate governance to oversee adaptation practises **(Madzwamuse, 2010)**	Well-funded global and national institutional structures for coordinating climate change activities.	Poor coordination causing limited public understanding of climate change impacts in the grassroots
Ecosystem management to promote sustainable use **(McKenzie et al., 2010)** **(Voeks & Rahmatian, 2004)**	Encourages stakeholder participation using monetary incentives as a critical factor influencing the likelihood of success.	Missing data as ecosystem services are extremely difficult to measure and hinders widespread adoption of the approach.
Co-management approach to facilitate dialogue in resource conflict resolution **(Sandström & Rova, 2010)**	Fosters the rise of functional conflict-resolution processes through exchange of information (grievances) and material resources among involved stakeholders	Compensation might involve long bureaucratic chains especially wildlife–related claims The concept of co-management is too broad with limited knowledge for challenges at rural regions.
Network governance to encourage actor cooperation **(Hennig et al., 2012)** **(Newig et al., 2010)**	Explains policy performance and outcomes in society Reveals social reality by visualising linkage results using sociographs	It is an emerging concept in natural resource management. It cannot capture reality on its own and thus not often sufficient to explain a phenomenon to the rural community.

The weaknesses highlight the fact that natural resource management problems are mainly power problems since human relationships are formed by a mix of cooperation and competition (Ratner et al., 2013). Additionally, resource governance faces two types of challenges – ecological and administrative challenges.

4.2.1. Ecological challenges

Ecological challenges are factors that reduce ecosystem services delivery through direct depletion of species and loss of habitat (ecosystemic changes). These are also referred to as proximate causes (Perrings et al., 1995) such as climate change and resource conflicts. The impacts of climate change on ecosystems services and resource conflicts have been discussed in chapter 2.

4.2.2. Administrative challenges

These are financial, technological and social factors that inhibit effective implementation of resource governance schemes leading to species depletion directly through the

destruction of habitat (Irwin et al., 2007; Perrings et al., 1995; UNEP, 2011). Relevant to this thesis are social management limitations such as legal pluralism, poor coordination and sectorial divisions as discussed in the previous section.

Consequently, the demand for new institutions to oversee resource governance grows as the economy becomes increasingly globalized, communications shift to the Internet, and ecosystem challenges increase in scale and transcend traditional decision-making boundaries (Irwin et al., 2007). The standard strategy by ecologists is to develop an "approach" or "framework" - defined as a nested set of theoretical concepts for organizing diagnostic and prescriptive inquiry to a particular problem (Ostrom, 2005). Frameworks provide a meta-theoretic language that can be used to compare theories and help the analyst generate the questions that need to be addressed when first conducting an analysis (Ostrom, 2005). Thus, the *ecosystem service governance approach* is my contribution to this framework development arena in a bid to solve the rural climate governance dilemma.

4.3. Ecosystem service governance (ESG) approach

The ESG approach builds further the Ecosystem Approach developed by the Convention of Biological Diversity. Ecosystem Approach is a "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (CBD, 2009). Though it endorses a participatory outlook, identifying stakeholders and more so *identifying diverse stakeholders* is not such a straightforward process (Prell et al., 2010). Therefore ESG proposes a systematic manner for narrowing down specific actors for focused rural resource governance. Its framework consists of four main phases (see also Figure 4.2).

1. The core comprises of the ecosystem services that support livelihoods and community economic growth,
2. The resources-determinates (challenges) that negatively influence ecosystem services
3. The social network structure that either manage the challenges or utilise ecosystem services
4. The desired outcomes from the ecosystem service governance (ESG) approach.

It is an iterative framework therefore; the implemented outcomes feed back into their respective phases to create a cycle that can be systematically analysed and readjusted for

successful conservation. This cyclic character gives the ESG approach a flexibility in preparing for disturbance (e.g. drought as a climate change impact), and responding to disturbance (e.g. seasonal resource conflicts). The former mode focuses on nurturing actor diversity through the collection and dissemination of area-specific social-ecological information, while the latter mode initiates effective collective action through more centralized forms of decision-making that are also all-inclusive (Ernstson et al., 2010).

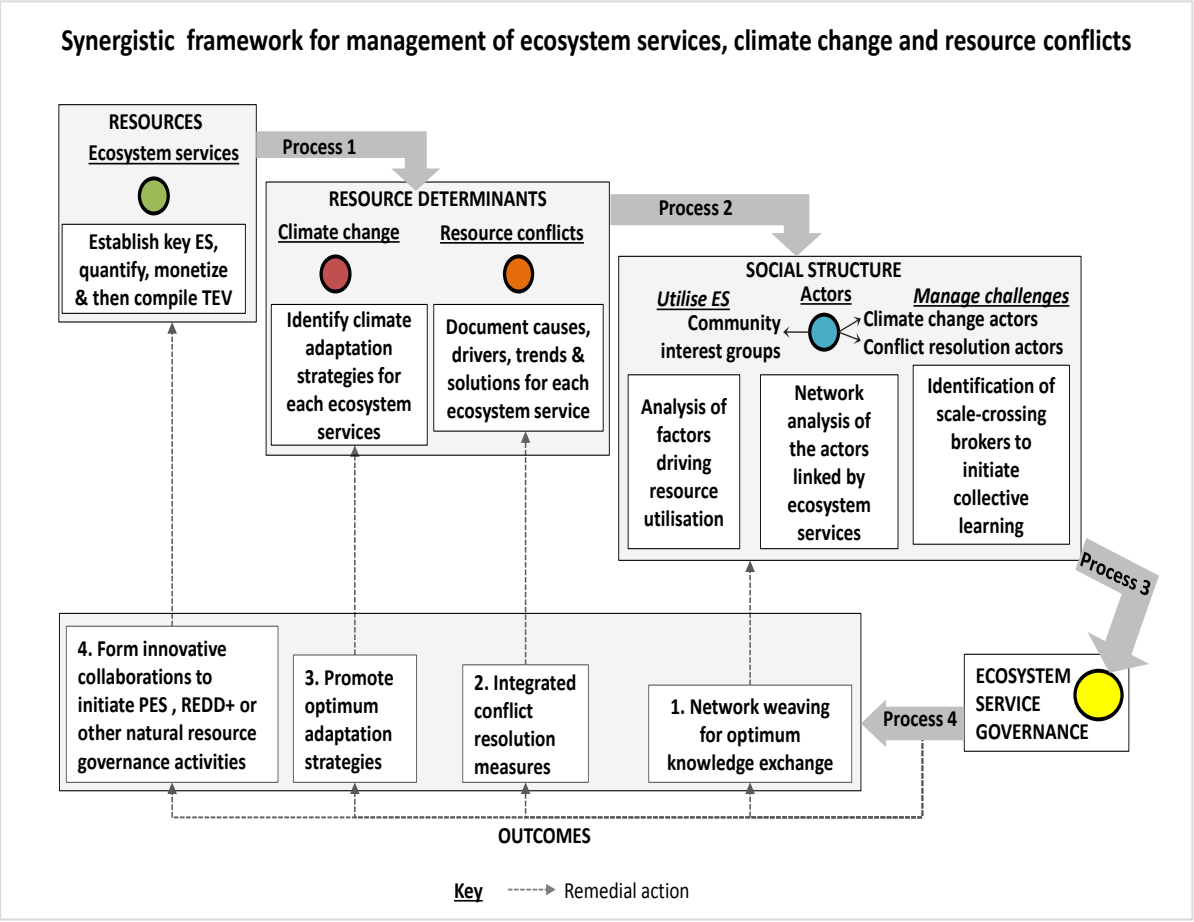


Figure 4.2: The conceptual framework of ecosystem service governance (ESG) approach. Source: The author.

4.4. Incorporated concepts into the ESG framework

Effective resource management demands identification of the type of information driving stakeholder decisions concerning ecosystem service utilisation. Drawing on two relatively new theories in resource governance, this section expounds what makes the ESG unique and effective in rural areas.

4.4.1. Economic valuation of ecosystem services

It is prominently and generally assumed that ecosystems are valuable, but the question that is routinely asked is how valuable are these ecosystem services? (Slieker, 2010) Studies opine that a major reason for the systemic decline of ecosystems is that many ecosystem services are not priced or assigned value by the prevailing systems of production, exchange, and regulation (Delang, 2006). Ecosystem valuation is an emerging science that attempts to define ecosystem service units in a way that is methodologically and economically consistent with the definition of goods and services used in the conventional income accounts (Boyd & Banzhaf, 2007). Valuation techniques are based on economic exchange processes that give ecosystem services monetary values as a basis for cost-benefits analysis or facilitating trade-offs for sustainable ecosystem development (Millennium Ecosystem Assessment, 2005).

ESG approach opted to include monetary valuation for the following benefits; a) Estimates of value help put local resources on the agenda of economic planners and policy-makers, who make their decisions based on the monetary returns of resource, land and investment options (Boyd & Banzhaf, 2007). b) Valuation enables resource managers address the effect of illegal markets for products such as herbal products (traded informally in rural areas) that may undermine conservation (Vorhies, 1997).

This proposed approach recommends the procedure below to obtain the economic values of ecosystem service units (Pearce et al., 2006; Voeks & Rahmatian, 2004);

1. Identification and ranking of ecosystem services by local stakeholders using economic importance and utilisation preference by community interest groups.
2. Quantification of identified ecosystem services in appropriate units (biophysical or otherwise), based on actual use levels.
3. Financial valuation of the identified ecosystem services using either market or non-market valuation techniques. If both methods are inappropriate then hypothetical markets may be created in order to elicit values. The choice of the proper method will depend on each situation, the information readily available, the time and budget available, and level of expertise. If valuing an entire ecosystem, then the Total Ecosystem Value (TEV) may be complied as a final step in this evaluation (De Groot et al., 2006).

The economic data is useful for trend analysis of the resource to infer a realistic picture of what is being lost or gained for accurate managerial decisions. This data may also be an accurate indicator of adaptation activity. In the long term, this economic information may be used to establish payment for ecosystem services (PES) or other incentive-based conservation programs, sustainable energy and other new technologies (Slieker, 2010).

4.4.2. Social network analysis

Social network analysis was selected for this approach because it helps to unlock deadlocks in various community dynamics. The ESG framework analyses the social network for network closure and heterogeneity (structural holes) to determine whether the network supports or impedes collective learning. The analysis also identifies brokers who are responsible for driving dissemination of adaptation and resource conflict resolution information at the community. This is because if information is stockpiled, ignored or is too basic then it will not lead to sustainable development, therefore actors must share in at least some actions and events rather than just sit on information (Saunders, 2007).

After a clear identification of the actors and their roles within the network is done, then the final step involves bringing together the scale-crossing brokers (SCB) identified using cluster analysis. These are persons deemed to be strategically positioned and can be effective as a community resource management team. SCB are linked together using network weaving[30] with the main aim of promoting the local sustainable development agenda (Irwin et al., 2007). This is a gradual process whereby the brokers are obligated to,

1. Build relationships particularly across previously unrelated sectors and activities for holistic sustainable development.
2. Facilitate diverse collaborations for mutual benefit (Krebs & Holley, 2004).
3. Utilise their connection to source for adaptation funds, additional governance training opportunities for new business ventures and nurturing emergent leadership roles for interested actors in the community.

[30] Network weaving is a process of building relationships across traditional divides so that people have access to innovation and important information (Krebs & Holley, 2004).

Theoretically, the constituted SCB team can enhance ability of the community to switch modes and respond to disturbances by either initiating or coordinating collective action (Ernstson et al., 2010).

4.5. Predicted outcomes of the ESG approach

The suggested approach seeks to build clear pathways for the exchange of relevant information and resources on ecosystem services, climate change and human wellbeing across the network. The ESG outcomes embody the 5-step action agenda developed by Irwin et al., (2007) for effective ecosystem management. Whereby, the four outcomes of the ESG not only emphasise the crucial role that ecosystem services play at the grassroots in terms of livelihoods but also reveals how the rural community may play a significant role in managing them.

These are:

1. Network weaving[31] for optimum knowledge exchange. The selected team (scale-crossing brokers) oversee local comanagement and improve social and economic connectivity for positive transformation in resource governance in a network.
2. Integrated conflict resolution strategy that is achieved by identifying all actors concerned with a specific ecosystem service for grievance discussion and effective resolution monitoring.
3. Optimum adaptation measures that are developed by local adaptation knowledge actors for local resource users so as to promote indigenous adaptation methods and reduce maladaptation. This outcome also enhances accountability by enabling tracking of adaptation activities funded by external donors.
4. Ecosystem service valuation provides a practical program for monitoring ecosystem services for sustainability that may also be used to initiate innovative incentive-based conservation programs such as Payments for Ecosystem Services (PES) or Reducing Emissions from Deforestation and Forest Degradation (REDD+) to provide additional sources of income to rural households.

These outputs validate ESG approach as an effective resource governance tool for regions that do not have a cohesive and formal sustainable development agenda. Moreover,

[31] Network weaving is a process of building relationships across traditional divides so that people have access to innovation and important information (Krebs & Holley, 2004).

it also provides a basis for case study assessment of both single and multiple ecosystem services for coordinating actions by actors because institutional compatibility at different prefectures and different tiers definitely increases effectiveness of natural resource governance and conflict resolution at the grassroots (Mowo et al., 2013). Subsequent stable network structures can link to similar networks in other regions to create new products, services and markets on land management and resource management (Krebs & Holley, 2004).

Chapter summary

Network relations are not seen as answers in themselves but **as patterns requiring interpretation** on community "behaviour" (Saunders, 2007). The ecosystem service governance is an advanced resource governance tool that incorporates economic valuation to provide useful information and recommendations for decision-making (International Centre For Environmental Management, 2003) and social network analysis to evaluate actor linkage for governance effectiveness. It is formulated theoretically to deconstruct an empirical governance phenomenon in order to strengthen social dynamics, proactively minimize potential social conflicts and provides a means of institutionalizing learning on facts and deliberation on value judgments (Carlsson & Sandström, 2008; Newig et al., 2010). Hence, the ESG approach extends the participatory resource governance discourse to focus on what is utilised and who is actually involved for rural communities to understand the bigger picture of resource governance. But the question that sticks out now - is it *functional* in reality?

CHAPTER 5: RESEARCH METHODOLOGY

5.1. Introduction to chapter

This chapter presents the process used to practically implement the complex but functional ecosystem service governance. Following the procedures outlined below, resource managers and researchers can formulate **a simple questionnaire** to gather data on a specific ecosystem service involving actors, adaptation activities and conflict circumstances. They can then use social network analysis software to identify the scale-crossing brokers and restructure their resource networks for effective governance.

5.2. Data collection

Before starting my field work, I obtained an ethics approval and research permit from the Ministry of Higher Education, Science and Technology in Nairobi, Kenya. I conducted the empirical component of my research during two field visits in March-May and October-December 2012 at Nairobi, Kajiado and Loitoktok districts in Kenya. The main component of my empirical work included interviews and application of a semi-structured questionnaire. I was able to interview diverse stakeholders such as officials and staff members of government bodies, the scientific, and business community and local, national and international non-governmental organisations (NGOs) and community-based organisations (CBOs). Interviewing stakeholders from a wide range of groups aims at getting insights into constraints and opportunities of people as well as a comprehensive picture of the demands, needs and expectations of stakeholders concerning adaptation implementation and knowledge transfer at the grassroots (Remling, 2011). I obtained verbal consent from all my subjects before I commenced any interview and took notes during and immediately after my interviews. I conducted the interviews in Swahili and English.

A structured questionnaire divided into three sections was used to collect two types of variables, i.e. resource attributes and relational data, as described below (Appendix 3). The attributes from crops, livestock, medicinal plants and water were obtained for documenting resource governance activities concerning climate change and resource conflicts.

5.2.1. Climate change matters

The first section collected information about climate impacts, the perceived threats, adaptation strategies and drawbacks to adaptation in the agricultural, medicinal plants, wildlife and water sectors from community members. This section was developed to suit the respondent's livelihood activity in relation to the four ecosystem services, for example a conservationist answered the wildlife section while a pastoralist was given the agricultural section for ease of understanding.

5.2.2. Resource conflicts and resolution

The second section queried the trends of conflict, causes, underlying drivers (political or socioeconomic) and resolutions adopted over conflicts over the four ecosystem services. This section was administered to all respondents equally.

5.2.3. Governance collaborations

The final section collected relational (network) data using questions about the personal contacts that resource users gain resource knowledge. This used the saturation sampling technique because the study network was small and allowed for detailed and complete analyses of each and every network location (Lin, 1999). Thus, a respondent was asked to name a maximum of five actors they have collaborations in terms of financial support, research & training and project implementation to enhance food production. This actors' list was compiled and where possible, mentioned actors were located and asked about their partners in resource governance, this went on until no new actors were mentioned in the community. A clear interaction relation/tie between the actors was defined to constitute exchanges involving economic, technological and/or social (humanitarian & cultural) resources according to the social resources concept.

Additional data on the attributes of actors (in relation to the research question) are required to create a comprehensive composition-structure framework of explanation (Prell, 2012). This information is important in social network analysis because the logical or mathematical formula of social network analysis only supplies part of the full meaning of a realistic construct (Ramirez-Sanchez, 2007). Thus, for accuracy, I categorised the actors

according to their attribute i.e. type (public, private and civic) and sectors (crops, livestock, wildlife, medicinal plants and local administration).

5.3. Secondary data

5.3.1. Ecosystem services production and utilisation

1. Agricultural production

   The district agricultural office facilitated collection of data (2007-2011) of the yearly production rates, coverage and production rates for subsistence, fruit crops and the horticultural crops. While the district livestock office provided data (2009 to 2011) of the numbers, breeds and types of livestock, livestock trade trends and costs of livestock products.

2. Medicinal plants utilisation

   I collected information on ailments treated by herbalists, plants species commonly used, average number of patients, costs per ailment and treatment duration.

3. Wildlife diversity and population

   Information was sought from relevant actors on wildlife species, population, trends and associated touristic activities.

4. Water resources

   Data was requested on the volumes of water obtained from diverse natural or man-made water sources such as dams, rivers, lakes, springs, boreholes, wells and oasis and the cost of water per litre in the urban centres from the water stakeholders.

5.3.2. National climate change response strategy

The strategy stipulates specific adaptation activities for each ecosystem service that is commercially exploited except medicinal plants. Hence, I studied the strategy and extracted the adaptation measures proposed for agriculture, medicinal plants, wildlife and water ecosystem services (Appendix 4). This action will enable me to compare adaptation activities implemented at the grassroots against what is proposed at the national level.

Scope and limitation

Defining a network boundary is complicated (Prell, 2012) by the fact that actor linkages are transboundary in nature and extend infinitely according to the unproven “six degrees of separation” theory. Also, complications arise from issues associated with population and sampling complete networks. Therefore it is imperative to designate a boundary for the community network. Subsequently, I chose the administrative district boundary designated in December 2006 and gazetted by the government in 2007 as the ideal boundary marker.

Obtaining ecosystem services data become complicated as the barely decade old district did not have comprehensive data records on certain natural resources such as wildlife and medicinal plants. Also monetary valuation of ecosystem services is a fairly new concept in resource governance.

During data collection, I confirmed the sensitivity surrounding public declaration of herbal practice in relation to witchcraft claims since a detailed explanation was required to promote discussion and participation. This fear of being labelled as “primitive” or “evil” reveals that the public is not adequately informed about the rights of, history behind, opportunities and benefits of herbal products and medicinal plant species.

CHAPTER 6: DATA ANALYSIS

6.1. Introduction to chapter

I administered the questionnaire to 152 respondents and conducted interviews with 54 experts in Nairobi, Kajiado and Loitoktok towns. For a detailed overview of the expert interview partners see Appendix 5. The questionnaire also guided 6 group discussions in Loitoktok (Appendix 6). Analysts assume that once the population of interest has been defined, then the system is closed, but in reality actor relations extend to the other localities in complex social integration with the larger polity (Ramirez-Sanchez, 2007). Therefore, in this chapter it is assumed that the ESG approach is investigating the conditions under which actors access and use ecosystem services only within the Loitoktok vicinity. The collected data was analysed as follows.

6.2. Monetary valuation of ecosystem services

I followed the guidelines developed by Pearce et al., (2006), Voeks & Rahmatian (2004) and De Groot et al., (2006) for conducting the economic valuation of ecosystem services.

6.2.1. Food products

The monetary value of crops and livestock in Loitoktok district was calculated using the 2013 Base Exchange rate ($ 1= KES. 85), as follows:

1. Economic valuation of all the crop types grown in the district was calculated using the harvest rates and available annual market prices.
2. The monetary value of livestock was calculated using current market prices for live animals which gave the total value of estimated annual livestock population. Livestock products were similarly cost using market prices and the trade (import and export) compounded from the extension officers data.
3. Valuation of honey was done using the two-step formula below
   a) To estimate the total quantity of honey harvested per hive

$$Honey_{Kg} = H \times 0.8 \times 11\ Kg \times 3$$

Where:

H = Number of hives,

0.8 = Hive occupation rate,

11kg = Estimated yield per hive per harvest,

3 = Harvests possible per hive per year

b) To get monetary value of honey in dollars,

$$Honey_{\$} = Honey_{Kg} \times \frac{150}{85}$$

Where: 1 Kg of crude honey = KES 150.00

6.2.2. Medicinal plants

Obtaining raw medical plants purchase costs is almost non-existent because many herbalists harvest the plants from their own farms and also practise barter trade among each other. Thus, economic valuation of medicinal plants was done using the reference method to calculate the income generated from prescribing herbal products as an indirect measure of their economic value. This method is preferred because it compares medicine costs charged by herbalists against established costs of treatment from health centres for the 14 key identified ailments in the district.

6.3. Resource determinates

The choices about climate adaptation and resource conflict issues by respondents were ranked according to percentiles to reflect stakeholder preferences.

6.4. Social network analysis

The actor relation data was entered into an excel spreadsheet as a matrix where each cell is indexed by a row index and a column index. Both rows and columns were labelled with similar actors creating a square matrix whereby each cell is referenced by specifying a row actor i and a column actor j to give a cell content of, a_{ij}. Relations were non-valued i.e. either present or absent

$$a_{ij} = 1, if\ the\ relation\ was\ present$$

$$a_{ij} = 0, if\ the\ relation\ was\ absent$$

There was also a second entry, a_{ji}, indexed by the same two actors but in the opposite order.

Standard tools of inferential statistics do not apply directly to network data. The reason is that observations in network data are not independent: hence, estimating standard errors, computing test statistics, and assessing the probability of null hypotheses can produce "false positive" answers more often than "false negative" ones (Hennig et al., 2012; Ramirez-Sanchez, 2007). Alternative numeric methods are used to calculate distributions of statistics directly from observed networks as implemented in specialized software for social network analysis (Borgatti et al., 2002; Hanneman & Riddle, 2005).

Guided by network theory, equations for the selected measures of social networks that quantify patterns of interactions and indicate the level of synergy among actors involved in ecosystem service governance are given below.

6.4.1. Network closure

6.4.1.1. Density

This is an indicator of how actors are linked together (Prell, 2012). The density (di) formula below calculates the proportion of ties present in a network and helps to understand the community behaviour, attitudes and performance.

$$d_i = \frac{L}{n\,(n-1)/2}$$

Where:-

n = number of actors connected to actor i

L = number of lines between the actors

6.4.1.2. Degree centrality

This equation measures the size of a focal actor's local network as an inference to the level of involvement in the network. The equation below calculates centrality values for binary and symmetric data matrices (Prell, 2012).

$$C_D(i) = \sum_{j=1}^{n} x_{ij} = \sum_{i=1}^{n} x_{ji}$$

Where:

x_{ij} = the sum of all ties from actor i to actor j

n = the number of nodes in the network

6.4.2. Structural holes - Betweenness (medial) centrality

This captures how much potential control an actor has over the flow of information in the network. If an actor rests between many other actors then this actor can choose to withhold or distort information that circulates in the community (Bodin & Prell, 2011).

$$C_B(k) = \sum_{i \neq j \neq k} \frac{\partial_{ikj}}{\partial_{ij}}$$

Where:

∂_{ikj} = number of paths linking actors i and j that pass through actor k

∂_{ij} = number of paths linking actor i and j

6.4.3. Beta centrality

In order to verify the centrality results, Bonacich developed the "beta-centrality" which is an index that simultaneously critiques other centrality measures to identify the actual powerful actors in the network but who could be in the periphery of the network (Prell, 2012). The equation for beta-centrality is

$$C_\beta(i) = \sum_{j=1}^{n} A_{i,j}\left(\alpha + \beta C_\beta(j)\right)$$

Where:

α = a scaling parameter to normalize the score

β = value reflecting the amount of dependence of actor's i centrality on others directly connected

$A_{i,j}$ = the adjacency matrix

$C_\beta(j)$ = the centrality of j (i.e. the centrality of i's partners)

Note: To compare centrality scores of actors across networks, the scores must be mapped to a common scale. One of the methods used is normalisation whereby each centrality score is divided by the sum of all scores to yield the share of importance for each particular actor.

I used UCINET program to conduct the social network analysis and then converted the results into attribute matrices for visualization by the Netdraw program by (Borgatti et al., 2002).

Chapter summary

In this chapter I have outlined the systematic procedure for analysing data under the guidance of the ecosystem service governance approach. Unfortunately, this study only assessed the monetary values of agriculture and medicinal plants sectors, as they had enough quantitative data to give reliable valuation results. Lack of comprehensive data on wildlife species and population, and water source data from the respective resource managers made the holistic valuation process almost unmanageable for the district.

CHAPTER 7: RESULTS

7.1. Introduction to chapter

This chapter presents results obtained from implementation of the ecosystem service governance approach. The monetary values clearly reveal recovery trends in ecosystem service production following the 2009 drought episode. Analysis of climate change responses confirms that the community recognizes the need to adapt to the environment to safeguard their livelihoods. While, the conflict resolution measures reveal a collaborative structure that spans only three sectors since there were no conflicts recorded in the medicinal plants sector. Finally, Illustration of the entire social network reveals the central actors and how they are linked to achieve their recourse governance objectives. Collective results confirm that holistic analysis social structure does indeed reveal constraints and incentives that influence how individuals to think and/or act a particular way (Prell et al., 2010).

7.2. Monetary valuation of ecosystem services

7.2.1. Crops

Crop production was approximately valued at $400million[32] per year and comprised of 98.53% subsistence crops, 1.4% horticultural and 0.07% fruit crops (Table 7.1). The results also reveal the effect of the 2009 drought episode on crop yields and incomes whereby subsistence farmers suffered 69.2% ($330million) loss in income due to a loss of 68.5% in production especially maize and beans. Similarly, harvest of horticultural crops fell by 52% but since these crops are traded in external affluent markets, the prices increased marginally to give farmers some income despite the low yields. The type of fruits planted have deep root-systems to survive drought episodes, thus fruit farmers' reaped a bumper harvest (94.4%) and the subsequent demand-supply dynamics ensured super profits for the farmers.

[32] The exchange rate used is $1 = KES 85.

Table 7.1: Crop coverage, production rates and monetary values, and the estimated impacts from the 2009 drought in Loitoktok. Source: The author.

Estimated annual performance of crop farming in Loitoktok district						
Categories of crops	Total area (Ha)	Av. production (T/yr)	Gross value KES/yr (million)	Gross value $/yr (million)	Drought impacts in 2009	
					Monetary value	Productivity
Subsistence	68,614.37	919,435.41	33,523.00	394.39	-69.2 %	-68.5 %
Horticultural	1,171.20	23,884.00	475.15	5.59	0.13 %	-52.2 %
Fruit	117.00	1,426.25	24.25	0.28	82.1 %	94.4 %

The prominent survival strategy of famers is planting subsistence and horticultural crops with fruit trees to provide additional incomes.

Trends in crop production

Crop diversity demonstrated irregular productivity trends in the district (Figure 7.1). For example, chillies (*Capsicum annuum*) cultivation has diminished while the cultivation of kales and sorghum has increased. In 2010 (post-drought), there was a large increase in indigenous crops such as kale (*Brassica oleracea*), pigeon peas (*Cajanus cajan*) and sorghum (*Sorghum bicolor*), that have low water requirements but give high returns since demand is consistently high. Only dolichos and French beans, which are both horticultural crops and are sold in urban centres, had almost regular production rates. Maize, beans, tomatoes and onions were excluded from the graph because of their high production values.

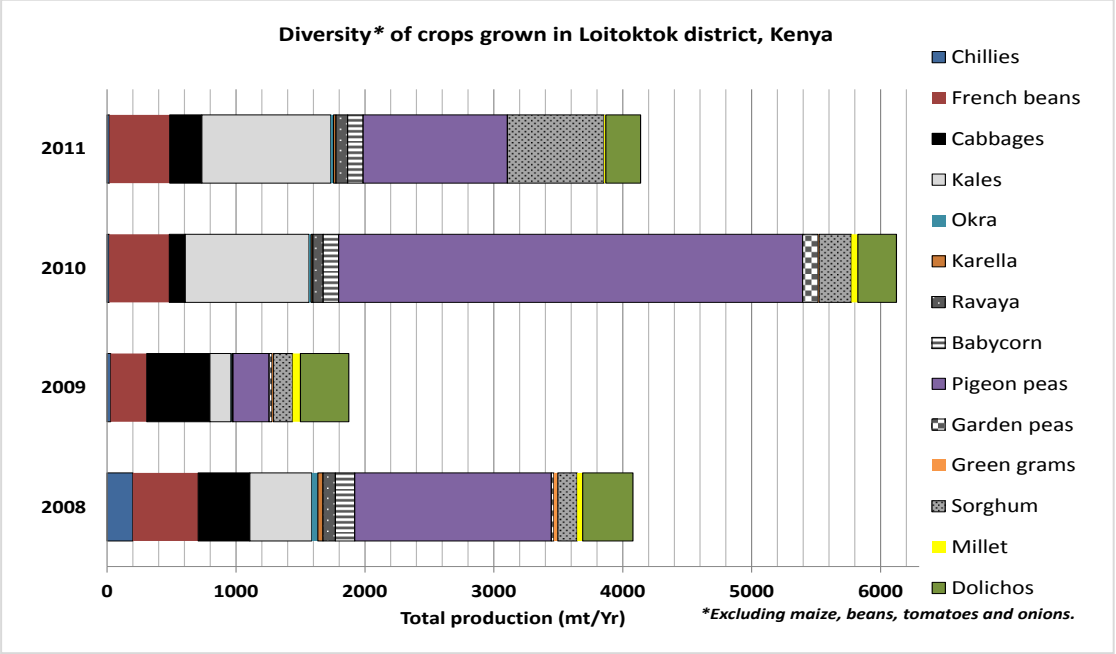


Figure 7.1: Diversity of crops and related production values in Loitoktok district. Source of data: District Agricultural Office

7.2.2. Livestock

Summation of livestock population gave an average annual figure of 723,382 individual animals in Loitoktok district. In the district, milk (43 million L/yr.) is the highest produced item followed by beef, mutton, eggs, poultry and pork at 21,084kgs, 10,422kgs, 106,884 trays, 37,421kgs and 2,100kgs per year respectively (Figure 7.2). Honey production is slowly gaining ground as the community has acquired over 16,000 beehives (including 10,240 commercial hives) in order to engage in the lucrative sector.

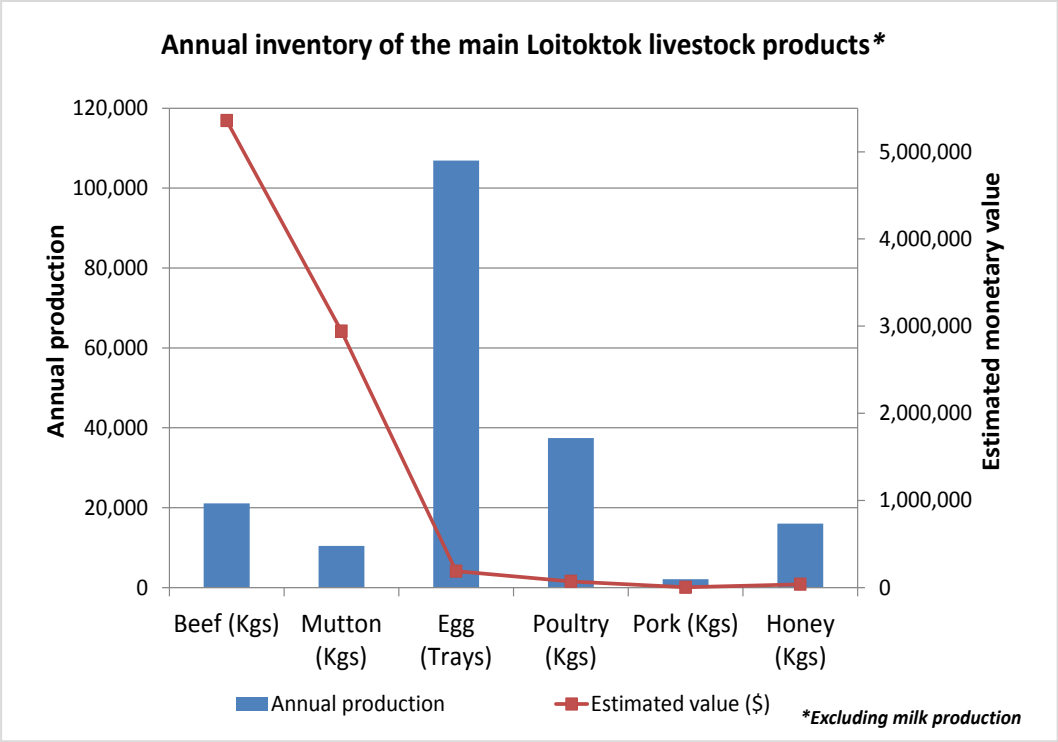


Figure 7.2: Production and monetary values of livestock in Loitoktok. Source of data: District Livestock Office.

The estimated annual monetary value of livestock population and associated products is $126.13million (Table 7.2). Scrutiny of the livestock market reveals higher export values than import costs. Whereby exported livestock comprise of cattle, goats, sheep and hides that were valued at $0.36m, $0.9m and $0.4m in 2009, 2010 and 2011 respectively. Livestock imports earned $0.038m (2009), **$0.052m (2010)** and $0.026m (2011) for the district. Analysis shows a slight increase in 2010 of 34.8% that could be as a result of the community buying more dairy cattle and goats to restock their herds after drought decimated the livestock population in 2009. The community also bought Dorper sheep,

Galla goats and camels that are indigenous to arid environment, have high demand by meat traders and also give good profits to the farmers.

Table 7.2: Estimated monetary values for the entire livestock sector (per annum) in Loitoktok. Source of data: District Livestock Office and own calculations

Livestock (2009-11)	Categories	Gross value KES/year (million)	Gross value $/year (million)
Domestic	Livestock population	9,120.71	107.30
	Associated products	1,600.05	18.82
Commercial	Export	47.21	0.55
	Import	3.27	0.03

7.2.3. Medicinal plants

The survey identified fourteen ailments that are treated by herbalists in Loitoktok. Valuation was based on the prevalence rate of the diseases in Kenya and the income estimated from a thousand patient visits per herbalist. Table 7.3 shows the amounts charged by herbalists compared to costs averaged from 6 formal health centres and estimated incomes. The herbalists gain an income of KES3.78million (personal calculations – Table 7.3) with a difference of KES1.042million against the formal health centres relatable income. The difference is attributed to low overhead costs for herbalists and the fact that they do not process herbal products into complex forms like capsules or packaged syrups. To avoid health complications, herbalists refer critical patients to hospitals especially for suspected cancer, Tuberculosis or advanced HIV cases.

Table 7.3: Ailments treated and estimated income per Loitoktok herbalist. Source: The author.

	Common ailments	Cost of Medicine (KES)		Income per 1000 patients (KES)	
		Herbalist	**Allopathic**	**Herbalist**	**Allopathic**
1	Amoebiasis	300	769	24,752	63,463
2	Malaria	300	558	13,985	26,028
3	Typhoid	800	2,175	9,901	26,918
4	Tonsillitis	800	733	35,314	32,371
5	Brucellosis	800	1,508	75,908	143,117
6	*Trichomonas vaginalis*	1,500	482	69,926	22,454
7	Blood pressure	4,000	2,649	346,535	229,493
8	Bronchitis	4,000	3,040	181,518	137,954
9	Fibroids	2,000	9,750	206,271	1,005,569
10	Hormonal imbalance	2,000	2,202	92,409	101,743
11	Ulcers	3,000	4,316	678,218	975,729
12	Prostate cancer	10,000	19,500	387,789	756,188
13	Goitre	10,000	5,280	482,673	254,851
14	Colitis	15,000	13,350	1,175,743	1,046,411
Total KES (million)				**3.78**	**4.82**
Total $ million				**0.044**	**0.057**

*The charges shown are only the cost of medicine consumed and do not include consultancy, diagnosis and laboratory charges found in the formal (allopathic) healthcare system.
* The costs are compared with formal health care costs to calculate average income for a herbalist per 1000 patients in Loitoktok

The indicator used to confirm the nature of this thriving sector is the increasing domestication of certain "imported" plant species from other regions that are found to have wide variety of uses in medicinal products prepared by herbalists. These are *Mondia whytei, Annona Squamosa, Moringa oleifera, Tamarindus indica* and *Azadirachta indica*.

7.3. Resource governance assessment

The correspondents agreed that the supply of ecosystem services has declined generally in the area except of course the agricultural sector which has flourished in terms of crop diversity and harvest rates. In particular, habitat degradation was the highest culprit driving biodiversity loss, followed by livestock interference in protected areas, which was also seen as a potential transfer point for livestock-wildlife diseases (Figure 7.3). The interviewees also felt that variable precipitation and temperature changes were somehow responsible for decline of natural resources but majority believed that rainfall and droughts are beyond their control.

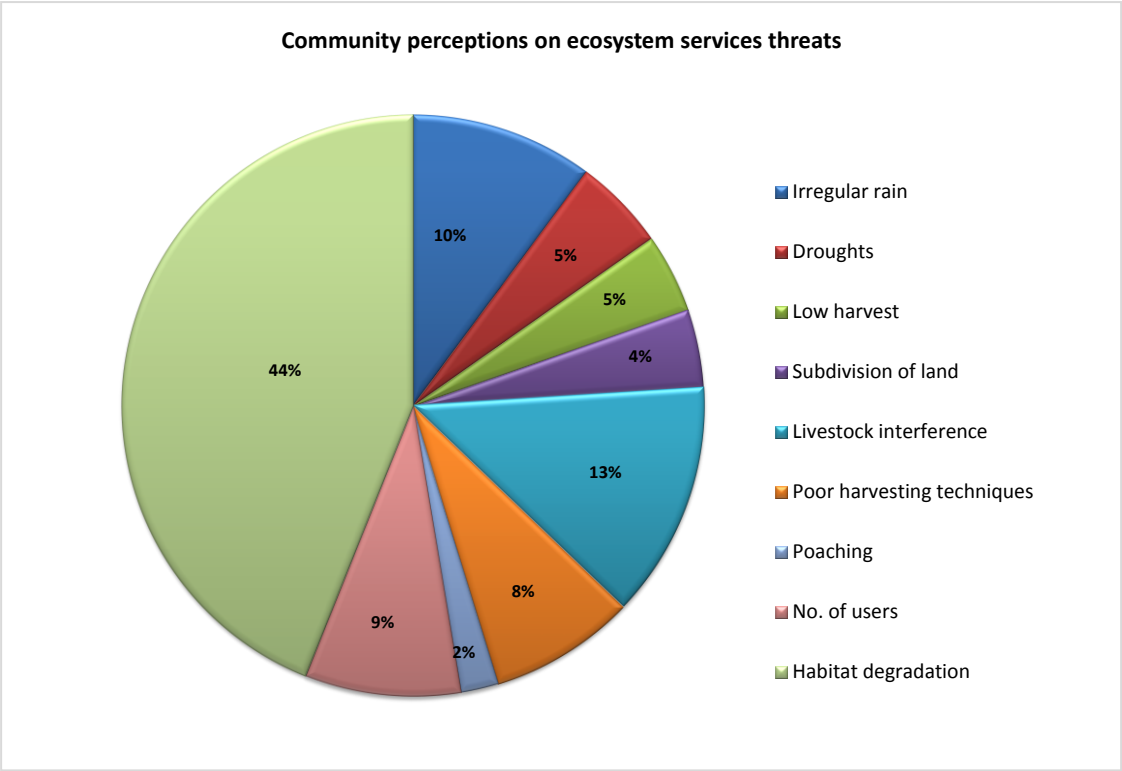


Figure 7.3: Factors affecting ecosystem services supply in Loitoktok.

7.3.1. Climate change perceptions

Respondent results were variable to a certain extent i.e. the agricultural and water sectors were the most affected by the unreliable precipitation patterns while the wildlife and medicinal sectors were most affected by biodiversity loss due to ecosystem changes. The drought episodes affected all sectors almost equally. The interesting thing is that the temperature variation (especially increase) was not seen as a major factor in ecosystem service production (Figure 7.4). This could be an indicator of low existence of climate change information among the respondents regarding temperature influence on environmental conditions.

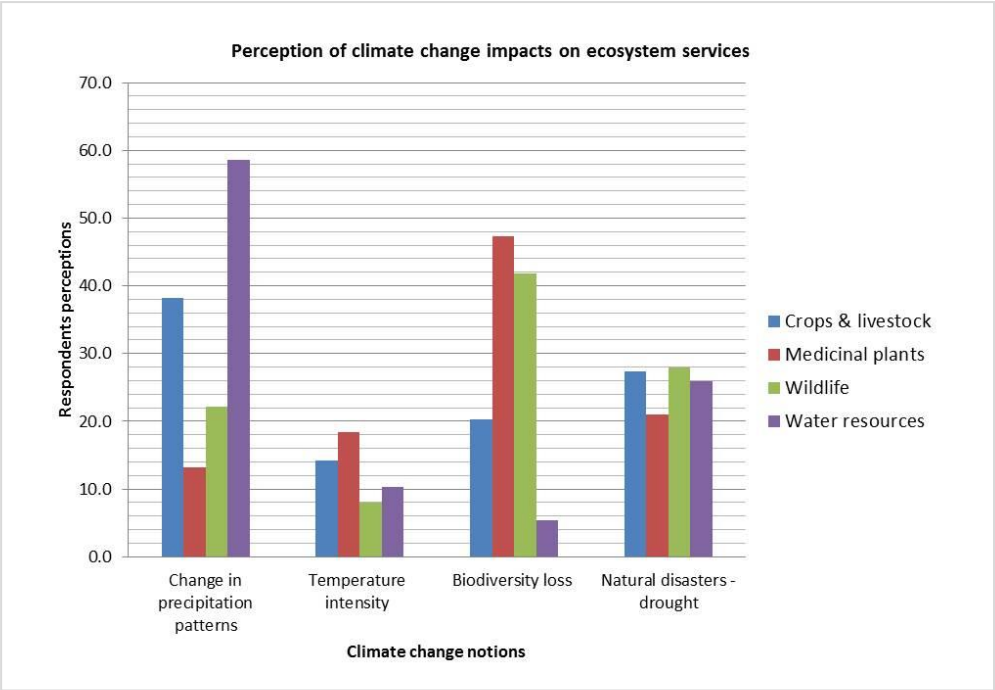


Figure 7.4: Respondents view of climate change impacts on ecosystem services in Loitoktok.

7.3.2. Adaptation activities

Respondents identified several measures they have adopted to ensure supply of ecosystem services, boost their livelihoods and income generation (Figure 7.5). These include: Their first priority was to secure their water resources through rain water harvesting and efficient irrigation methods. Second, they favour participating in training workshops to gain more knowledge on sustainable resource use on water use, viable herbals harvesting techniques. Third, they also implement soil and nutrient management measures to ensure good harvest and prevent soil erosion, and also buy "improved" crop seeds and livestock breeds that are mainly indigenous to the arid climate. Fourth, to encourage the community to embrace wildlife conservation, stakeholders have increased incentives to conservation activities such as shared incomes with the community and identified problematic wildlife are translocated to other parks. An interesting find is that majority of the respondents admitted to have planted medicinal plants within their homesteads to secure their own individual supply. Few activities were not popular in the community, namely, adoption of alternative livelihood activities since people preferred to continue with their cultural-related livelihoods. Also, the respondents stated that there were few public wildlife conservation awareness campaigns in the district.

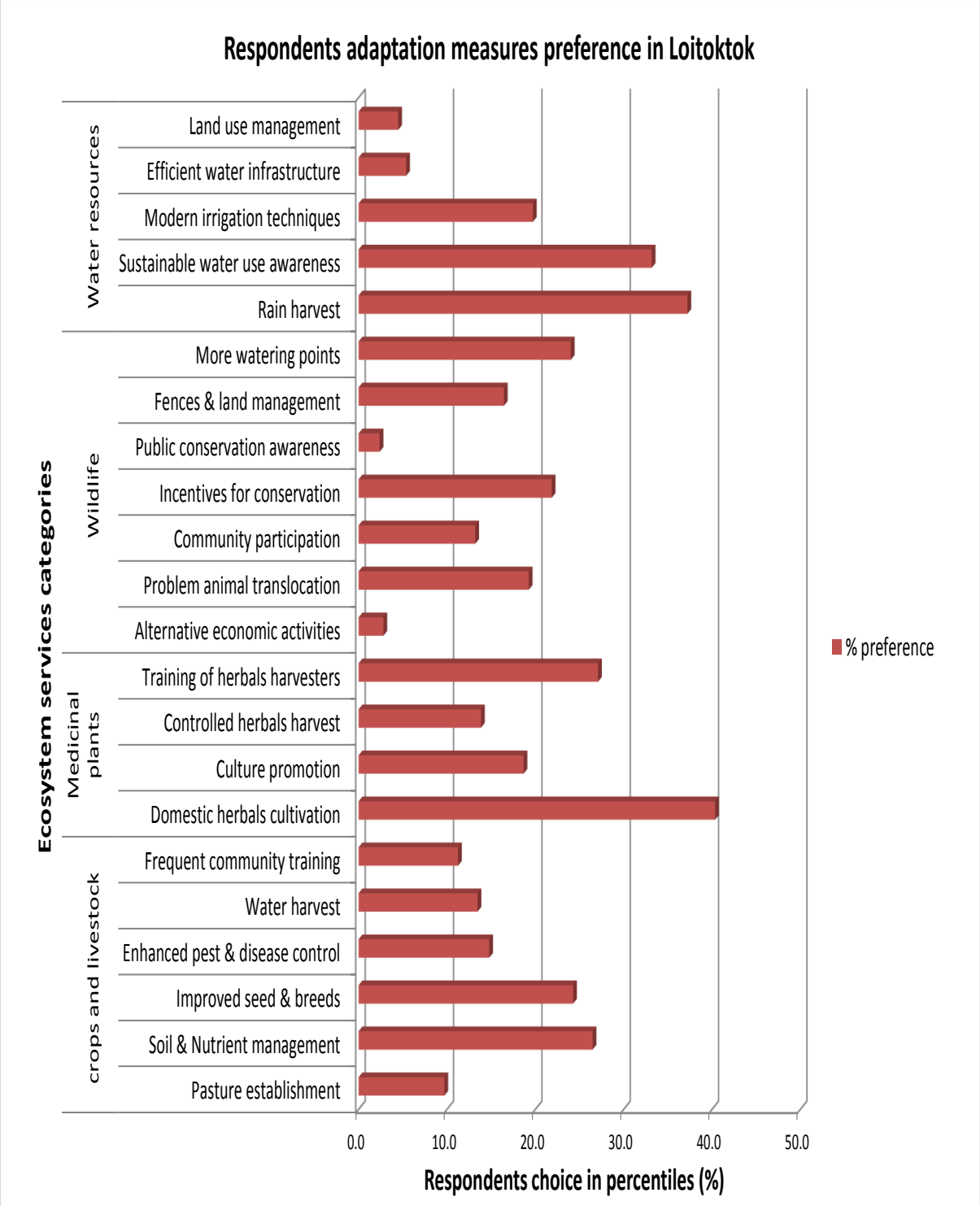


Figure 7.5: Remedial measures adopted by the community to safeguard resource security in Loitoktok.

7.3.3. Resource conflict resolution

All respondents agreed that inclusion of culture in the conflict resolution process gave the community confidence in decisions agreed after deliberations and that the main aim of a conflict resolution was to reduce tension or violence by bringing the conflicting parties together. This coincides with principles of natural resource management that emphasize the

need for cooperation as a necessary precondition for sustainable conflict resolution. Table 7.4 illustrates practically how different resource conflicts were resolved between November 2011 and November 2012 at Oloolopon Location in Loitoktok.

Table 7.4: The annual resource conflict report of Chief Leonard Kasine in-charge of Oloolopon Location in Loitoktok district

Resource	No. of conflicts	Conflict site	Resolution	Stakeholders involved
Water	3	Shurie	Compensation	Council of elders, Chief and residents
	7	Impiron	Community discussion	WRMA and Chief
	1	Airstrip	Community discussion	Nolturesh Water Board and Chief
Livestock	16	Korinko village	Fine after agricultural assessment	Agricultural extension officers, police, Chief
	26	Inkariak-Rongena	4 fined by court 22 fined after agricultural assessment	Agricultural extension officers, police, Chief
	11	Kamukunji	Compensation to farmer	Agricultural extension officers, Chief
Wildlife	30	Sompet	Compensation	KWS, Private investor – Elephant Research Org.
	6	Ilmisigiyio	Compensation	KWS, African Wildlife Foundation

It is evident that resolving resource conflict is not the responsibility of a single person or institution, but that even minor conflicts were resolved by a small stakeholders meeting for fair decisions to aggrieved parties e.g. conflict over water at Impiron. The most recommended discipline measure is compensation by the guilty actors to the aggrieved party according to the level of destruction or damage. In extreme cases, when the community felt aggrieved and the situation was thought to likely spread community tension, the chief was obligated to call for joint meetings "*barazas*" for all relevant stakeholders and entire community.

7.3.4. Hindrances to efficient resource governance

The Loitoktok community identified three common factors that were hampering inhibiting dissemination of adaption knowledge and effective governance in the district

(Figure 7.6). First, low finances were cited as a major factor since extension officers and wildlife resource managers needed funds to hold more training sessions to transfer knowledge about improved seeds, animal breeds, technology or acquisition of equipment such as water tanks to the community. Second, low qualified manpower hindered regular and widespread dissemination of climate adaptation and mitigation strategies in the district. From the survey the district extension officers are less than 25 in number in the district but were expected to disseminate all information from private actors across the district. Finally, poor coordination among actors was cited as a hindrance to the flow of information in the social network, whereby government agencies were conducting programs without reference to each other.

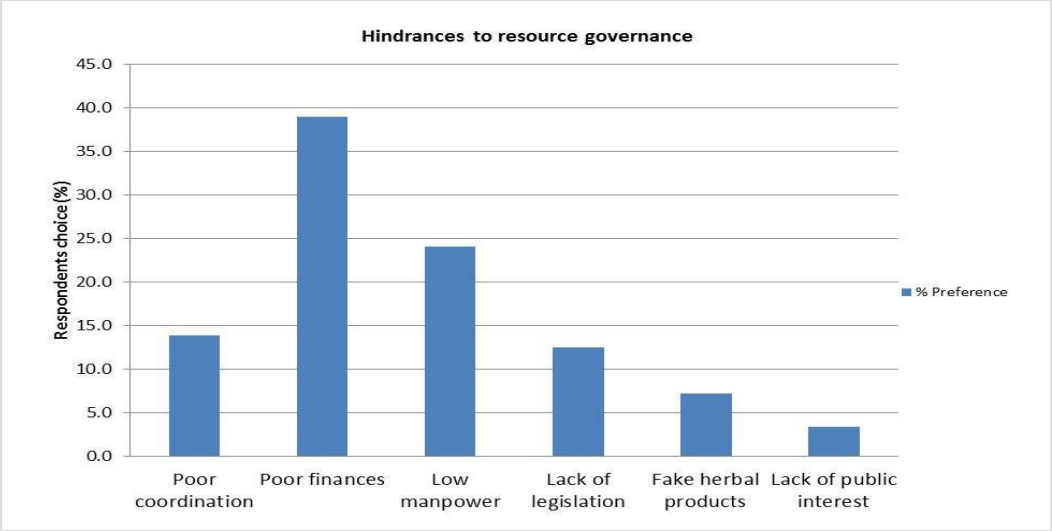


Figure 7.6: Identified hindrances to effective resource governance in Loitoktok.

However since the medicinal plants sector did not have resource conflicts, the respondents suggested their own governance hindrances in Loitoktok. The primary hindrance originates from the fact that medicinal practise is still not recognized as a valid economic sector in Kenya. The other secondary hindrances include; influx of fake herbal products and lack of public interest to learn the cultural practises behind this sector. These factors have led to over-extraction of local species. For example, this action had decimated local plant species like *Olea europaea* "Oloirien" that were now only being obtained from neighbouring Narok and Chyulu Hills and the multiple use *Rhamnus prinoides* that was previously abundant in the area.

7.4. Social Network Analysis

Loitoktok social network is a fairly large one comprising of actors from four main organizational sectors, namely; 24 government agencies (public), 15 non-governmental agencies (NGOs), 39 private companies and 30 types of community interest groups (civic) (Appendix 7). Figure 7.7 shows the breakdown in representation per sector. The agriculture, water and medicinal plants governance are dominated by government agencies and wildlife governance by private actors. In addition, medicinal plants governance is also facilitated by civic actors under the Loitoktok Herbalists Association.

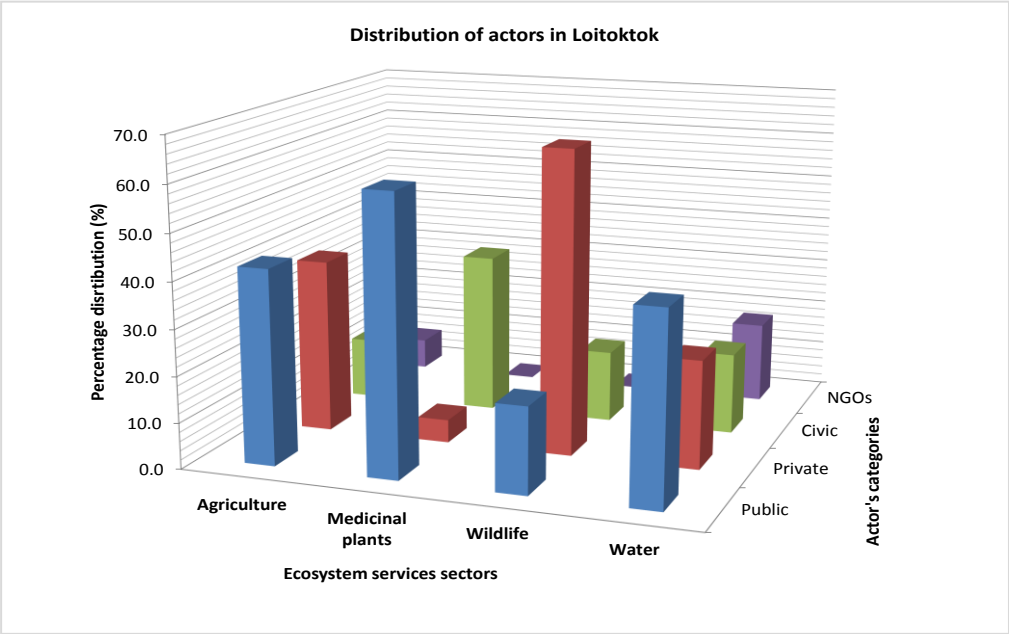


Figure 7.7: Categories of actors involved in resource governance in Loitoktok.

Further analysis of community groups revealed diverse theme-based aggregations in the district (Table 7.5). According to data obtained from the MoGCSD officer, the total number of registered community groups in Loitoktok was 1153 and the highest number of groups recorded is found in crop farming (130), business activities (106), and livestock keeping (51). Only 34 community groups were mainly involved in environment related activities such as maintenance of tree nurseries and tree seedlings sale projects. All these interest groups are formally registered by the social development office (DSdO) before commencing their activities in the district.

Table 7.5: Community interest groups in Loitoktok district.

Economic interest groups		Non-economic interest groups	
Farming groups	130	Welfare groups	91
Business groups	106	Self-help groups	50
Water project groups	66	Education groups	45
Livestock groups	51	Environmental groups	34
Cultural bomas	19	HIV/Aids & Health groups	26
Self-loan groups	7	Anti-female genital mutilation (FGM)	1
Beadwork groups	4	**Total**	**247**
Water resource users association	2		
Herbalist groups	1		
Total	**386**		

Although the total number of registered community groups in Loitoktok was 1153, only activities of 633 groups could be accounted in the district. Assessment of the data register revealed several weaknesses that could hinder implementation of any integrated adaptation strategy in the district. Laxity in data capture of the groups during registration resulted in incomplete data entries, common being missing registration dates. Also, 284 groups did not have the location data and 520 groups did not have the activity data recorded. Such attitude in the administration stakeholder networks indicates ignorance of the importance of proper record keeping which could affect coordination during follow-up, support or audit activities.

In relation to the Revolving Fund Scheme: The WEF funded activities include poultry farming, cattle trade, cereal trade, purchase of water tanks and micro-finance initiatives by the women groups. Similarly, the YEDF funded activities include crop farming, bee-keeping, curio trade, barbershops, carwash stands, steer fattening, cattle trade and poultry keeping. This confirms high economic dependence of the community on natural resources that are susceptible to unreliable rain patterns and frequent droughts associated with climate change.

Loitoktok network is made up of eight major cohesive subgroups, namely, water, agriculture (crops), livestock, wildlife, health (human), education, forestry and social development (Figure 7.8). The subgroups are all interlinked because they are managed mainly by extension officers and other resource managers employed by the government and

hold occasional meetings to plan the district development strategy. Besides, these distinctive subgroups are a sign of an active and structured grassroots organisation.

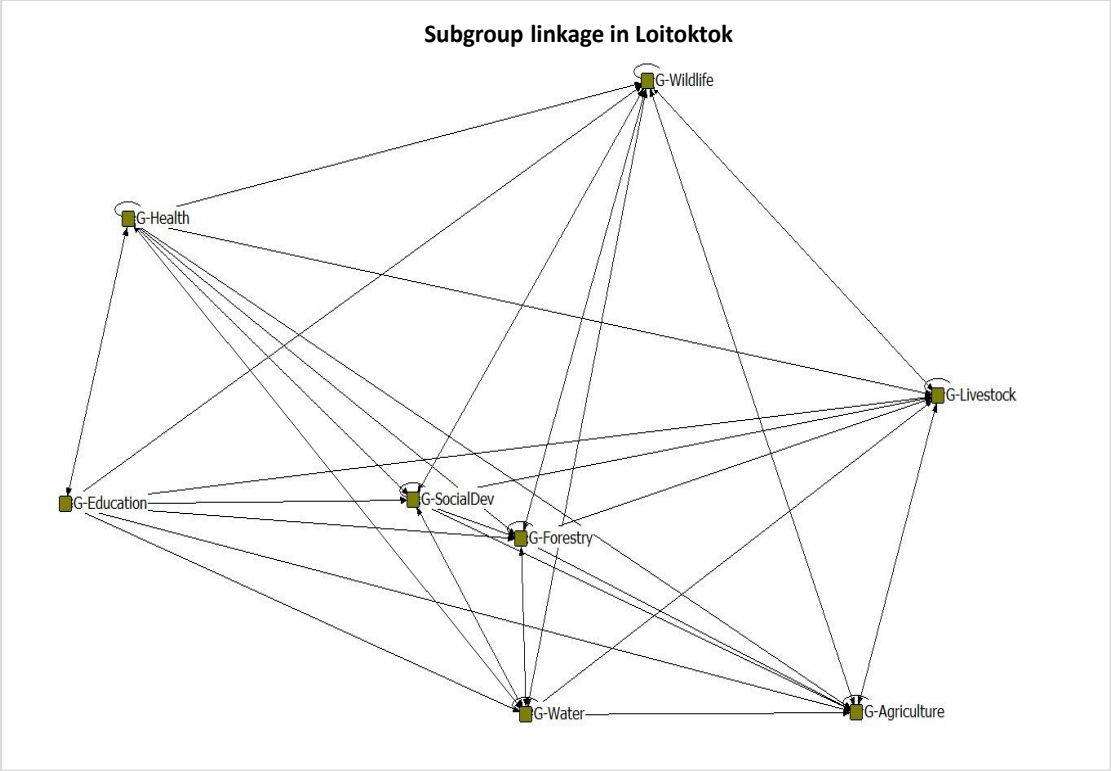


Figure 7.8: Subgroups within the Loitoktok network (G=group).

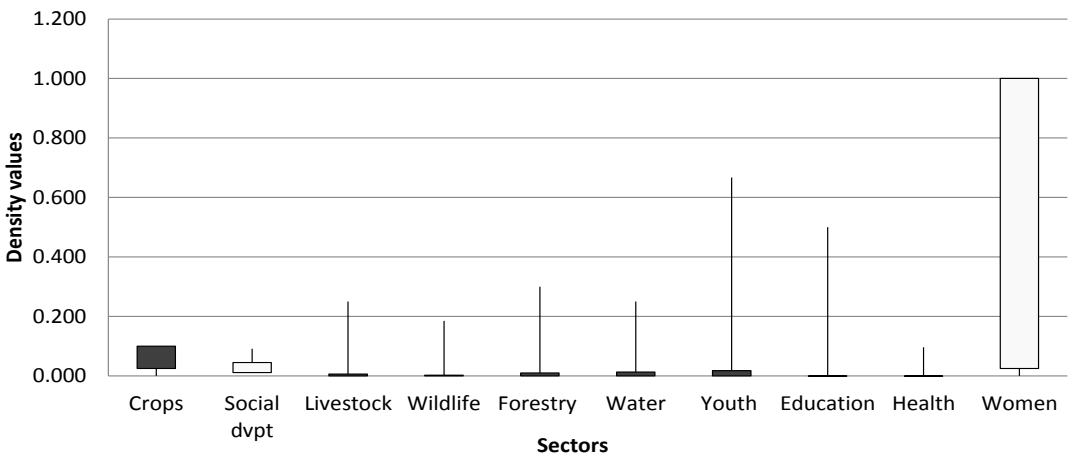
But in-depth network analysis further divided the sectors using the natural and external financial resources driving local ecosystem service utilisation. Therefore the Loitoktok community comprises of 10 actor sectors namely, crops, social development, livestock, wildlife, forestry, water, youth, education, health and women. The youth and women sectors were specially delineated because of the Revolving Fund that specifically targets this demography and hence they operate differently from other community interest groups.

7.4.1. Network closure

Network closure for the Loitoktok community is 0.100. The calculated overall density[33] is 0.029 which indicates that the proportion of ties in the rural community is quite low since only about 3% of the active actors are fully connected to each other. Figure 7.9 indicates

[33] Density measures range from 0 to 1, whereby the closer the value is to 0, the sparser the network is while the closer the value is to 1, the denser the network (Prell, 2012).

that sectors with many actors such as agriculture or wildlife have low density while sectors with few actors like women have high densities. But a look at the diagraph in Figure 7.10 shows the factor behind the density-actor disparity, the agriculture, wildlife and health sectors have the private and NGO actors only connected to the extension office and not to each other. This reduces the actual linkage in the sectors. The same explanation also applies to the social development sector (government agencies and community groups) that is connected to all other sectors but not to all actors in the network. The women sector has the highest density but this is because it comprises of two actors who are well connected in the community network.



Ties within sectors										
	Crops	Social dvpt	Livestock	Wildlife	Forestry	Water	Youth	Education	Health	Women
Number	38	22	14	102	6	14	4	3	15	2
Density	0.100	0.048	0.250	0.185	0.300	0.250	0.667	0.500	0.096	1.000

Figure 7.9: Calculated density measures within sectors and also between resource sectors in Loitoktok.

Secondly, the calculated network centralization is 25.39%, a low value to indicate the lack of a single key core actor in the network. There are **ten** key centres of power in the community namely District Kenya Wildlife Service (DKWS), District Agricultural Office (DAO), (Local Government (DLG), District Health Office (DHO), Tourists, Social Development Office (DSdO), District Livestock Officer (DLO), Game scouts, District Water Office (DWO) and District Kenya Forest Service (DKFS) with centrality values of 30, 28, 22, 18,17,16,15,14,13 and 11 respectively. A full description of the actor labels and their centrality values are given in appendix 8a.

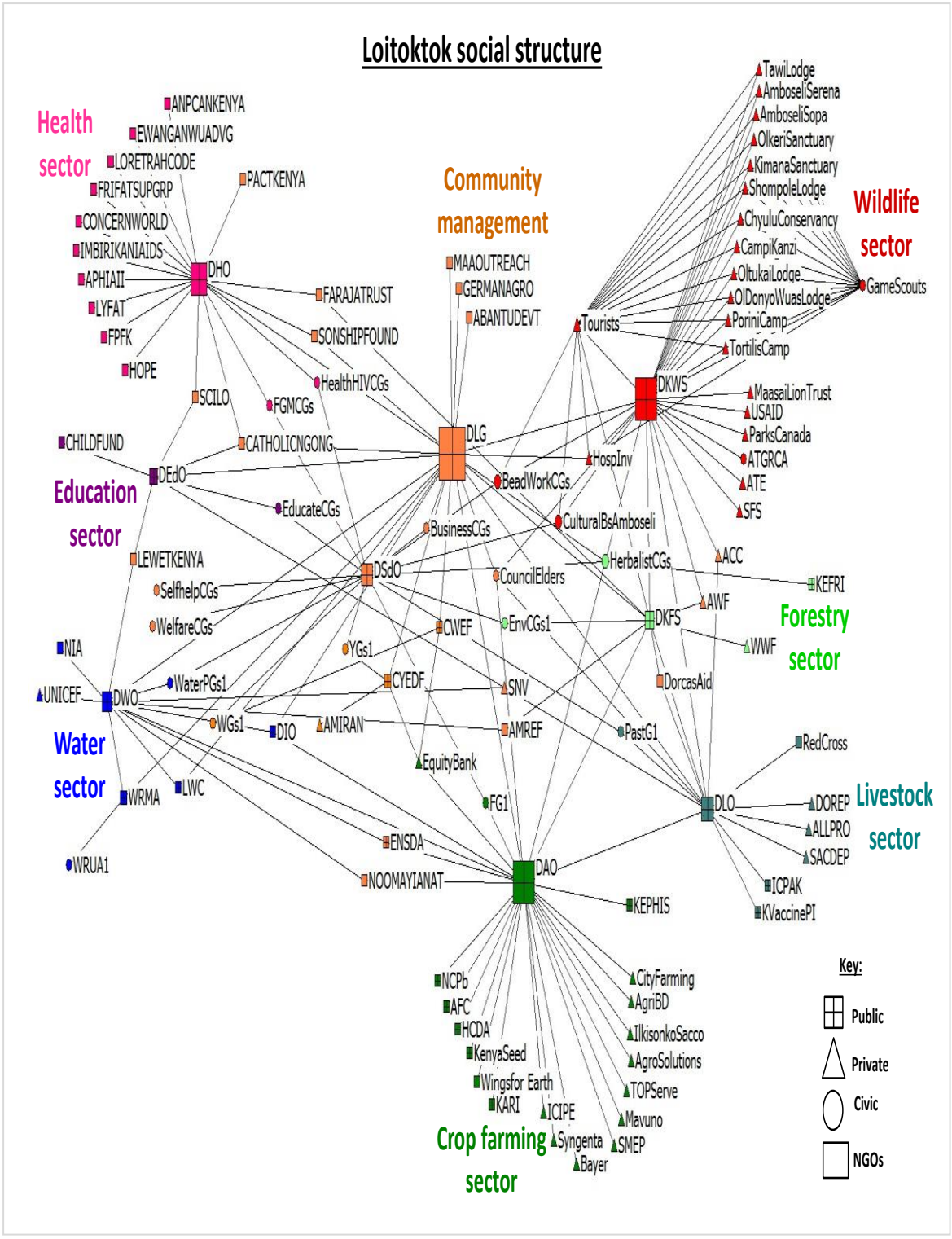


Figure 7.10: Sociograph[34] illustrating actor linkages in resource governance at Loitoktok community

However, Bonacich's power centrality results indicate a different order of central actors in the community i.e. DKWS, Tourists, DLG, Game scouts, DAO, DLO, Hospitality Investors,

[34] The size of the actors was determined using their betweenness values.

DKFS, Council of Elders, Hotels and Lodges, DWO, Beadwork community groups (BeadworkCGs), Cultural Bomas and DSDO with normalised scores of 5.1, 3.2, 2.8, 2.7, 2.7, 2.1, 1.7, 1.6, 1.5, 1.3, 1.2, 1.1., 1.1 and 1.0 respectively. This confirms the *prominence of the wildlife tourism sector* in the resource governance agenda of Loitoktok district.

7.4.2. Structural holes

Actors with the highest values are more visible, have the highest degree of ties and are involved centrally in resource governance in the network. i.e. DAO, DKWS, DLG, DSdO, DLO, Tourists, DWO, District Health Office (DHO), DKFS, Game scouts, District Education Office (DEdO) and Constituency Youth Enterprise Fund office (CYEDF). The calculated betweenness scores for these identified central actors are 713.9, 614.2, 406.4, 235, 180.9, 128.5, 120, 96, 81.5, 78, 22 and 12 in the same order respectively. The rest of the actors and their respective betweenness scores are in appendix 8b.

In addition, deeper analysis of this network revealed that the DSdO (registration institution) and the revolving fund institutions are not connected to each other. Hence, out of the 1153 registered community interest groups only 96 groups are accounted for in the official fund network meaning that the remaining 757 registered youth, women and self-help groups together with their activities are unaccounted in Loitoktok. If Loitoktok is to have an effective adaption strategy then these missing groups need to be identified and weaved into the network to safeguard the local resource stock.

7.4.3. Brokers

Brokerage opportunities were mainly noted for 12 actors with the potential to create more than 10 new links in the community. More specifically, these brokers are: DKWS, DAO, DLG, Tourist, DSdO, DLO, Game scouts, DWO, DKFS, DHO, DEdO and CYEDF. Their values are 764, 729, 426, 241, 236, 189, 156, 130, 87, 66, 17 and 12 respectively. The rest of the actors and their respective brokerage opportunities are in appendix 8c.

DAO, DLO and DWO connect actors with adaptation knowledge (source) to resource users to boost their productivity and incomes. While, the DSdO connects the 1153 community groups to the local government office (DLG) for accreditation. After accreditation, the community groups link with the Constituency Development Funds offices

(CYEDF & CWEF) for financial support that currently sponsors 71 youth groups and 25 women groups in the district. An interesting fact is that tourists are very important to this network as they link the community (curio[35] sellers and cultural "bomas") to the hotels and lodges through cultural dance sessions at the lodging premises. Tourists also link the community to the wildlife agency though their use of game scouts during nature drives for the holistic wildlife safari experience. Similarly, the game scouts bridge the gap between the hospitality investors, wildlife protection agency and the community. DKFS brokerage value is high because it is connected to other actors with more connections thus raising its own brokerage values. This also makes it a valid third party to many conservation projects or negotiations. The same explanation applies to the DWO and DEdO who coordinate community actions with other actors.

7.5. Single ecosystem service network analysis

A closer look at each resource governance network will enhance understanding of the social network analysis results.

7.5.1. Food production governance network

The Loitoktok food production network comprises of 45 actors. The network has a centralization score of 57.2% because it has four main information centres, namely crops (DAO), livestock (DLO), local administration (DLG) and social development (DSdO). The calculated network density of 0.66 explains the speed in post-drought recovery and outstanding adaptation activity because network theory states that the closer the density value is to 1, the faster speed at which information diffuses among the nodes. Thus the sector is characterised by diverse adaptation measures that target increased yields and incomes for its users. Furthermore, the sector has a collaborative well-established resource conflict resolution structure that seems to be effective in dealing with conflicts as they occur (Figure 7.11).

[35] Wikipedia defines curios as strange and interesting objects. In my view, these items are associated with the culture and practises of indigenous people and are usually bought by tourists as souvenirs.

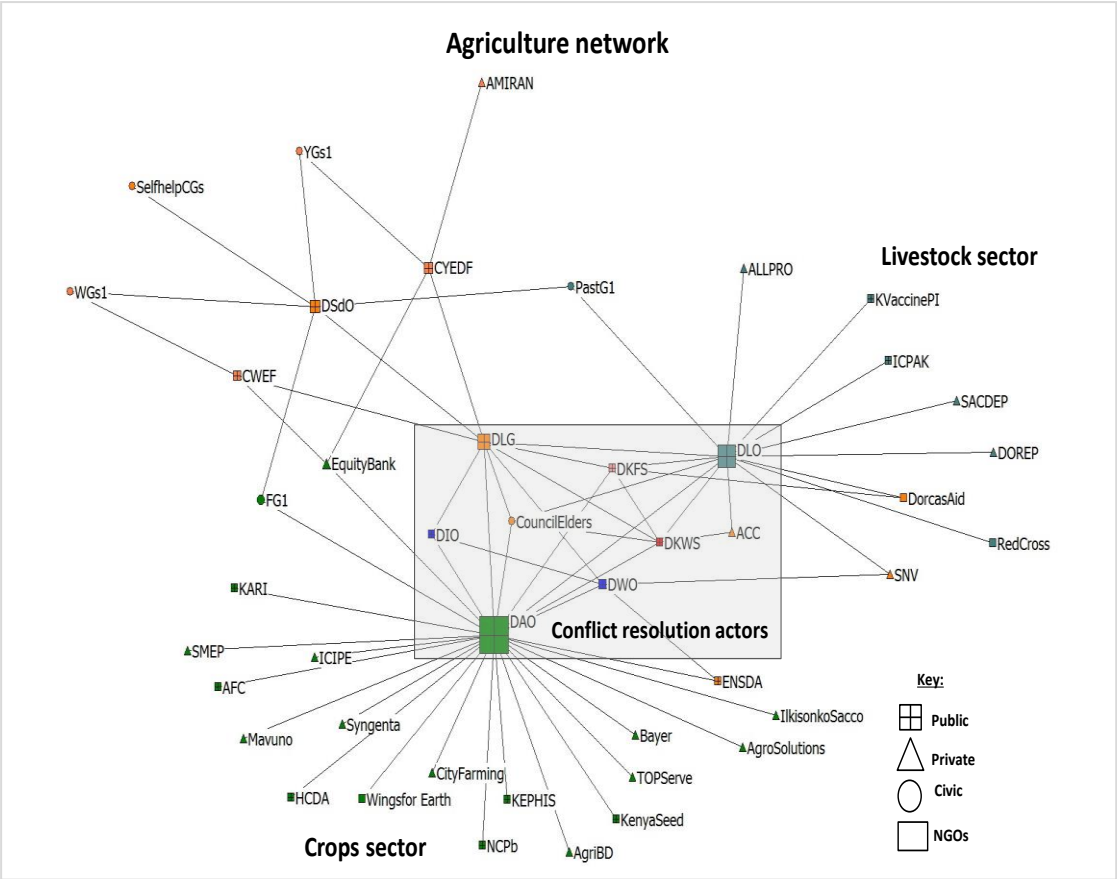


Figure 7.11: Loitoktok food production sector.

7.5.2. Medicinal plants governance network

The medicinal plant sector involves only four actors in the entire district namely, herbalists, Kenya Forest Research Institute (KEFRI), District Kenya Forest Service (DKFS) and environmental community groups (EnvCGs). It has a network density of 0.142 confirming low linkage of medicinal plants actors and the rest of the stakeholders supposed to be part of medicinal plants governance. The network centralization score was 48.5% due to the two main centres of power - District Local government (DLG) and District Social Development Office (DSdO) that link the two separate components of the network together (Figure 7.12).

Adaptation practises in this sector are carried out on an individual basis and revolve around domestication of medicinal plants and public awareness/training by herbalists. The rest of the network remains disassociated with the sector despite the potential strong contribution by medicinal plant activities to crop farming, livestock keeping, tourism, education and health sectors.

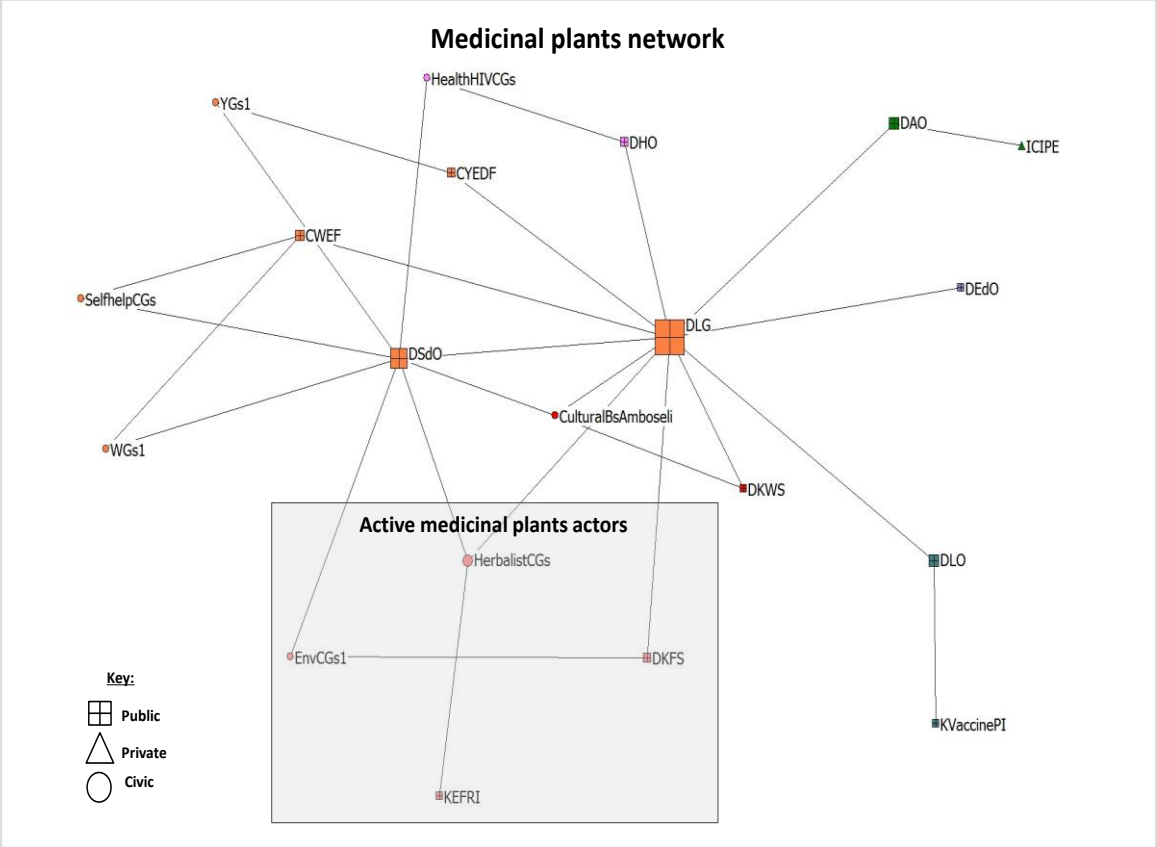


Figure 7.12: Medicinal plants sectors in Loitoktok.

7.5.3. Wildlife (tourism) governance network

The Amboseli network size comprises of 32 stakeholders actively involved in managing the wildlife and tourism sectors in the ecosystem (Figure 7.13). The network has a low density of 0.146 indicating poor linkage among its actors. It has a network centralization score of 87.53% from having one major central actor - District Kenya Wildlife Service (DKWS) – with a betweenness score of 766 and who controls most of the network connections. The other minor central actors are tourists and game scouts with betweenness scores of 241 and 156 respectively.

There are several diverse adaptation measures that are implemented both collaboratively and also at an individual level especially by research organisations. Whereby, the private research actors have projects that have been going on for many years such as the Amboseli Baboon Project started in 1963, Amboseli Research and Conservation Project started in 1967 and Amboseli Elephant Research Project started in 1972.

Similarly, resource conflict resolution is done collaboratively by involving private actors and the traditional council of elders into conflict deliberations.

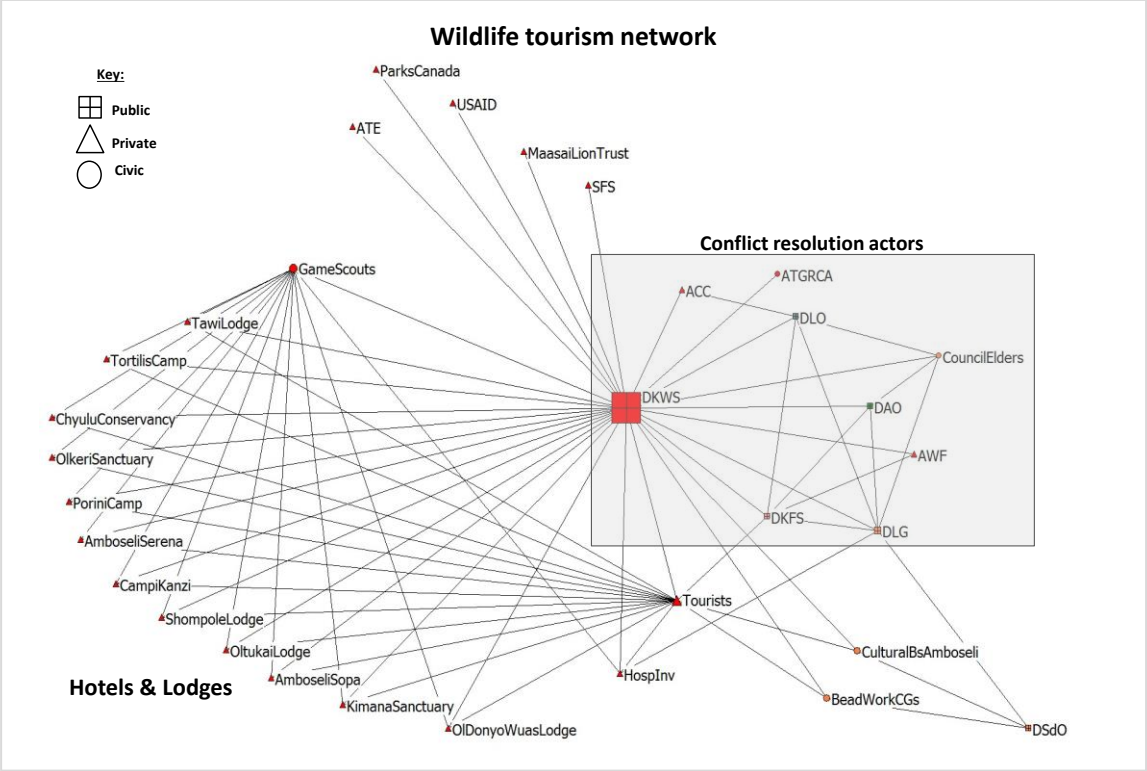


Figure 7.13: Wildlife tourism sector in Loitoktok.

7.5.4. Water resource governance network

The network has a density of 0.13 indicating low linkage between stakeholders involved in water governance. The actor with the highest linkage "power" in the network is DWO who is 55% linked to the rest of the stakeholders (Figure 7.14). In terms of structural holes, DWO has an ego betweenness value of 109, DLG has 37, DAO has 18, WRMA has 4 while Water project groups and Noomayianat each have 2, and the rest of the actors have zero values. The potential knowledge brokers in the network are DWO, DLG, DAO, WRMA and Noomayianat.

The few implemented adaptation measures are mainly done by individuals due to the poor coordination in this sector. While water conflicts are resolved using guidelines stipulated in the Water Act of 2002.

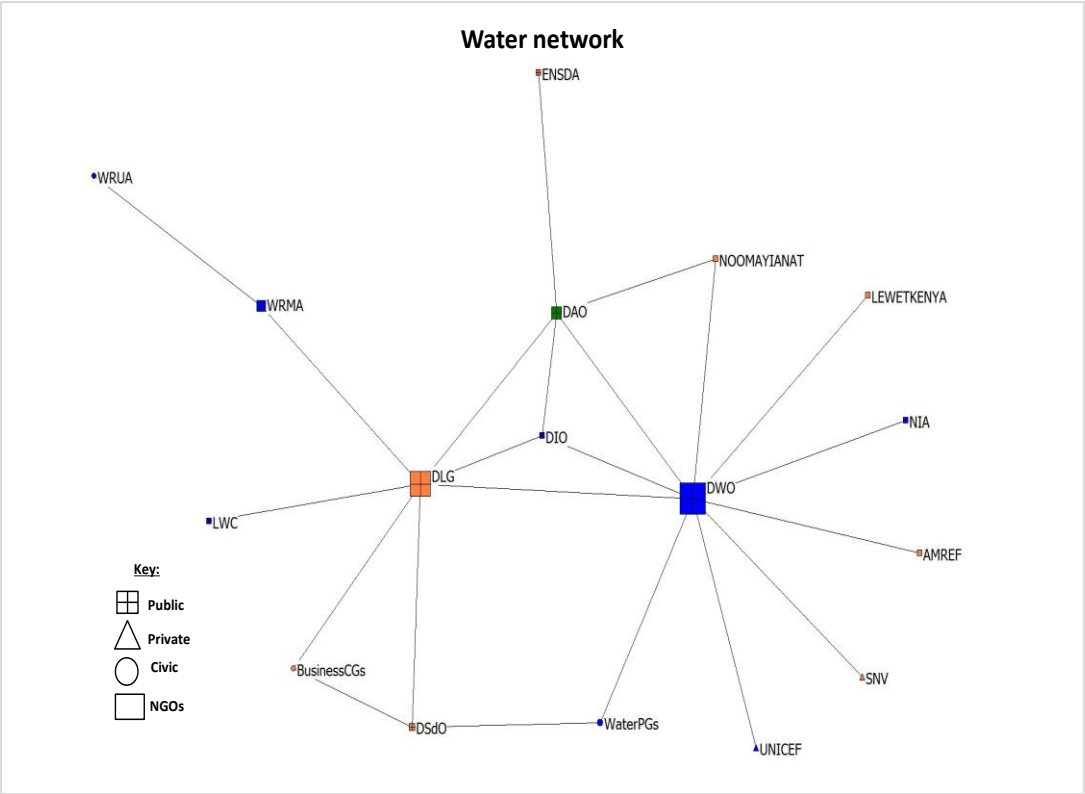


Figure 7.14: Water sector at Loitoktok

Chapter summary

Analysis of the community setup confirms the high influence of the Revolving Fund government scheme in fostering aggregation among women and youth towards forming business-oriented interest groups. Results indicate that the agriculture sector has diverse private actors all using the extension officers to disseminate their information and/or products to the community and hence the rapid post-drought recovery. While the wildlife sector has private actors from hotels and lodges who work with game scouts and KWS to ensure that the rich wildlife status is conserved for their tourist clients. Conversely, poor linkage in the water sector and absent actor linkages in the medicinal plants sector hinders collaborative water conservation and adaptation. The study identifies rural extension officers as the key scale-crossing brokers enabling accurate knowledge transfer regarding complex socio-ecological issues like climate change. Since these brokers are all government agencies then network brokerage longevity is assured *but* a simple change in government policy may cause the Loitoktok network to disintegrate.

CHAPTER 8: DISCUSSION

8.1. Introduction to chapter

This chapter discusses significance of the results obtained using the ecosystem service governance approach in Loitoktok district. This discussion is divided in four sections. First, it evaluates the performance of the proposed approach on identifying actors together with their governance activities and hindrances. Second, it describes the implication of social network analysis on adaptation knowledge exchange and resource conflicts resolution. Third, it analyses planned adaptation using the five pillars of adaption developed by (UNECE, 2009). Finally it describes characteristics of the "optimum" resource governance structure simulated through network weaving that creates missing actor links to enhance information transmission in Loitoktok. In summary, interaction by diverse actors increases social capital which is seen as the engine of economic growth and sustainable development in every society.

8.2. Performance of ESG approach

Efficiency of the ESG approach is seen clearly in results obtained from the climate adaptation and resource conflicts sectors. The general highlights include;

1. There is no monopoly of power in terms of one agency or actor controlling all information flow or resource governance in the district.
2. Presence of ICPAK which is a governmental parastatal responsible for climate change studies indicates that the government is also involved in community-level adaptation activities.
3. High collaboration between KWS, game scouts and hospitality investors explains why the poaching levels are low and Amboseli National Park was ranked among the top destinations in Kenya. In other areas of Kenya, poaching is a major problem.
4. The key custodian of community participation data is the district social development office which is in-charge of registering community interest groups that gives them validity to apply for loans and grants (e.g. Revolving Fund Scheme) to support their livelihood activities or establish mentorship programs by external actors.
5. Poor connection in the medicinal plants sector denies the sector relevant financial support, discourages practitioners, promotes illegal medicinal plants trade and perpetuates negative views of herbal medicine.

6. Incomplete linkage among the Loitoktok water resources actors has created many structural holes that hinder new information introduction and contribute to poor community representation in the network. To cushion this predicament, agriculture, wildlife and medicinal plants sectors include water harvesting, efficient use and afforestation strategies as part of their adaptation strategy.
7. An interesting discovery is the clear link between climate change impacts on resource scarcity, poverty and social vices, seen in the multiple HIV/Aids projects by the huge community health network. The integration of civic and non-governmental organisations and confirms that the community is not only active in reducing stigma and HIV infection rates but is also concerned about securing future human resources to sustain local economic development in the community. This is a potential future research topic.

Specific performance of the ESG is given by results which indicate that after drought episodes, the community had instituted specific changes through directing their resources to known risks to alleviate major negative impacts to their livelihoods. These changes are further described below.

8.2.1. Monetary valuation of ecosystem services

The economic component of ESG approach was used to reveal factors that influence adoption of proposed adaptation activities by stakeholders in Loitoktok (Table 8.1). First factor is *yield performance*, whereby a farmer desires high crop yields and fast maturing animals that can be sold after a season or in less than a year. Second, the proposed adaptation activity must have stable *financial returns* in terms of ready markets (crops, livestock or medicinal product) and also fetch good prices consistently.

Monetary valuation of the food production sector also reveals the trends of crops and livestock production whereby, the farmers have adopted seeds and livestock breeds that are more suitable to the ASAL-region and also have high local demand regardless of environmental conditions. In addition, using diverse arid-indigenous species also increases integrity of the natural environment and lessens damage from climate change impacts.

The monetary valuation also reveals significance of the informal trade of medicinal plants because majority of rural people are dependent on them for food supplements and

also medical treatment in Kenya. If each of the 22 registered Loitoktok herbalists attends to a thousand patients, they could collectively be earning a total gross income of KES.83.2million. To satisfy the growing product demand, herbalists are planting plant species that are becoming scarcer in the region. Unfortunately, (for the government), this income stream is currently untaxed and valuation results from this study should thus convince the county government that medicinal plants and herbalists practice is a potential revenue source. But, when collected this revenue should be returned to the local sector for further research and product development.

8.2.2. Adaptation and coping measures

The diversity in adaption and coping strategies is the direct outcome of a well-linked and functional social network structure that links extension-officers and external stakeholders with the community in Loitoktok. The high number of external (private & NGOs) actors is the avenue through which the community is able to mobilize multiple adaptation options to solve diverse drought-related production problems (Table 8.1). For example, a farmer's exposure to information from seed producers, safe agrochemicals and livestock breeders not only enables the farmer to discard unsustainable traditional practices but also to increase his knowledge for additional income generating activities. Secondly, the consolation fee by a wildlife conservationists and coordinated activities support the basis for the collaborative efforts that have effectively lowered poaching levels to make Amboseli ecosystem among the most attractive tourist sites in Kenya. Most of the technical knowledge on water harvesting and efficient irrigation comes from government agencies. Hence, this study confirms that rural resource governance is not rigid but utilising internal linkages and indigenous knowledge to enhance ecosystem service supply. These results comprise of the first step to implementing what Remling (2011) recommended in her study, which was to develop a catalogue of best practise examples and exchange experiences with different coping strategies and long-term adaptation.

However, despite the high number of private wildlife researchers, integration of these findings into school curricula is minimal to say the least as evidenced by low youth interest in ecological studies and poor research of species apart from the *big five* in protected areas.

8.2.3. Resource conflict resolution

The ESG revealed the dense connectivity in resolving resource conflicts at the community level that is founded on an intricate small committee collectively responsible for easing tension among conflicting parties and even organizes community meetings to discuss large-scale issues (Table 8.1). The key actor responsible for community aggregation is the Amboseli-Tsavo Group Ranches Conservation Association (ATGRCA) which serves as a forum for community participation where importance of wildlife tourism to the local economy is emphasised. It also campaigns for increased compensation packages from the government for deaths and crop destruction caused by wildlife in the area.

Table 8.1: Implemented adaptation measures and the respective knowledge source actors in Loitoktok

Ecosystem service governance component	Indicative result	Knowledge source actor. Full names in Appendix 7
Monetary valuation	Growing low water requirement crops e.g. Kales, onions, sorghum etc.	Kenya Seed, NCPB
	Keeping aridly indigenous livestock e.g. Camels, Galla goats, dorper sheep, Sahiwal bulls	ACC, DorcasAid, DOREP, SACDEP, ALLPRO,
	Increase in horticulture, fruits growing for consistent income	HCDA, EquityBank, AMIRAN, SMEP, Wings for Earth, AFC
	Domestication of wild medicinal plants for constant supply	DKFS, EnvCGs, Herbalists,
Climate adaptation and coping strategies	Incentives for biodiversity conservation	AWF
	Training of herbal plant harvesters	Herbalists, KEFRI
	Epidemic control in livestock i.e. Rift Valley fever, East Coast fever that are both climate related	KVaccinePI
	Frequent training sessions for resource users	SNV, ICPAK, AgriBD, Ilkisonko Sacco, ACC, FARAJA trust, PACT, KARI, WRM, Lewet-Kenya, Noomayianat and Nia
	Pasture reestablishment and hay storage for livestock	GOK, KWS
	Modern irrigation technology	Red Cross (Canal lining), ENSDA, LWC, DIO
	Creation of new watering points to ease pressure in existing water sources	KWS, AMREF, SNV, Lewet-Kenya, Noomayianat and Ni.
	Rain harvest (Individual) and run-off storage	DAO, DIO, AMREF
	Modern (efficient) irrigation technology	Red Cross (Canal lining)
	Water source protection (Springs)	ENSDA
	Controlled herbals harvest through collaborative forest management	DKFS, Herbalists

	Promotion of herbal practise among the youth	Herbalist Association
	Pest and disease prevention for crops	TOPServe, Bayer, KEPHIS, AgroSolutions, CityFarming, Syngenta, ICIPE
	Soil nutrient management	Mavuno fertilizers
	Land use management & Afforestation	DAO, KWS
	Protect natural water sources e.g. springs	ENSDA, DKFS, KWS
	Control of invasive plant species e.g. Solanum species	KWS
	Alternative economic activities	DAO, DLO
	Sustainable water use awareness (3Rs - recycle, reduce & reuse)	Lewet-Kenya, Noomayianat and Nia
	Public conservation awareness	SFS
	Expand water infrastructure (pipes)	WRMA, DKWS, SNV, AMREF
	Water, Sanitation & Hygiene (WASH) programs	NGOs, UNICEF, AMREF
	Culture promotion	Herbalists, Cultural bomas
	Protected area monitoring and patrol	KWS, Game scouts
	Acquisition of private land as dispersal area for wildlife	AWF
	Removal of problematic wildlife such as elephants	KWS
Resource conflict resolution measures	Import prey for resident carnivores to reduce an escalation of livestock predation	KWS
	Payment of consolation fee to community	Olkeri sanctuary
	Community participation during conflict resolution meetings	ATGRCA
	Construction of fences & land management to keep off wildlife from homesteads	KWS, USAID, Parks Canada
	Intersector negotiations for fair compensation	Council of Elders, DLG, ATGRCA,DAO, DLO, DKWS, DWO, WRMA

8.3. Adaptation knowledge exchange

Loitoktok has incorporated traditional and private actors who have financial and technical ability with the formal institutions and the non-governmental organisations to support the community in sustainable use of biodiversity. These actors complement hierarchical bureaucracies and indirectly facilitate adaptation knowledge dissemination across informal networks in the rural community.

The identified actors who influence information quality and flow in Loitoktok are:

8.3.1. Extension officers

The actors are District Agricultural Office (DAO), District Livestock office (DLO), District Water Office (DWO), District Kenya Forestry Service (DKFS) and District Kenya Wildlife service (DKWS). These extension officers are connected to their respective community interest groups and have enabled resource users to gain diverse practical information from the private and NGO actors (public-private partnerships) about sustainable resource use. Therefore, specialised training of extension officers in adaptation technology and water harvesting for subsequent transfer to the community will not only buffer food security (crop and livestock products) but will also strengthen the local economy through creation of additional livelihood opportunities in a climate change context.

8.3.2. Council of elders

There are two types of Council of Elders. First, the council of elders that is appointed by the State and is made up of men from the three major tribes in the district to help in administration issues such as immigration and conflict resolution in the agriculture sector. This administrative council of elders is administered under the DLG office as a physical representation of the government in the community. Second, the traditional Council of Elders made up of persons of integrity and objectivity who have distinguished themselves in one way or another and have been recognized as such by the Maasai community. This council is highly regarded in the wildlife sector where it plays a key role in either agitating for action by the government or calming the Maasai community after a serious human-wildlife incident. Interestingly from the social network analysis, the council of elders is not among the top central actors because of the administrative dichotomy in the district. But the fact still remains that they are well connected to each resource sector thereby giving them a stronger knowledge dissemination power in the community.

8.3.3. Local chief

Loitoktok has 16 locations each governed by a chief and 31 sub-chiefs who are in-charge of sub-locations. These chieftaincy positions are not elective but the person is nominated by the government to participate in decision-making at the grassroots. The chiefs work under

the District Local Government Office (DLG) and are called upon by the government depending on the conflict situation in the community.

Chiefs identify isolated community interest groups for training in resource governance including conflict resolution since unmanaged informal groups form many small and dense clusters with little or no diversity with little adaptation knowledge that become resistant to change e.g. pastoralists who view livestock as a form of wealth and calls to dispose of healthy animals before onset of drought is viewed with suspicion. Furthermore, chiefs are foremost in organizing barazas on civic lessons among their constituents as a means of promoting integration and coexistence and dispelling false information to foster the concept of "a common people with a common destiny" (Aapengnuo, 2010).

8.3.4. Private investors and researchers

Loitoktok network hosts many private actors such as hotel owners, seed companies' researchers, humanitarian workers etc. in all the resource sectors. These actors have contributed the most in resource knowledge and ecosystem dynamics which has increased resilience of the Loitoktok community. For example, the private actors in the agriculture sector have introduced novel seeds and livestock breeds that have boosted food security and income generation in Loitoktok. Whereas the private actors in the wildlife sector actors are more effective in resolving human-wildlife conflicts as a way of preserving wildlife for tourism purposes. In addition, private actors in the water sector promoted improved sanitation and hygiene practices as a way of reducing waterborne diseases. UNICEF, SNV and Red Cross and smaller community based organizations also initiate leadership interventions for increased collective actions in water infrastructure.

8.4. Resource conflict resolution

Conflict resolution is critical to adaptation as conflict restricts many drought adjustments involving peaceful interaction between pastoralists and other stakeholders. Loitoktok conflict resolution strategy seems efficient as it is structured to incorporate views from various actors during negotiations for compensation for crop damage or livestock deaths (Figure 8.1). This integration has borne different conflicts resolving mechanisms though cooperative efforts to ensure economic growth. These are:-.

8.4.1. Policy-guided conflict resolution plan

This is a mechanism found in the water sector and is clearly outlined in the Water Act of 2002. The aggrieved parties meet with water officials (WRMA) at the first instance of conflict. In some occasions, the local chief is an optional mediator. If the conflict is not resolved through negotiation then it is either forwarded to the courts for legal action against the offender or to the Water Appeals Board for further arbitration.

Therefore, a well formulated policy is recognised as the first key step in effectively resolving resource conflicts at the grassroots. The resource policy as an institution by itself must be easy to implement by resource managers and understood by resource users at the grassroots. Secondly, public awareness as a major component of conflict resolution policy is important as seen in the water sector where the community (WRUA) has been empowered to undertake citizen arrests of persons breaking the law especially upstream farmers who over-extract water. An interesting aspect in resource governance is that in addition to carrying out regular training sessions, WRMA also provides grants to WRUA's projects that aim to enhance the quantity and quality of water.

8.4.2. Quasi-formal conflict resolution plan

This arrangement in the agricultural sector was identified as the most practical as all parties deliberate on an equitable recompense action. It is used to solve two forms of conflict that affect agricultural output. These are a) Human-wildlife conflicts that emanate from diminished wild habitats that drive wildlife to invade farms for fodder or livestock (prey) and to access water sources. b) Farmer-pastoralist conflicts that occur when livestock destroy crops while trying to access watering points since communal grazing areas have been lost following mass group ranch subdivision.

The agricultural conflict resolution committee comprises of the formal council of elders (administrative type), local chief, agricultural extension officers and police. This arrangement is termed as quasi-formal because the elders and chief are nominated from the community by the government unlike in the water sectors that only works with civil servants in conflict resolution. The committee uses a crop damage or livestock death report prepared by the extension officer to guide negotiations after which the aggrieved party is compensated either in kind (livestock) or in cash form. Police are involved to ensure that the

conflict resolution process can be transferred to court if the offender fails to fulfil the stipulated compensation. Though the council of elders are part of the community, they are appointed by the government and this relationship causes the community sometimes to view unfavourable rulings with suspicion.

8.4.3. Hybrid site-specific conflict resolution plan

The wildlife sector exhibits a unique conflict resolution strategy as a result of inadequate government policies. This strategy comprises of the traditional council of elders, formal government agencies, private investors and researchers who come together to cover shortcomings of the wildlife conflict management strategy. For example, absence of compensation for livestock deaths and crop destruction by wildlife previously led to wanton slaughter of lions, elephants, or zebra's. Current modest payments to aggrieved families by private investors such as Mr Luke of Olkeri Sanctuary for losses incurred by predators or elephants have reduced cases of revenge wildlife killings. Another example was seen at Mbirikani group ranch whereby game scouts (members of the community) conduct regular patrols and respondents state that poaching levels have reduced since the community wildlife policing begun. Such site-specific measure infers that community members are prone to cohesively use their own knowledge if they are assisted in developing an efficient way of collaborating to enhance their livelihoods.

However, these two actions do not comprehensively deal with human-wildlife conflicts since there is no concrete government strategy to ensure survival of wildlife during drought episodes responsible for instigating the recurrent human-wildlife conflicts. In addition, the weak wildlife management policy has also exposed the community to manipulation by politicians seeking voter mileage at the expense of the human-wildlife incidents.

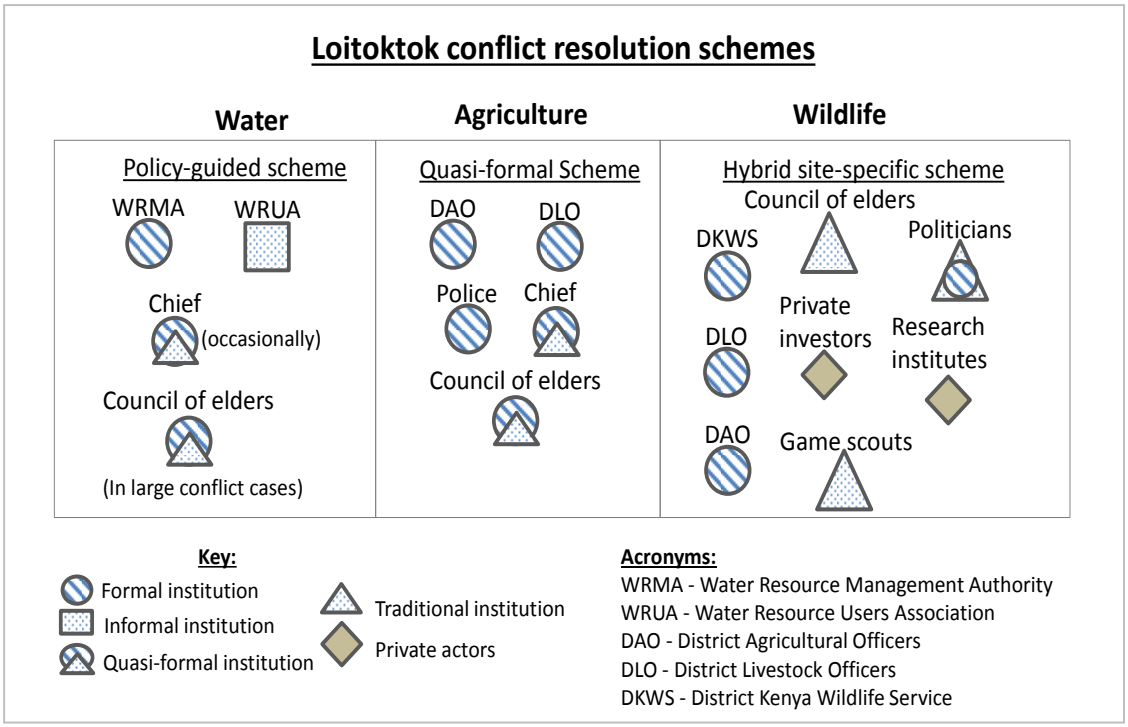


Figure 8.1: The different resource conflict resolution mechanisms in Loitoktok district. Source: The author.

These identified mechanisms reveal how complex resource conflict resolution is at the grassroots.

8.5. Analysis of planned adaptation in Kenya

The five pillars of adaptation as developed by UNECE (2009) are well represented in the planned adaptation strategy. But there is little focus on the response and recovery pillars that are most important to prevent a community recovering from a climate disaster such as drought, from slipping further into poverty. The prevention and resilience improvement pillars consist of simple environmental management activities that can be adopted by the community as demonstrated by the Loitoktok actors (Table 8.2). However, the remaining pillars – preparation, response and recovery comprise of high investment actions that are almost impossible to implement by a simple rural community. Loitoktok has managed to implement a few of these adaptation measures but through donor funding such as UNICEF that conducts the WASH (Water, Sanitation and Hygiene) programs with the community NGOs.

From the study, the planned adaptation measures do not differ significantly from the measures adopted by resource users at Loitoktok (Table 8.2). Most measures focus on preventing negative effects on ecosystem services supply and building resilience against

impending climate change. Interestingly, the planned adaptation has acknowledged the powerful role of indigenous information by highlighting the need to extract measures that empower communities to utilise their own cultural knowledge to strengthen local adaption measures.

Since the planned adaptation strategy is yet to commence, there is urgent need for the government to initiate high quality research and information technology projects that are locally unattainable due to their high financial investment and research commitment. These include,

1. Weather forecasting technology to deliver accurate, reliable and user-friendly information that is easily available to the community. This information can subsequently be used by researchers to model future climatic conditions to strengthen long-term development plans such as urban disaster management in Vision 2030.
2. Insurance against crop failure requires intensive data analysis to justify its introduction and sustainability in the community, but current climate data gaps complicate its implementation. Hence the government can institute large-scale research programs to hasten implementation of these schemes.
3. Food storage facilities require high financial capital for construction and maintenance to give affordable quality services to the community. The government can allocate funds to every constituency to construct silos for both food and fodder storage at subsidized costs.

These few cases among many others show an urgent need to revaluate the objectives and activities of planned adaptation in Kenya. Otherwise, if the government continues with this duplication strategy it will be overlapping natural resource ministerial (water, agricultural and wildlife) duties that are centred on increasing yields and incomes for its users. This duplication will divert available funds away from crucial research & technology projects as mentioned above.

In addition, planned adaptation seems *deficient* in acknowledging the relation between resource scarcity and resource conflicts, whereas the Loitoktok community have factored this issue into resource governance. This was prominent in the conflict resolution process whereby the council of elders guided the community on negotiating with other stakeholders and private actors (investors) who have provided alternative means of solving human-

wildlife conflicts. In addition, construction of strong homestead fences was promoted as additional measures towards reducing wildlife attacks on livestock pens.

Table8.2: Using the UNECE strategy to compare the NCCRS proposed adaptation against implemented adaptation measures at Loitoktok. Highlighted activities are specific to Loitoktok.

Adaptation pillars	NCCRS Planned adaptation measures	Reactive & autonomous adaptation
Prevention	Water efficient irrigation technologies	Modern (efficient) irrigation techniques
	Reduce run-off during floods and soil erosion	Soil & Nutrient management
	Enhance extension services	Frequent community training
	Strengthen pest management systems	Enhanced pest & disease control
	Regular vaccination and cross-border disease surveillance	Land use management
	Efficient water resource management	Protect natural water sources e.g. Springs
	De-silting rivers and dams to improve carrying capacity	More watering points
	Protect water catchment areas	**Domestic herbals cultivation**
	Intensive afforestation and reforestation programmes	**Fences construction**
	Promotion of alternative energy sources	**Inter-sector resource conflicts negotiations**
	Creation of community wildlife conservancies	Incentives for conservation
Resilience improvement	Diversifying local economies	Alternative economic activities
	Introduction of indigenous and drought tolerant crops	Sustainable water use awareness (3Rs)
	Promote conservation agriculture	**Training of herbals harvesters**
	Breeding animals from various agro-ecological zones	Improved seed & livestock breeds
	Inventorying indigenous knowledge on climate adaptation	Culture promotion
	Decentralised municipal water recycling facilities	Expand water infrastructure
	Extensive water harvesting & water quality monitoring	
Preparation	Establish local technology centres	Water & rain harvest
	Develop proper food storage facilities	Public conservation awareness
	Harvest and storage of fodder	Water, Sanitation & Hygiene (WASH) programs
	Construction of inter-basin and intra-basin water transfers	
	Development of a National wildlife adaptation strategy	
Response	Strengthening disaster preparedness	Controlled herbals harvest
	Enhancing system for conveying climate information	Problem animal translocation
	Climate change awareness	
	Wildlife translocation during extreme droughts	

Recovery	Insure farmers against crop failure	Pasture establishment
	Introduction of subsidies for acquisition of technology	Maintain water infrastructure
	Remediation of degraded rangelands	

It is still apparent that the medicinal plants sector is neglected in the national agenda but fortunately, the resource users have commenced their own adaptation measures to ensure supply of their products i.e. personal herbals tree nurseries and regular training in sustainable harvesting techniques.

8.6. Merits of the ecosystem service governance approach

Using a typical rural location, this study set out to apply the Ecosystem Service Governance approach to answer "is social network analysis the elixir to such holistic resource governance?" **Yes,** because social network analysis delineates actors according to their governance role and eases understanding of how they influence ecological and administrative agendas in a community. The ESG approach is effective in identifying each actor's responsibility in the adaptation and resource conflict resolution agenda. This actor-to-governance activity clarifies the knowledge transfer channels that can also be used to investigate origin of inaccurate adaptation activities for governance effectiveness. The actor-to-governance outcomes are synergistically achieved through:

1. Using monetary values of ecosystem services exposed adaptation incentives, adaptation trends in agriculture, actors introducing preferred activities (indigenous products), and economic significance of herbal medicinal practice and neglect of buffer zones in development plans of Loitoktok.
2. Incorporating the entire rural social structure enabled the study to illustrate clearly how resource users are linked to several subgroups in order to access adaptation knowledge. The analysis also identified central actors influencing information flow within the rural network and who can act as scale-crossing brokers to institute new governance structures in remote rural areas or post-conflict zones. Likewise, missing connections are highlighted to explain poor performance in resource governance. Such results allow stakeholders to understand local dynamics and unlock deadlocks in various community processes for effective natural resource management.

3. The approach documented all adaptation and coping measures implemented at the grassroots and enabled a formal comparison against planned adaptation. This action identified the shortcomings and duplicative nature of the planned climate adaptation strategy. It also identified neglected sectors i.e. medicinal plants and well-funded but poorly coordinated sectors i.e. water sector.
4. Moreover the ESG has proven its diverse flexibility in conducting resource governance analysis whereby, it has been used on a single resource sector e.g. crop or livestock production, multi-sector analysis e.g. wildlife tourism and entire ecosystem e.g. Loitoktok. This suggests that it can be used by resource managers at any administrative level to resolve their governance challenges.

8.7. Demerits of the ecosystem service governance approach

The blight in ESG approach is found in the economic valuation of ecosystem services whereby many technical challenges still hinder successful application of this strategy at the grassroots.

First an expert ecological economist is required to carry out valuation exercises because a layman can potentially generate problems such as,

1. *Double counting* arises when a service is valued at two different stages of the same process providing human welfare, e.g. a forest providing water flow (as a regulating service) and water supply for hydropower (as a provisioning service) (Ojea et al., 2012).
2. *Value underestimation* is the production of only one value for two types of services having different outputs and that reduces the total value of the analysed ecosystem.

Secondly, lack of comprehensive data on wildlife species, population, water volumes, sources and trends from the resource managers and stakeholders hindered calculation of the monetary values of wildlife and water.

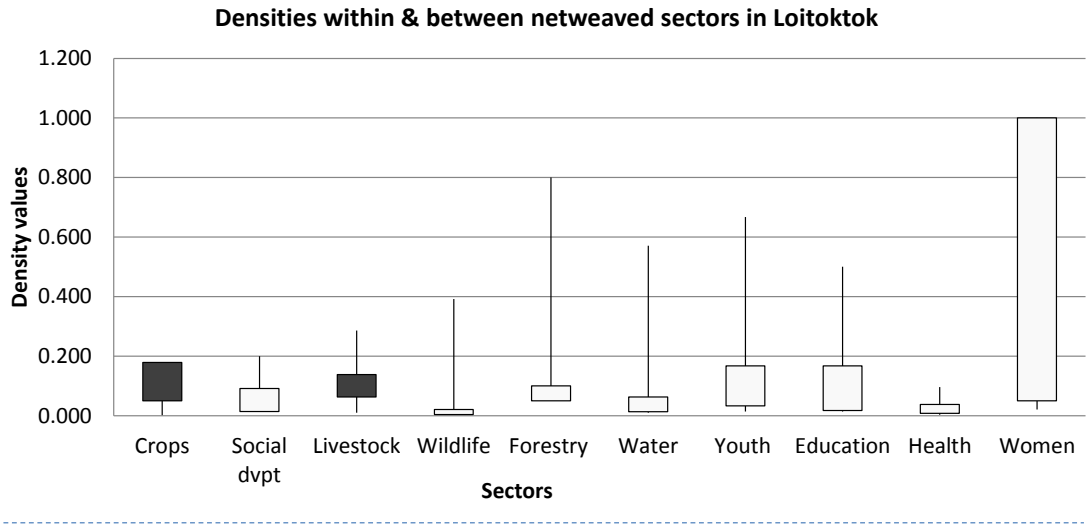
Moreover, wildlife valuation is usually done together with the tourism component which then becomes complicated because of the multiple variables considered in estimating the value of a single species in a protected area (See Tisdell & Wilson, 2003 for more information).

8.8. Network weaving for sustainable resource development and conservation

The final action in the ESG approach is to simulate how the brokers (scale-crossing brokers - SCB) build relationships, particularly across traditional divides, so that other actors under them can have access to innovative adaptation information. This information may be in the forms of funds for new business ventures, additional training and even mentoring emergent leaders in the community (Krebs & Holley, 2004).

From the study, the Loitoktok community seems to have adequate adaptation knowledge circulating among actors *but* poor coordination and sectorial divisions still exist. Therefore, I implement network weaving which restructures the network for enhanced collaboration between different actors in collective ecosystem service governance. This process theoretically improves social and economic connectivity, enhances grievance discussion and effective conflict resolution monitoring in the community.

The subsequent network closure for the new network structure is 0.406. In particular, the new density becomes 0.070 due to an increment of 0.041 from increased linkage between actors within the community. Significance test results are given in Appendix 9. The weaving process sought to resolve poor coordination and representation especially of the forestry and water sectors that are crucial pillars in the rural climate adaptation agenda. Consequently, the forestry sector has the highest increase in density followed by the water sector due to intensified inter-sector and intra-sector connections in the community. The densities for the crops and wildlife sectors also significantly increase due to increasing internal linkages, while the livestock and social development sectors increase their densities marginally. The youth, education, health and women sectors do not have any changes in densities since they were not included in the netweaving process (Figure 8.2).



Ties within sectors										
	Crops	Social dvpt	Livestock	Wildlife	Forestry	Water	Youth	Education	Health	Women
Number	68	32	16	144	16	32	4	3	15	2
Density	0.179	0.069	0.286	0.261	0.800	0.571	0.667	0.500	0.096	1.000

Figure 8.2: Calculated density measures for the net-weaved community.

The deliberate linking of actors to achieve specific functions in resource governance also increased the centralization score from 25.39% to 35.39% which subsequently created more channels of information (Figure 8.3). Furthermore, the number of actors sealing more than 10 structural holes increased by 60%. These elevated actors are herbalists, EnvCGs, council of elders, ICIPE, Pastoralists, CulturalBs, WaterPGs and CWEF. A key point is that the community interest groups gained “power” in resource governance which indirectly implies more of their participation in decision-making. However, as these six actors gain structural control, two other key actors i.e. tourists and DKWS lose 66.5 and 48.7 structural holes control respectively.

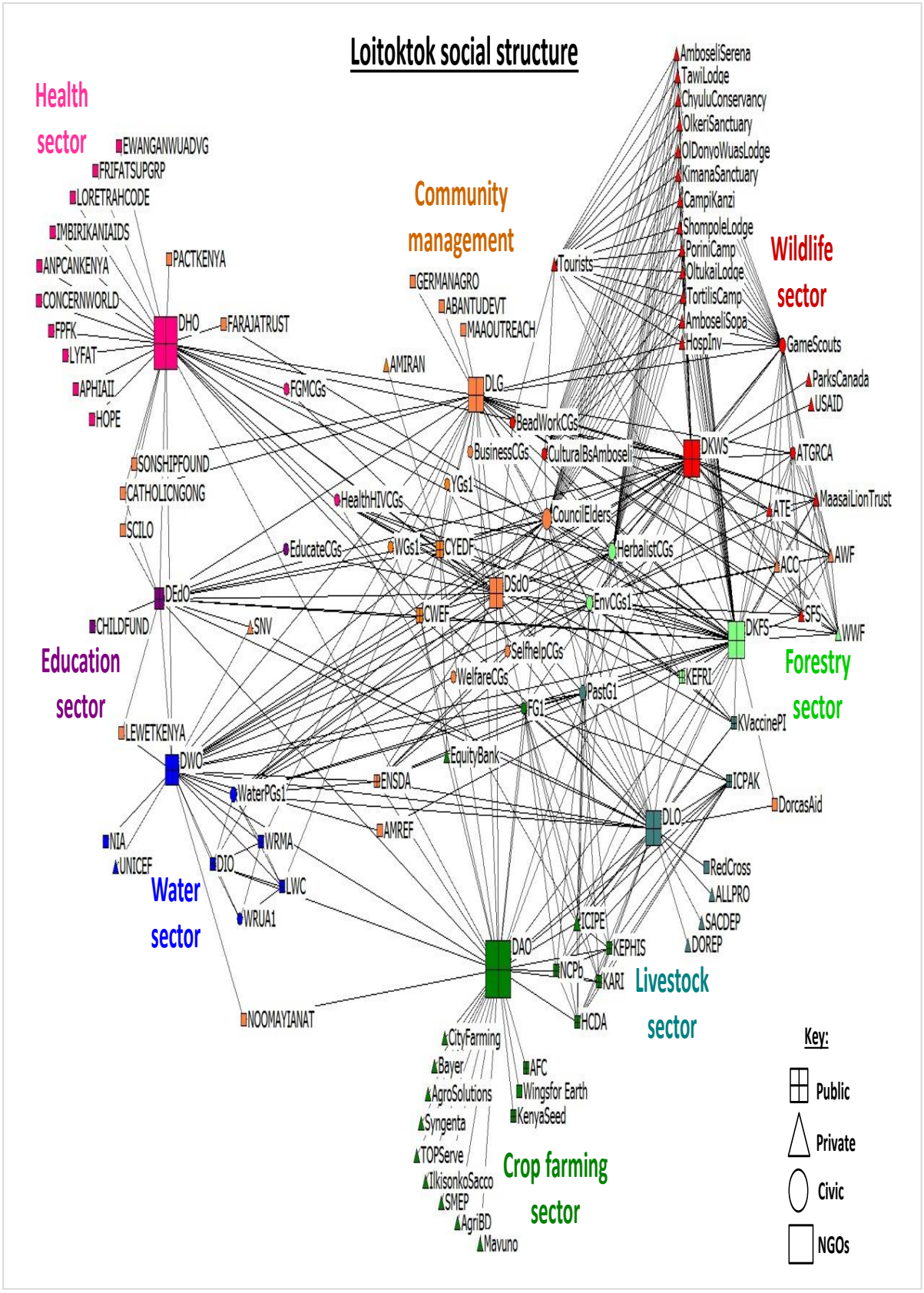


Figure 8.3: Proposed network structure for optimum resource governance at Loitoktok community

The proposed governance objectives can be divided into the following subgroups in the woven network (Figure 8.5):-

8.8.1. Biodiversity monitoring

Lack of comprehensive ecosystem services data was identified by this study as the major obstacle in implementing efficient resource governance. Therefore, network weaving can strengthen the links between DKWS, DKFS, EnvCGs, herbalists and game scouts towards collaboratively developing a database on both wildlife and medicinal plants in protected areas of Loitoktok. The overseers of this hub will be DKWS and DKFS who are the mandated custodians of natural biodiversity in Kenya. This action will allow for identification of specific zones to be reservoirs for the community to harvest medicinal plants, demarcation of buffer zones for wildlife purposes.

Furthermore, the water sector also lacked a comprehensive water source occurrence, quantity, quality, distribution, and movement of surface and underground waters data. Thus creating linkages between DWO, DIO, WRMA, WRUA, LWC and water project groups will ensure that each actor forwards their user data to the key custodian – DWO to enable accurate monitoring of water in the district.

The data collected by these two monitoring hubs will resolve the poor coordination problem in the medicinal plants and water sectors. It will also enable formulation of a realistic land management plan that considers important; wildlife buffer zones, migratory paths, habitats for endemic and endangered species and future infrastructure expansion into rural development plans.

8.8.2. Habitat restoration

Combination of indigenous knowledge with scientific data could be used to restore degraded landscapes. The identified actors for this objective are DKWS, DKFS, herbalists, council of elders (traditional), EnvCGs, pastoralists, DLO, DWO, WaterPGs and ENSDA. These actors have the potential to restore overgrazed lands for livestock and wildlife, reduce soil erosion through afforestation and restore medicinal plants to their niches.

In Loitoktok, about 43 plant species are utilised for their pharmaceutical properties, whereby 20 species are harvested from communal land while protected areas provide 13 plant species to the market in Loitoktok. Since the use of medicinal plants in urban centres

may increase then this diversity highlights the urgency in establishing ex-situ extraction habitats to satisfy the growing demand. Further analysis of the species list using secondary data reveals several potential areas that could benefit from specific afforestation programs (Appendix 10). The riparian zone will be the highest beneficiary followed by the grasslands, dryland forests (acacia woodlands), disturbed areas in high utilization zones and the highlands on the mountain slopes respectively in Loitoktok (Figure 8.4). If such action is carried out then the natural environment will be preserved and will continue to support the community.

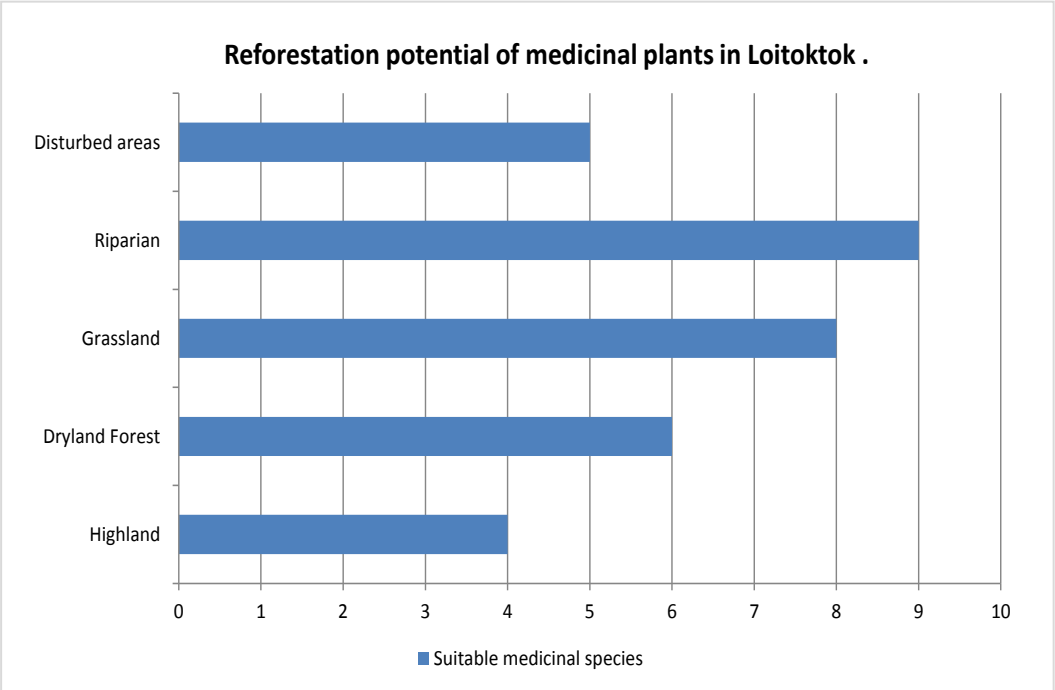


Figure 8.4: Five habitats targeted by the proposed reforestation program in Loitoktok. Source: The Author

Restoration of habitats offers benefits such as income from carbon credits as a result of increased carbon sequestration and enhanced supply of ecosystem services to the entire community. Monetary incentives can be given to communities or private landowners to maintain the environment especially indigenous forests and woodlands as a natural carbon sink (Millennium Ecosystem Assessment, 2005). Carbon sequestration projects may thus provide a win–win situation between environmental conservation and increase opportunities for economic development in Kenya.

8.8.3. Research and technology

Analysis of Loitoktok reveals that the water sector lacks research institutions, while the medicinal plants sector has research actors but they are not well-linked and the crop and wildlife sectors have the highest concentration of research actors.

Therefore to boost medicinal plants research and product development, links can be built among KEFRI, ICIPE, herbalists, KVaccinePI, HealthHIVCGs, EnvCGs and DKFS. Kenya Forest Research Institute (KEFRI) can focus on training the community on sustainable harvest techniques to counter the greatest social threat to wild medicinal plants. The International Centre of Insect Physiology and Ecology (ICIPE) already has a small national segment on herbal product development but that can be expanded to regional centres with collaboration with herbalists and also participate in training the community on environmental knowledge. Kenya Vaccine Program Institute (KVPI) can integrate indigenous knowledge of medicinal plants used to treat livestock diseases into research agendas to develop local vaccines and also promote culture. This is because Maasai who highly esteem livestock had certain plant species combinations that were effective against ailments and epidemics for healthy herds and this information is beneficial to the livestock sector.

Whereas the periphery public actors in the agriculture – KARI, HCDA, KEPHIS, NCBP, ICIPE, ICPAK, DAO and FGs can collaborate on community projects subsidised by the government. These actions will enable NCCRS mandate to be revised for it to concentrate on high investment projects such as early warning systems that serve all resource users.

8.8.4. Diversification in tourism activities

A new aspect of tourism is emerging – medical tourism, whereby people travel for medical treatment or acquisition of medical or traditional medicine knowledge. This aspect has not yet been established in Kenya but is promoted in various countries such as Israel where people go to the Dead Sea to use and learn about its rich mineral sea salts, algae and seaweed treatment or visits to India to learn about Ayurveda practice. Likewise the rich indigenous Maasai botanical knowledge can be internationally marketed to naturopaths and herbal practitioners to stay with the community and exchange knowledge that will enhance the sector. The actors identified to organise this activity are, herbalists, council of elders, culturalBs, hotels &lodges and DKFS. Whereby, the accommodation owners can market the medical tourism as part of their promotional activity. However, this objective can only be

achieved if the research component is facilitated by accurate biodiversity data, healthy ecosystems and efficient knowledge transfer networks that promote the medicinal plants sector just like the wildlife or agriculture sectors.

8.8.5. Knowledge dissemination centres (data banks)

There is need for a community adaptation hub consisting of DAO, DHO, DEdO, DLO, DWO, DLG, DKWS, DKFS, council of elders, DSdO, CYEDF and CWEF. These actors can develop a community data base to guide resource governance and also reduce sectorial divisions at the grassroots. Furthermore, this hub can be transformed into a central dissemination tool using technology and social media (e.g. blog, newsletter, monthly reports) to boost adaptation knowledge transfer, build adaptive capacity and secure livelihoods in Loitoktok.

Secondly, though the wildlife sector has many research institutions, their findings are not well disseminated in the community. Therefore weaving together, WWF, AWF, SFS, ATE, Maasai Lion trust, ATGRA, game scouts, DLG, DKFS, EnvCGs and DKWS will enable for creation of a unique wildlife conservation data bank that is accessible to the community and other researchers. This hub can have two coordinators – DKWS and DLG. In addition, to ensure continuity of biodiversity research especially on neglected species, these private research organisations can establish collaborative training centres where stakeholders can learn about ecosystem functions, in-depth ecology about plant species and conservation.

Thus, the Ecosystem Service Governance approach assures of better outcomes and efficient communication by influencing a small number of well-connected nodes towards resource governance than trying to access the top person or calling on random players in the policy network. Furthermore, if actors within the revolving fund social structure can be aligned with other community actors, then it can also serve as a basis for cooperation in the adaptation process between governments, citizen groups and business to reduce vulnerability to climate risks or to exploit opportunities.

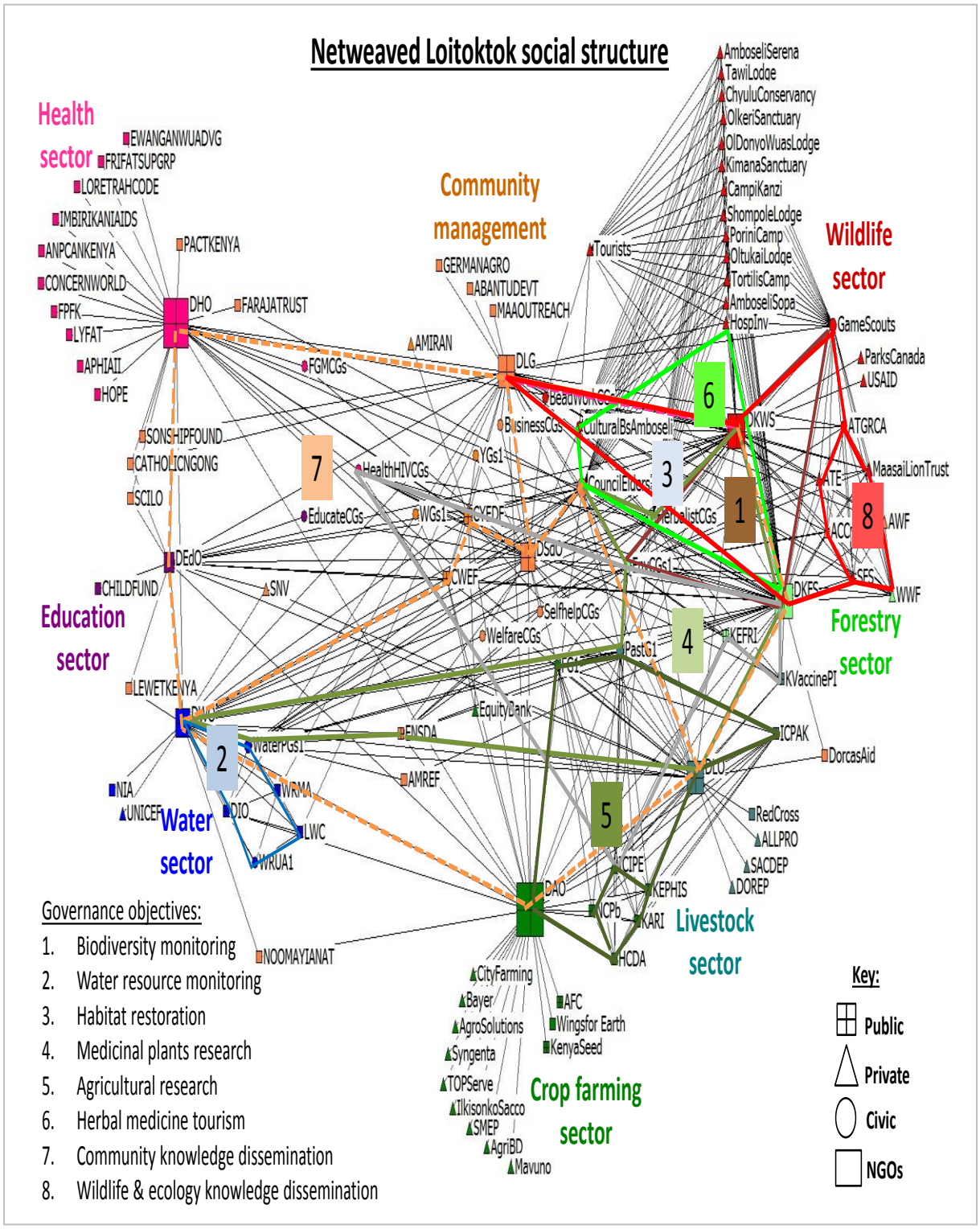


Figure 8.5: Location of the proposed governance sub-groups within the Loitoktok social structure.

Summary of results

Studies commonly use economic, political and ecological theories to explain resource governance challenges and associated conflicts in sub-Saharan Africa. However, few studies have incorporated social network analysis into governance methodologies for clarifying actor roles regarding climate adaptation and resource conflict resolution at the grassroots. Climate change indirectly threatens rural resource governance schemes through ill-conceived adaptation strategies that foster poor coordination through low grassroots actor participation and marginalisation of indigenous knowledge in Kenya. Furthermore, there is vague understanding of the specific contribution of actors which contributes to an inherent assumption of the lack of adaptation activity in rural communities. Consequently, my research question was based on *deconstructing an entire rural social structure* in order to understand how actor linkages influence adaptation and conflict resolution activities and also identify its inherent governance hindrances.

Guided by my research objectives, the outcomes of this study are as follows:

1. To resolve the identified governance challenges, I *formulate* a single functional "ecosystem service governance (ESG)" approach to focus on ecosystem services as single entities within a multi-sector environment. This is **my main contribution** to the climate governance discourse. The unique features in ESG originate from the incorporation of social network notions and economic valuation of ecosystem services. The outcome is a well-integrated governance tool capable of evaluating implemented climate adaptation and conflict resolution strategies that influence delivery of ecosystem services in a rural community network setting. The ESG also includes a feature for simulating the best governance scenario using identified actors to achieve specific adaptation and sustainable development goals.
2. **My second contribution** involves *validation* of the functionality of the theoretic ESG approach in analysing actor linkages regarding climate adaptation and resource conflict resolution activities on the Loitoktok social structure. I select food production, medicinal plants, wildlife and water as the key ecosystem services driving economic growth in Loitoktok.

   ESG proves to be very effective in identifying ecosystem service trends and actor responsibilities in relation to adaptation and conflict resolution activities. The analysis reveals that extension officers, council of elders, local chief and private

investors are responsible for dissemination of information and social cohesion in the community (*with whom*). Results confirm that a rural network structure is able to empower its stakeholders (community) with post-drought adaptation knowledge to sustain their incomes and livelihoods (*do what*). This is achieved through active public-private partnerships (PPP) that target increased economic productivity (*how*). Furthermore, illustration of the Loitoktok ecosystem service networks enables identification of missing actor linkages which are viable indicators of hindrances to efficient network performance (*why not*).

3. Strength of the ESG approach rests on its efficiency of identifying each actor's responsibility in the adaptation and resource conflict resolution agenda. This actor-to-governance activity clarifies the knowledge transfer channels that can also be used to investigate origin of inaccurate adaptation activities for governance effectiveness. However, the shortcoming of the ESG approach is revealed in its economic valuation aspect due to its innate requirement for large amounts of data, quantitative knowledge and human resource capacities that are simply not available to many rural resource managers.
4. **My final contribution** is the simulation of an *optimum* resource governance structure to resolve poor coordination and sectorial divisions through network weaving using identified Loitoktok actors. The goals of the "new" network are to; conduct regular and comprehensive biodiversity monitoring, initiate extensive habitat restoration, establish local research centres, promote medical tourism and construction of knowledge dissemination centres in the community. These five goals are built on the inherent heritage of medicinal plants culture that if successfully implemented will boost conservation, ecosystem services supply, livelihood diversification and carbon sequestration.

Apart from achieving the stated objectives, the analysis also *reveals several successful adaptation strategies* by resource users. This shows that rural communities are not only implementing adaptation measures but are also resourceful to incorporate site-specific measures that address their challenges. The food production (agriculture) and wildlife (tourism) sectors are the best performing networks due to the high number of private actors responsible for introducing diverse adaptation knowledge into the network. Though the water sector is plagued by minimal actor linkages and lack of private research actors, it also

manages to implement a number of effective adaptation and coping strategies to enhance local water security. As expected, the medicinal plants sector has the poorest performance mainly because it is not a legally recognized economic activity, despite its significance among rural communities.

This study also confirms that in post-colonial Kenya, resource governance still contains vestiges of traditional institutions especially for collective grievance discussion towards effective conflict resolution. It does this by *revealing social structures that resolve conflicts* at the grassroots i.e. the water sector relied upon its comprehensive policy; agriculture used a quasi-formal arrangement while the wildlife sector formulated its own hybrid arrangement that involved private investors and traditional council of Maasai elders. These innovative arrangements make use of indigenous knowledge to calm the aggrieved and agitate for compensation by the government. In extreme cases, the community came together in *barazas* to air their concerns and agree on a collective decision acceptable to all relevant stakeholders. As a result, the society is bound together based on brotherhood notions for enhanced resource utilisation and livelihoods regardless of climatic conditions.

Finally, the thesis also uses the UNECE "five-adaptation pillars" to analyse implemented adaptation measures and proposed national adaptation strategy contained in the NCCRS by the government. Results indicate that both planned and reactive adaptation strategies are well represented in the prevention and resilience improvement pillars. Planned adaptation strategy also features a unique strategy of developing an inventory of indigenous climate adaptation knowledge as a key adaptation measure. No doubt that gathering of cultural knowledge will illuminate potential indigenous adaptation measures and upscale them to regional or national projects. Loitoktok has few activities in the preparation, response and recovery pillars because of the inherent technical and financial constraints synonymous to majority of rural communities in Kenya. On the other hand, planned adaptation seems to duplicate ministerial mandates targeting increased yields and incomes for its users. Therefore there is need to *rethink national climate governance* and use available adaptation funds to develop high quality research and information technology products that will supplement ministerial agendas.

Outlook

Limitations of this research

Though some ecosystem services with consistent data could be valued e.g. crops, livestock in this study, more work is recommended to develop simple technical assessments that can be used by any layman to carry out economic ecosystem services assessments for development of sector-specific schemes that align economic decisions with local ecosystem health at the rural level.

Secondly, lack of comprehensive data on wildlife and water resources hindered calculation of their monetary values as an indicator of their significance in the rural community. Hence there is urgent need for data collection or (in some cases) data sharing among stakeholders to create extensive ecosystem services database for efficient monitoring and evaluation in Kenya.

Future areas of research

This study has compiled a regional best adaptation practises *list* through systematic identification of local actors and their respective adaptation roles in Loitoktok. Hence, the next step should be development of a national best practise database. Such a database will have a threefold effect; reduce effort duplication, enhance funds disbursement per location per adaptation program activity and clearly define responsibilities of funded actors involved in the management of national adaptation to climate change in Kenya.

The ESG approach can also be further developed using the actor-network theory so as to examine the motivations and actions of groups of actors who form heterogeneous networks of aligned interests in relation to nonhuman actors such as technological artefacts (Walsham, 1997). In addition, this approach can also be used to evaluate influence of technology e.g. mobile phones and donor funds on adaptation knowledge transfer in remote rural communities.

Climate change provides new opportunities for Kenya which, if embraced, can create new development opportunities and drive economic growth. Hence, there is need for feasibility studies of medical tourism based on traditional herbal medicine. This innovation can also integrate aforementioned reforestation projects and earn rural communities income from carbon credits trade.

Specific recommendations to enhance achieving Kenya's Vision 2030

1. The revolving fund business model seems successful at empowering the grassroots but lacks a strong component of environmental monitoring of natural resources and transfer of climate adaptation knowledge. Therefore, the social networks formed by the revolving fund can serve as a basis for cooperation in the adaptation process between governments, citizen groups and business to reduce vulnerability to climate risks or to exploit opportunities. Whereby, the Ministry of Environment and Mineral Resources (MoEMR) can deploy ecologists or environmental managers to the different fund agencies to vet business proposals before they are implemented and give recommendations on acceptable business practises. As an incentive, projects that substantially reduce climate vulnerability, or are identified as priorities in national adaptation strategies like green energy proposals, can be given preferential treatment (Ngaruiya & Scheffran, 2013). This action can also be duplicated in the recently established Uwezo and Juhudi Kilimo funds.
2. Using the local stakeholder database and the already created business forums, MoEMR can be able to train mobilized stakeholder groups collectively on resource-specific adaption measures as well as teach comprehensive environmental education instead of relying on cumbersome bureaucratic procedures to mobilize people. In addition, the National Environmental Management Authority (NEMA) can disseminate simple evaluation forms to extension and fund officers to monitor local environmental effects of financed projects.
3. Endless possibilities emerge from this ESG approach that enables identification of governance obstacles and restructuring networks to enhance specific aspects in natural resource management. This is because Kenya is currently undergoing "teething" problems with regard to implementing devolution according to the new constitution which was promulgated in 2010. Citizens are requesting for enhanced transparency in governance and more inclusion into decision-making. Therefore, County governments may find a solution in ESG towards streamlining inherited municipal and central government ministerial mandates for objective climate governance. Furthermore, the onus for realistic resource policy formulation is now squarely at the grassroots "courts" and if utilised properly then climate-related conflicts should not be a future threat to development.

Conclusion

The flourishing field of social network analysis provided the framework for the study. I set out to investigate; *with whom* does a natural resource user *do what? How?* If, not possible, then *why not?* regarding climate adaptation and resource conflict resolution. This complex research question led to **formulation** of an advanced resource governance tool – ecosystem service governance – that contributes to adaptation and resource governance in two main ways. First, it incorporates economic valuation in a business-like approach for analysing adaptive capacity and actions by actors towards competent decision-making. Secondly, analysing actor linkages facilitates delineation of clear knowledge exchange channels to guarantee governance effectiveness in a community. Therefore, the ESG is able to successfully connect *an actor* to their *respective activities* and *partners*, and also identify *hindrances* in the network that correspond to governance failures manifested in the community.

The formulated ESG approach is implemented on the Loitoktok network. This location is selected because it represents a typical rural area in terms of its cultural diversity, economic sectors and resource conflict profile in Kenya. From the study, adaptation activities are actively taking place in rural Kenya. But the crucial pillars in the rural climate adaptation agenda i.e. forestry and water sectors, are plagued with poor coordination and sectorial divisions. Therefore, to eliminate these two obstacles the ESG **simulates** an optimum resource governance structure using network weaving. The theoretical outcomes include; biodiversity conservation, enhanced adaptation performance, extensive cultivation of medicinal plants, poverty alleviation, culture preservation and improvement of ecosystem services provision. Carbon sequestration is introduced as an envisioned long term objective that reverses deforestation, enhances microclimate regulation and generates additional income from global carbon markets.

As a contribution to the climate & security discourse, this study highlights two measures, if widely embraced will help overcome climate change-related capacity challenges at the grassroots in Africa. First, clear conflict resolution policy in natural resource governance as seen in the water sector will not only solve local conflicts but will enable stakeholders understand conflict genesis to effectively prepare for unpredictable climatic conditions.

Secondly, involving diverse actors from the community in resolving conflict as seen in the wildlife sector also has potential in serving as a conduit of adaptation knowledge sector to empower the community despite policy inadequacies. Moreover, traditional institutions like the council of elders are a potential source of civic knowledge that can be integrated with local values and customs for local self-reliance and citizen empowerment in the community.

In conclusion, devolution of natural resource management from the central to the county governments opens a new chapter in climate governance in Kenya. Subsequently, the mandate to formulate site-specific governance policies marks the start of enhanced adaptive capacity and resilience of rural communities. This study illustrates how the neglected medicinal plants sector has much potential in formally contributing to county revenue and the adaptation agenda. It is a fact that community members are prone to value their own insights and knowledge systems if they are assisted in developing an efficient way of learning about the ecological, social, and economic system in which they live. Therefore, since there is no specific national legislation guiding medicinal plants utilisation, conservation and trade, the County government of Kajiado (where Loitoktok belongs) can take the initiative and establish its own policy to safeguard this sector. Similarly, county governments can netweave local actors to develop site-specific climate governance policies to increase resilience and secure ecosystem services for tomorrow's development.

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Appendix 1: Publications produced during this PhD study

1. Ngaruiya G. W. & J. Scheffran. (2013) Reducing climate adaptation deficits using revolving fund network schemes in rural areas of Kenya: Case study of Loitoktok district *African J. Economic and Sustainable Development* **2 (4):** 347 - 362

2. Ngaruiya G. W. Does reactive adaptation exist? Using the ecosystem service governance approach to evaluate post-drought rural food security in Kenya. *Natural resources* (special issue on resource security) **5**: 392-407.

3. Ngaruiya G. W., J. Scheffran & L. Lang. (2014) Social Networks in Water Governance and Climate Adaptation in Kenya. In Handbook of Sustainable Water Management by W. Leal F. and V. Sumer (Editors) in Cambridge University Press.

4. Ngaruiya G. W. Ecosystem Service Governance: A synergistic approach developed from key natural management schemes relevant in rural areas**.** *Ecosystem Services* journal*.*

5. Ngaruiya G. W. Reweaving stakeholder networks: Enhancing climate adaptation and culture promotion using medicinal plants in Kenya. *Ecosystem Services* journal*.*

6. Ngaruiya G. W. Using social network theory to analyse climate change adaptation and human-wildlife conflict resolution in the Amboseli wildlife tourism sector. To be submitted to *Journal of Sustainable Tourism*

7. Ngaruiya G. W. & J. Scheffran. Intricacies of resource conflict resolution under advancing climate change in rural Kenya. To be submitted to *Conflict resolution*.

8. Ide T., Schilling J., Scheffran J., **Ngaruiya G. W**. Kominek J. and T. Weinzierl (2014) On Exposure, Vulnerability and Violence: Spatial Distribution of Risk Factors for Climate Change and Violent Conflict across Kenya and Uganda. Submitted to *Political Geography* for a special issue on climate change and conflict

Appendix 2: List of medicinal plants species harvested and utilised to manage different ailments in Loitoktok district. It also shows propagation methods for domestication purposes.

	Botanical name	Common name	Uses	Propagation
1.	*Rhamnus prinoides*	Olkonyil	Blood cleanse, pneumonia, rheumatism, aches, syphilis & gonorrhoea, flu/cold, brucellosis.	Seeds
2.	*Lannea welwitschii* (near threatened)	Muumbu (Swahili)	Diarrhoea, haemorrhoids, sterility in women, menstrual troubles, gonorrhoea, epilepsy, skin infections and ulcers	Seeds
3.	*Acacia mellifera*	Oiti	For stomach-ache, sterility, pneumonia, malaria and syphilis	Seeds
4.	*Ficus sycomorus*	Orng'aboli	Scrofula, coughs, chest diseases. Dysentery, snakebites, laxative and anthelmintic.	From cuttings or truncheons
5.	*Azadirachta indica*	Mwarubaini (swahili)	Boils, pimples, eye diseases, hepatitis, leprosy, rheumatism, ringworm and ulcers, malaria	Seeds
6.	*Tamarindus indica*	Oloisijoi	Sores, ulcers, boils and rashes, asthma, amenorrhea, throat infections, cough, fever, Nausea intestinal worms.	Seeds and by marcotting, grafting and budding,
7.	*Kigelia pinnata*	Mvungavunga , mwicha (swahili)	Gonorrhoea, syphilis, anaemia, Kidney diseases, piles; antidotes for snakebite and rheumatism	Seedlings and wildings
8.	*Albizia anthelmintica*	Ormukutan	Syphilis & gonorrhoea, arthritis, flu/cold, aches, pneumonia, brucellosis	Seeds
9.	*Erythrina abyssinica*	Olepangi	Eye infection, general body swellings, syphilis, abdominal pains, worm infestation	Seeds, seedlings, cuttings or direct sowing.
10.	*Ajuga remota*	Mataliha (luo)	Indigestion, menstrual problems, malaria and convulsions.	Seeds
11.	*Physalis peruviana*	Munathi (kikuyu)	Diuretic and antiasthmatic as well as an enema to relieve abdominal ailments in children.	Seeds

	Botanical name	Common name	Uses	Propagation
12.	*Rhamnus stado*	Olkokola	Gonorrhea, syphilis, fevers and menstrual problems	
13.	*Warburgia ugandensis*	Osokonoi	Stomach-ache, constipation, skin diseases, toothache, cough, and fever, chest complaints, muscle pains	Seeds cuttings, seedlings and direct sowing
14.	*Acacia nilotica*	Olkiloriti	Cure impotence, diarrhoea, dysentery and leprosy, ulcers, cancers and tumours (ear, eye testicles)	Seeds
15.	*Balanites aegyptiaca*	Mjunju (swahili)	Treat malaria, oedema, chest pains, stomach pains and heartburn	Seeding
16.	*Salvadora persica*	Oremit	Dental caries, relieve toothache and gum disease	Seeds
17.	*Olea europaea*	Oloirien	Malaria and worms	Wildings and seedlings (difficult)
18.	*Moringa oleifera*	Mzunze (swahili)	Fungal infection, Herpes zoster, Genital thrush, Herpes simplex, Syphilis, Anaemia, Arthritis	Seeds or cuttings
19.	*Annona Squamosa*	Mutomoko Custard apple	Supplements thiamine, potassium and dietary fibre	Seeds
20.	*Mondia whytei*	Mukombera, African viagra	Anorexia, STIs, stomach ailments and impotence as an aphrodisiac	Seeds

Note*: Moringa oleifera, Annona Squamosa* and *Mondia whytei* were introduced by George Muiruri (Farmer) in the district. While *Azadirachta indica* and *Tamarindus indica* are newly propagated by J. Parmuat (Herbalist) in the area.

Appendix 3: The questionnaire used to collect resource attribute and relational data

Enhancing synergy between climate change adaptation and resource conflict resolution of ecosystem services in Loitoktok District, Kenya

Name: Grace W. Ngaruiya, University Of Hamburg

QUESTIONNAIRE No _____ DATE _____

NAME OF ADMINISTRATOR _____ LOCATION_____

RESPONDENT CHARACTERISTICS

ORGANIZATION _____ YEAR OF ESTABLISHMENT _____

Area of action	International ☐	National ☐	Regional ☐	Local ☐
Type of organization	Public ☐		Private ☐	Civil ☐
Source of funds	Donor ☐	Business ☐	Exchequer ☐	Membership ☐
Specific sector	Monetary & trade ☐	Sustainable resource use ☐	Awareness & communication ☐	Research & value addition ☐

Section A: CLIMATE CHANGE CONCERNS

CC Parameter	Precipitation ☐	Temperature ☐	Biodiversity ☐	Natural disasters ☐

Climate adaptation measures - Agriculture

Threat to agriculture	Irregular rainfall ☐	Habitat degradation ☐	Low/ poor harvests ☐	No. of users ☐
Adaptation strategies (Climate smart Agriculture)	Soil & Nutrient management ☐	Diversified agricultural activities ☐	Improved seeds/breeds ☐	Frequent training of resource users ☐
	Agroforestry/ Revegetation ☐	Enhanced pest and disease control ☐	Conservation agriculture ☐	Water harvest & Use ☐
Drawbacks	Poor coordination ☐	Lack of finances ☐	Low manpower /capacity ☐	Lack of legislation ☐

Climate adaptation measures – Medicinal plants

Threat to medicinal plants	Poor rainfall ☐	Habitat loss ☐	Poor harvesting ☐	No. of users ☐
Adaptation strategies	Domestic cultivation ☐	Alternative livelihoods ☐	Controlled harvest ☐	Training harvesters ☐
	Agroforestry ☐	Culture promotion & Public awareness ☐	Land management ☐	Value addition incentives ☐
Drawbacks	Poor coordination ☐	Fund availability ☐	Politics ☐	No legislation ☐
Solution threats	Population growth ☐	Corruption & poor management ☐	Low local research input ☐	Lack of public interest ☐

Climate adaptation measures – Wildlife

Threat to wildlife	Poor pasture regeneration ☐	Wildlife habitat loss ☐	Livestock inteference ☐	Poaching ☐
Adaptation strategies	Pasture management ☐	Alternative economic activities ☐	Problem wildlife translocation ☐	Community participation ☐
	Incentives for conservation ☐	Public awareness ☐	Fences & Land management ☐	More watering points ☐
Drawbacks	Poor coordination ☐	Lack of finances ☐	Low manpower /capacity ☐	Lack of legislation ☐

Climate adaptation measures – Water

Threat to Water supply	Irregular rainfall ☐	Water catchment area loss ☐	Floods/ droughts ☐	No. of users ☐
Adaptation strategies	Rain harvest ☐	Diversified water sources ☐	Efficient water infrastructure ☐	Frequent training resource users ☐
	Agroforestry/ Reforestation ☐	Public awareness /Recycle & reuse ☐	Land use management ☐	Modern irrigation techniques ☐
Drawbacks	Poor coordination ☐	Lack of finances ☐	Low manpower /capacity ☐	Lack of legislation ☐

SECTION B: RESOURCE CONFLICTS & RESOLUTION

Trend of conflict	Increasing ☐	Seasonal ☐	Decreasing ☐	
Key conflict resource	Water ☐	Crops ☐	Livestock ☐	Wildlife ☐
Cause of conflict	Habitat loss ☐	Wildlife attacks ☐	Poaching ☐	Development/ infrastructure ☐
	Water scarcity /shortage ☐	Land use Competition ☐	Land use Competition ☐	No. of water users ☐
Conflict driver	Ineffective institutions ☐	Low finances ☐	Cultural information ☐	Lack of policy ☐
Outcome	Community tension ☐	Targeted violence ☐	Poor or no collaboration ☐	Project/ Program sabotage ☐
Conflict arbitrator	Council of Elders ☐	Government officials ☐	Investor or Coordinator ☐	NGO/FBO ☐
Solutions	Resource use negotiations ☐	Fines/Jail term ☐	Compensation ☐	Reallocation of land ☐
Public awareness	Barazas ☐	Posters/fliers ☐	Workshops ☐	Media ☐

SECTION C: SOCIAL NETWORKS

Funding partners	1.	2.	3.	4.	5.
Research & training partners	1.	2.	3.	4.	5.
Project Partners (implementation)	1.	2.	3.	4.	5.
Feedback frequency	Regular ☐	Weekly ☐	Monthly ☐	Irregular ☐	None ☐

Appendix 4: Targeted planned adaptation measures by NCCRS

1. **General**
    a. Conducting climate change awareness campaigns to underscore the importance of sustainable use of resources - comprehensive communications plan
    b. Building or enhancing systems for conveying climate information.
    c. Diversifying local economies through sericulture, apiculture, sustainable fisheries, tree nurseries and value addition initiatives
    d. Strengthening disaster preparedness
    e. Establish local technological centres and providing incentives to local innovators to promote more research on local technologies

2. **Agriculture**
    a. Indigenous and more drought tolerant food crops like cassava, millet, sorghum sweet potatoes can be reintroduced into the farming systems
    b. Reconfiguring irrigated production systems to use water more efficiently
    c. Increase rain-water infiltration, reduce run-off during floods, reduce soil erosion, and help trap sediments
    d. Promoting conservation agriculture (CA),
    e. Insure farmers against crop failure due to droughts, pests or floods
    f. Enhancing agricultural extension services to train farmers on how to better cope with climate variability and change
    g. Strengthening integrated and environmental friendly pest management systems to cope with increased threats
    h. Developing proper food storage facilities to cater for surplus harvest
    i. Breeding animals from various agro-ecological zones that adapt well to climatic vagaries,
    j. Regular vaccination campaigns and cross border disease surveillance to reduce infections by migrating animals
    k. Investing in programmes to harvest and store fodder for use during dry seasons.
    l. Inventorying indigenous knowledge that has conventionally been used by local communities to cope with erratic climate,

3. **Water**
    a. Constructing inter-basin and intra-basin water transfers
    b. Investing in decentralised municipal water recycling facilities
    c. Enactment of laws and regulations required for efficient water resource management,

d. Construction of waterways, strategic boreholes and other water harvesting structures
e. Building capacity for water quality monitoring
f. A strategic fund to purchase water purification chemicals for disinfection of community wells and shallow boreholes during floods and drought episodes
g. De-silting rivers and dams to improve carrying capacity
h. Protecting and conserving water catchment areas, river- banks, and water bodies from degradation and contamination
i. Introducing financial instruments such as subsidies to promote technologies that use water efficiently.

4. Medicinal plants – Forestry

a. Intensified and sustained afforestation and reforestation programmes
b. Promoting alternative livelihood systems such as beekeeping, silkworm rearing, *Aloe vera* and gum arabic farming to take pressure off forest resources.
c. Promoting alternative energy sources, energy conservation initiatives, and efficient charcoal production

5. Wildlife/tourism

a. Developing a National Wildlife Adaptation Strategy
b. Monitoring, management and remediation of degraded rangelands
c. Wildlife translocation during extreme droughts
d. Creating community wildlife conservancies to help in the conservation of wildlife

Appendix 5: List of experts and key resource managers interviewed during the field study.

Name	Organisation	Position	Focus of interview
Dr. Harun Warui	Africa Adaptation Program - Kenya	National Programme Manager	Adaptation activities in Kenya
Dr. Njeru	Ministry of Livestock development - MoLD	District Vet officer	Climate change impacts and livestock keeping
Dr. O. Nyakweba	Ministry of Forestry & Wildlife	Deputy Director in Conservation	Forests and climate condition in Kenya, Status of medicinal Plants as a solution
Mr. A. L. Alusa	OPM – Climate change coordination Unit	Climate change policy advisor	Climate Innovation Centre and early warning systems
Mr. A. Musili	Ministry of Livestock development - MoLD	District Livestock production officer	Climate change impacts and livestock keeping
Mr. Abebe	Intergovernmental Panel on Climate Prediction and Adaptation Kenya	Project Officer	Climate change predictions and projections for Kenya
Mr. Anthony Kasanga	Maasai Lion Trust Program	Field Officer	Human-Wildlife conflict management
Mr. B.M. Kariuki	Survey of Kenya (Headquarters)	Adjudication areas dept. Officer	Availability of maps indicating the ongoing land subdivision.
Mr. Benjamin Pareno	Kenya Forest Service	Loitoktok Forest Officer in-charge	Community based forest associations and status of medicinal plants in forest conservation
Mr. Benson Ngigi	Ministry of Agriculture	Loitoktok Agricultural Officer	Climate change and crop production
Mr. David Gitonga	Ministry of Tourism	Chief Tourist Officer	Climate change impacts on the tourism industry
Mr. George Muiruri (Wonderful)	Private Farm	Owner	Household resilience and unreliable climate impacts on livelihoods
Mr. George W. Mutuku	African Medical and Research Foundation (AMREF)	Project Officer WASH	Water scarcity and sustainable water use
Mr. Guracha Guyo	Youth Enterprise Development Fund-MoYSA	Deputy Director for Research	Role of revolving fund on resource utilisation and livelihoods
Mr. J. N. Mukui	MPND & Vision 2030	Director Rural Planning Directorate	Grassroots data collection for effective state planning
Mr. J. Parmuat	Loitoktok Herbalist Association	Chairman	Economic value, role and status of medicinal plants in Loitoktok.
Mr. Jack Marubu	Kenya Wildlife Service - Nairobi	GIS and remote sensing department	Land-use and encroachment of protected areas in Loitoktok.
Mr. John Kinyua	Water Resource Management Authority	Training Officer	Role of training water users in reducing conflicts
Mr. K. Musau	Water Resource Management Authority	Director	Implementation of the Water Act of 2002 at the local level

Name	Organisation	Position	Focus of interview
Mr. Kaloki Kitavi	Amboseli National Park – KWS	Community Warden	Human-wildlife conflicts and climate adaptation and mitigation activities in the park
Mr. Kasaini	County council	Chief for Olooloipon Location	Resource conflict causes, trends and resolutions
Mr. Kiiru	Ministry of Finance	Economist	2007/2008 and 2002/2003 development budgets
Mr. Kimata	Ministry of Water & Irrigation	Loitoktok Water Officer	Climate change and water
Mr. Koikai	Amboseli –Tsavo Group Ranches Association	Director	Climate change, wildlife and tourism in Loitoktok
Mr. M. Lampat	Ministry of Water & Irrigation	Water officer	Nature of collaborative projects done by the ministry to ensure water security
Mr. Michael Macharia	Senate High School	Geography teacher	Climate change awareness in the school curricula
Mr. Molu Halake	Loitoktok District administration	District Education Officer	Climate change, sustainable use and conflicts in school curricula
Mr. Mulwa	Loitoktok District administration	District Treasury	Allocation of funds for resource governance by national government
Mr. Ndambuki Mwiu	Kenya Wildlife Service	Research Scientist Amboseli	Climate change, wildlife and tourism in Loitoktok
Mr. Nyaga	Kenya Wildlife Service - Kajiado Office	Deputy Warden for Amboseli Ecosystem	Wildlife conflict history vs. development agenda
Mr. Odhiambo	Loitoktok Water Company	Director	Water governance at the community level
Mr. Oscar Mayunzu	Kenya Forestry research Institute (KEFRI)	Research Scientist - Natural products	Innovations and investment by the government in the medicinal plants sector
Mr. P. Mwangi	Kenya Forest Service - Kajiado office	District Forest officer	Stakeholders in forest conservation & initiatives
Mr. P. Ngugi	Ministry of Finance	Director of Budget	Allocation by donors in the Kenyan development budget
Mr. Ron Guijis	Tawi Lodge in Amboseli National Park	Hotel Manager	Climate change, wildlife and tourism in Loitoktok
Mr. Samuel Muchiri	Kenya Meteorological department (Headquarters)	Research Liaison Officer	Status of climatic data for the study area. Effectiveness of early warning systems in Kenya.
Mr. Seleyan	Ministry of Planning	Loitoktok development Officer	Trends in population and community structure over the last 20 years.
Mr. T. Kinyajui & Mr. D. Omondi	Ewaso Nyiro Development Authority -ENSDA	Field Officers	Water governance at the community level
Mr. Wachira	Kajiado Lands office	District surveyor	Information on subdivision status of the community group ranches in Loitoktok.
Mr. Wanyoike & Daniel (field)	Youth Enterprise Development Fund	Loitoktok program officers	Role of revolving fund on resource utilisation and livelihoods

Name	Organisation	Position	Focus of interview
Mr. William Obuyo	Ilkisonko High School	Geography teacher	Climate change awareness in the school curricula
Mrs. Fatuma Hussein	MEMR – Climate Change Secretariat	Climate Change COP Negotiator	Vision and Mission of the national climate change secretariat
Mrs. I. Masinde	DANIDA Funds in Ministry of Environment	Technical Advisor Environmental Policy	Impact of adaptation funds on livelihoods in Kenya
Ms. Betty and Lidia Karanja	Ministry of Environment - NEMA office in Kajiado	Field Officers	Environmental issues in the district
Ms. Jane-Rose Maina	Water Resource Management Authority	Water Rights Officer	Structure and systems of sharing water in Loitoktok
Ms. L. Lengete	Women Enterprise Fund	Loitoktok program officer	Role of revolving fund on resource utilisation and livelihoods
Ms. Linda Etale	Act, Change & Transform Kenya	Program assistant in conflict program	Resource conflict causes, trends and resolutions
Ms. Mary Kamau	Loitoktok District administration	District Officer I	Resource conflict causes, trends and resolutions
Ms. Millicent Omala	Kenya Climate Change working group	Community Resource Management Officer	Climate change impacts and adaptation activities in Loitoktok
Ms. Nancy Njeri	AYICC – African Youth in Climate Change	Coordinator	Youths and climate change
Ms. Peris M. Kariuki	Kenya Research in Indigenous Knowledge (KENRIK)	Research Scientist	Studies on medicinal plants as part of sustainable development in Kenya
Ms. Rahab Wandia	African Conservation Centre	Administrative assistant	Activities carried out under the Amboseli Conservation program.
Ms. Rose Akombo	Kenya Forestry research Institute (KEFRI)	Assistant Director - CC response Programme	Afforestation activities and renewable energies at the grassroots
Prof. John Kiringe	School of Field Studies – USA	Director of Loitoktok school	Community participatory projects that enhance conservation and livelihoods

Appendix 6: Details of group discussions held at Loitoktok**.**

Location	Resource sector	Composition	Focus of interview
Group discussion with 15 members from Entarara village	Water Resource Users Association	WRUA members	Effect of legislation on rural water supply and resource conflicts
Group discussion with Agnes, Lesanta, Matayo, Jackson, Musa and Solomon	Kuku B Group Ranch	Group Ranch members	Subdivision and effects on resource governance
Group discussion with Elijah, Noah, Kasaini, Sakimba and Isaac	Mbirikani Group Ranch	Group Ranch members	Subdivision and effects on resource governance
Group discussion with Samuel Maiyani, Panian and Mauel.	Kimana Group Ranch	Group Ranch members	Subdivision and effects on resource governance
Individual interviews with 10 men randomly selected in the district	Community interviews	Diverse livelihoods	Climate change impacts on livelihoods, and resource governance
Individual interviews with 12 women randomly selected in the district	Community interviews	Diverse livelihoods	Climate change impacts on livelihoods, and resource governance

Appendix 7: List of actors involved in resource governance at Loitoktok**.** Actors classified under social development are involved in more than one governance activity and/or actors.

No.	Label	Full Name	Type	Sector
1	ABANTUDEVT	Abantu Development Organisation	NGO	Social development
2	ACC	African Conservation Centre	Private	Social development
3	AFC	Agricultural Finance Corporation	Public	Agriculture
4	AgriBD	Agriculture Business Development	Private	Agriculture
5	AgroSolutions	Agro-Solutions Limited	Private	Agriculture
6	ALLPRO	ASAL-Based Livestock and Rural Development Programmes	Private	Livestock
7	AmboseliSerena	Amboseli Serena	Private	Wildlife
8	AmboseliSopa	Amboseli Sopa	Private	Wildlife
9	AMIRAN	AMIRAN Kenya Ltd	Private	Agriculture
10	AMREF	African Medical and Research Foundation	NGO	Social development
11	ANPCANKENYA	African Network for the Prevention and Protection against Child Abuse and Neglect	Civic	Health
12	APHIAII	AIDS, Population and Health Integrated Assistance Program	Civic	Health
13	ATE	Amboseli Trust for Elephants	Private	Wildlife
14	ATGRCA	Amboseli-Tsavo Group Ranches Conservation Association	Civic	Wildlife
15	AWF	African Wildlife Foundation	Private	Social development
16	Bayer	Bayer Solutions Kenya	Private	Agriculture
17	BeadWorksCGs	Bead-Work Community groups	Civic	Wildlife
18	BusinessCGs	Business Community Groups	Civic	Social development
19	CampiKanzi	Campi ya Kanzi	Private	Wildlife
20	CATHOLICNGONG	Catholic Church - Ngong branch	Civic	Social development
21	CHILDFUND	Christian Children's Fund	NGO	Education
22	ChyuluConservancy	Chyulu Conservancy	Private	Wildlife
23	CityFarming	City Farming Kenya	Private	Agriculture
24	CONCERNWORLD	Concern World Wide	NGO	Health
25	CouncilElders	Council of Elders	Civic	Social development
26	CulturalBSAmboseli	Cultural Bomas in Amboseli	Civic	Wildlife
27	CWEF	Constituency Women Enterprise Funds Office	Public	Social development
28	CYEDF	Constituency Youth Enterprise Development Funds Office	Public	Social development
29	DAO	District Agricultural Office	Public	Agriculture
30	DEdO	District Education Office	Public	Education
31	DHO	District Health Office	Public	Health
32	DIO	District Irrigation Office	Public	Water
33	DKFS	District Kenya Forest Service	Public	Forestry
34	DKWS	District Kenya Wildlife Service	Public	Wildlife
35	DLG	Local Government Office in district	Public	Social development

No.	Label	Full Name	Type	Sector
36	DLO	District Livestock Officer	Public	Livestock
37	DorcasAid	Dorcas Aid	NGO	Social development
38	DOREP	Desert Oasis Residents Empowerment programme	Private	Livestock
39	DSdO	District Social Development Office	Public	Social development
40	DWO	District Water Office	Public	Water
41	EducateCGs	Education Community Groups	Civic	Education
42	ENSDA	Ewaso Nyiro South Development Authority	Public	Social development
43	ENVCGs1	Environmental Community Groups	Civic	Forestry
44	EquityBank	Equity Bank	Private	Agriculture
45	EWANGANWUADVG	Ewanganwu Advocacy	Civic	Health
46	FARAJATRUST	Faraja Trust	NGO	Social development
47	FG1	Farmers Groups	Civic	Agriculture
48	FGMCGs	Anti-Female Genital Mutilation Groups	Civic	Health
49	FPFK	Free Pentecostal Fellowship- Kenya Organisation	NGO	Health
50	FRIFATSUPGRP	Frifat Support Group	Civic	Health
51	GameScouts	Game Scouts Association	Civic	Wildlife
52	GERMANAGRO	German Agro-action Kenya	NGO	Social development
53	HCDA	Horticultural Crops Development Authority	Public	Agriculture
54	HealthHIVCGs	Health & HIV Community Groups	Civic	Health
55	HerbalistCGs	Herbalist Association	Civic	Forestry
56	HOPE	Hope Kenya	NGO	Health
57	HospInv	Minor hospitality Investors	Private	Wildlife
58	ICIPE	International Centre of Insect Physiology and Ecology	Private	Agriculture
59	ICPAK	Intergovernmental Panel on Climate Prediction and Adaptation Kenya	Public	Livestock
60	IlkisonkoSacco	Ilkisonko Sacco	Private	Agriculture
61	IMBIRIKANIAIDS	Imbirikani- AIDS Support Group	Civic	Health
62	KARI	Kenya Agricultural Research Institute	Public	Agriculture
63	KEFRI	Kenya Forest Research Institute	Public	Forestry
64	KenyaSeed	Kenya Seed Company	Public	Agriculture
65	KEPHIS	Kenya Plant Health Inspectorate Service	Public	Agriculture
66	KimanaSanctuary	Kimana Sanctuary	Private	Wildlife
67	KVaccinePI	Kenya Vaccine Production Institute	Public	Livestock
68	LEWETKENYA	Lewet Kenya	NGO	Social development
69	LOTERAHCODE	Loretrah Code Kenya	Civic	Health
70	LWC	Loitoktok Water Company	Public	Water
71	LYFAT	Lyfat Organisation	Civic	Health
72	MAAOUTREACH	Maa Outreach	NGO	Social development
73	MaasaiLionTrust	Maasai Lion Trust	Private	Wildlife
74	Mavuno	Mavuno Limited	Private	Agriculture

No.	Label	Full Name	Type	Sector
75	NCPb	National Cereals and Produce Board	Public	Agriculture
76	NIA	NIA organisation	Civic	Water
77	NOOMAYIANAT	Noomayianat	Civic	Social development
78	OlDonyo-WuasLodge	OlDonyo-Wuas Lodge	Private	Wildlife
79	OlkeriSanctuary	Olkeri Sanctuary	Private	Wildlife
80	OltukaiLodge	Oltukai Lodge	Private	Wildlife
81	PACTKENYA	Pact Kenya	NGO	Social development
82	ParksCanada	Parks Canada	Private	Wildlife
83	PastG1	Pastoralists Groups	Civic	Livestock
84	PoriniCamp	Porini Camp	Private	Wildlife
85	RedCross	Red Cross	NGO	Livestock
86	SACDEP	Sustainable Agriculture Community Development Programmes	Private	Livestock
87	SCILO	SCILO Kenya	NGO	Social development
88	SelfhelpCGs	Self-help Community Groups	Civic	Social development
89	SFS	School of Field Studies (USA)	Private	Wildlife
90	ShompoleLodge	Shompole Lodge	Private	Wildlife
91	SMEP	Small and Micro Enterprise Programme	Private	Agriculture
92	SNV	Netherlands Development Organisation	Private	Social development
93	SONSHIPFOUND	Sonship Foundation Kenya	Civic	Social development
94	Syngenta	Syngenta Company	Private	Agriculture
95	TawiLodge	Tawi Lodge	Private	Wildlife
96	TOPServe	Top Serve Company	Private	Agriculture
97	TortilisCamp	Tortilis Camp	Private	Wildlife
98	Tourists	Tourists (Domestic & International)	Private	Wildlife
99	UNICEF	United Nations Children's Fund	Private	Water
100	USAID	United States Agency for International Development	Private	Wildlife
101	WaterPGs1	Water Project Community Groups	Civic	Water
102	WelfareCGs	Welfare Community Groups	Civic	Social development
103	WGs1	Community Women Groups	Civic	Social development
104	Wingsfor Earth	Wings for Earth	NGO	Agriculture
105	WRMA	Water Resource Management Authority	Public	Water
106	WRUA	Water Resource Users Associations	Civic	Water
107	WWF	World Wildlife Fund	Private	Forestry
108	YGs1	Youth Groups	Civic	Social development

Appendix 8a: Calculated degree centrality values for both current and netweaved social structure for Loitoktok community.

Degree centrality of actors in Loitoktok social structure			
Actor	**Original Network**	**Actor**	**Netweaved Structure**
DKWS	30	DKFS	45
DAO	28	DKWS	43
DLG	22	DAO	35
DHO	18	DLO	31
Tourists	17	DLG	31
DSdO	16	CouncilElders	29
DLO	15	HerbalistCGs	29
GameScouts	14	DHO	28
DWO	13	DWO	26
DKFS	11	DSdO	26
DEdO	7	GameScouts	25
CouncilElders	4	EnvCGs1	23
HospInv	4	PastG1	18
CYEDF	4	CulturalBsAmboseli	18
EquityBank	3	Tourists	17
SNV	3	DEdO	17
AmboseliSerena	3	ICIPE	15
AmboseliSopa	3	CYEDF	14
OltukaiLodge	3	WaterPGs1	13
TawiLodge	3	CWEF	13
TortilisCamp	3	ACC	12
PoriniCamp	3	FG1	11
CampiKanzi	3	AWF	11
ShompoleLodge	3	ATE	11
OlDonyoWuasLodge	3	ATGRCA	11
ChyuluConservancy	3	WWF	11
OlkeriSanctuary	3	SFS	11
KimanaSanctuary	3	MaasaiLionTrust	11
BeadWorkCGs	3	ENSDA	10
CulturalBsAmboseli	3	NCPb	9
WRMA	3	KEPHIS	9
DIO	3	ICPAK	9
CWEF	3	KARI	9
HerbalistCGs	3	HCDA	9
CATHOLICNGONG	3	HealthHIVCGs	8
ENSDA	2	KVaccinePI	7
DorcasAid	2	AmboseliSerena	7
FG1	2	AmboseliSopa	7
PastG1	2	OltukaiLodge	7

Degree centrality of actors in Loitoktok social structure				
Actor	**Original Network**		**Actor**	**Netweaved Structure**
AWF	2		TawiLodge	7
ACC	2		TortilisCamp	7
AMREF	2		PoriniCamp	7
EnvCGs1	2		CampiKanzi	7
WaterPGs1	2		ShompoleLodge	7
LWC	2		OlDonyoWuasLodge	7
YGs1	2		ChyuluConservancy	7
WGs1	2		OlkeriSanctuary	7
EducateCGs	2		KimanaSanctuary	7
HealthHIVCGs	2		DIO	7
FGMCGs	2		WRMA	6
BusinessCGs	2		LWC	6
FARAJATRUST	2		KEFRI	6
SCILO	2		HospInv	4
LEWETKENYA	2		WRUA1	4
NOOMAYIANAT	2		EquityBank	3
SONSHIPFOUND	2		SNV	3
AgriBD	1		BeadWorkCGs	3
KenyaSeed	1		CATHOLICNGONG	3
NCPb	1		DorcasAid	2
KEPHIS	1		AMREF	2
TOPServe	1		YGs1	2
Bayer	1		WGs1	2
AgroSolutions	1		EducateCGs	2
CityFarming	1		FGMCGs	2
Syngenta	1		BusinessCGs	2
Mavuno	1		FARAJATRUST	2
SMEP	1		SCILO	2
IlkisonkoSacco	1		LEWETKENYA	2
AFC	1		NOOMAYIANAT	2
DOREP	1		SONSHIPFOUND	2
RedCross	1		AgriBD	1
ICPAK	1		KenyaSeed	1
SACDEP	1		TOPServe	1
ALLPRO	1		Bayer	1
KVaccinePI	1		AgroSolutions	1
ATE	1		CityFarming	1
ATGRCA	1		Syngenta	1
USAID	1		Mavuno	1
ParksCanada	1		SMEP	1
WWF	1		IlkisonkoSacco	1

Degree centrality of actors in Loitoktok social structure				
Actor	**Original Network**		**Actor**	**Netweaved Structure**
SFS	1		AFC	1
WRUA1	1		DOREP	1
UNICEF	1		RedCross	1
WelfareCGs	1		SACDEP	1
SelfhelpCGs	1		ALLPRO	1
CHILDFUND	1		USAID	1
PACTKENYA	1		ParksCanada	1
NIA	1		UNICEF	1
FRIFATSUPGRP	1		WelfareCGs	1
IMBIRIKANIAIDS	1		SelfhelpCGs	1
LYFAT	1		CHILDFUND	1
ANPCANKENYA	1		PACTKENYA	1
APHIAII	1		NIA	1
LORETRAHCODE	1		FRIFATSUPGRP	1
EWANGANWUADVG	1		IMBIRIKANIAIDS	1
CONCERNWORLD	1		LYFAT	1
GERMANAGRO	1		ANPCANKENYA	1
ABANTUDEVT	1		APHIAII	1
FPFK	1		LORETRAHCODE	1
MAAOUTREACH	1		EWANGANWUADVG	1
MaasaiLionTrust	1		CONCERNWORLD	1
KARI	1		GERMANAGRO	1
HCDA	1		ABANTUDEVT	1
Wingsfor Earth	1		FPFK	1
HOPE	1		MAAOUTREACH	1
ICIPE	1		Wingsfor Earth	1
KEFRI	1		HOPE	1
AMIRAN	1		AMIRAN	1

Appendix 8b: Calculated betweenness values that represent structural holes for both current and netweaved social structure for Loitoktok community.

Betweenness values (structural holes) for actors in Loitoktok social structure				
Actor	Original Network		Actor	Netweaved Structure
DAO	713.9		DAO	818.0
DKWS	614.2		DKFS	606.9
DLG	406.4		DKWS	565.4
DSdO	235.0		DLG	454.3
DLO	180.9		DLO	401.3
Tourists	128.5		DSdO	292.6
DWO	120.0		DWO	259.3
DHO	96.0		DHO	253.5
DKFS	81.5		HerbalistCGs	167.1
GameScouts	78.0		GameScouts	104.3
DEdO	22.0		EnvCGs1	85.3
CYEDF	12.0		Tourists	62.0
EquityBank	6.0		CouncilElders	57.0
SNV	6.0		DEdO	54.7
CWEF	6.0		ICIPE	48.2
BeadWorkCGs	4.0		CYEDF	44.0
CulturalBsAmboseli	4.0		PastG1	36.4
WRMA	4.0		CulturalBsAmboseli	36.0
HerbalistCGs	4.0		WaterPGs1	30.5
HospInv	3.0		CWEF	18.0
FG1	2.0		HealthHIVCGs	6.4
PastG1	2.0		DIO	4.8
EnvCGs1	2.0		FG1	4.5
WaterPGs1	2.0		ACC	2.6
YGs1	2.0		AmboseliSerena	2.2
WGs1	2.0		AmboseliSopa	2.2
EducateCGs	2.0		OltukaiLodge	2.2
HealthHIVCGs	2.0		TawiLodge	2.2
FGMCGs	2.0		TortilisCamp	2.2
AWF	1.0		PoriniCamp	2.2
AmboseliSerena	1.0		CampiKanzi	2.2
AmboseliSopa	1.0		ShompoleLodge	2.2
OltukaiLodge	1.0		OlDonyoWuasLodge	2.2
TawiLodge	1.0		ChyuluConservancy	2.2
TortilisCamp	1.0		OlkeriSanctuary	2.2
PoriniCamp	1.0		KimanaSanctuary	2.2
CampiKanzi	1.0		HospInv	2.0
ShompoleLodge	1.0		WRMA	1.5

Betweenness values (structural holes) for actors in Loitoktok social structure				
Actor	Original Network		Actor	Netweaved Structure
OlDonyoWuasLodge	1.0		LWC	1.5
ChyuluConservancy	1.0		ENSDA	1.2
OlkeriSanctuary	1.0		BeadWorkCGs	1.0
KimanaSanctuary	1.0		KVaccinePI	0.8
AMREF	1.0		WWF	0.6
FARAJATRUST	1.0		SFS	0.6
LEWETKENYA	1.0		MaasaiLionTrust	0.6
AgriBD	0.0		KEFRI	0.5
KenyaSeed	0.0		AgriBD	0.0
NCPb	0.0		KenyaSeed	0.0
ENSDA	0.0		NCPb	0.0
KEPHIS	0.0		KEPHIS	0.0
TOPServe	0.0		TOPServe	0.0
Bayer	0.0		Bayer	0.0
AgroSolutions	0.0		AgroSolutions	0.0
CityFarming	0.0		CityFarming	0.0
Syngenta	0.0		Syngenta	0.0
Mavuno	0.0		EquityBank	0.0
SMEP	0.0		Mavuno	0.0
IlkisonkoSacco	0.0		SMEP	0.0
AFC	0.0		IlkisonkoSacco	0.0
DorcasAid	0.0		AFC	0.0
DOREP	0.0		DorcasAid	0.0
RedCross	0.0		DOREP	0.0
ICPAK	0.0		SNV	0.0
SACDEP	0.0		RedCross	0.0
ALLPRO	0.0		ICPAK	0.0
KVaccinePI	0.0		SACDEP	0.0
CouncilElders	0.0		ALLPRO	0.0
ATE	0.0		AWF	0.0
ACC	0.0		ATE	0.0
ATGRCA	0.0		ATGRCA	0.0
USAID	0.0		USAID	0.0
ParksCanada	0.0		ParksCanada	0.0
WWF	0.0		AMREF	0.0
SFS	0.0		WRUA1	0.0
WRUA1	0.0		UNICEF	0.0
DIO	0.0		YGs1	0.0
LWC	0.0		WGs1	0.0
UNICEF	0.0		WelfareCGs	0.0
WelfareCGs	0.0		SelfhelpCGs	0.0

Betweenness values (structural holes) for actors in Loitoktok social structure				
Actor	Original Network		Actor	Netweaved Structure
SelfhelpCGs	0.0		EducateCGs	0.0
BusinessCGs	0.0		FGMCGs	0.0
SCILO	0.0		BusinessCGs	0.0
CHILDFUND	0.0		FARAJATRUST	0.0
PACTKENYA	0.0		SCILO	0.0
NOOMAYIANAT	0.0		CHILDFUND	0.0
NIA	0.0		PACTKENYA	0.0
CATHOLICNGONG	0.0		LEWETKENYA	0.0
FRIFATSUPGRP	0.0		NOOMAYIANAT	0.0
SONSHIPFOUND	0.0		NIA	0.0
IMBIRIKANIAIDS	0.0		CATHOLICNGONG	0.0
LYFAT	0.0		FRIFATSUPGRP	0.0
ANPCANKENYA	0.0		SONSHIPFOUND	0.0
APHIAII	0.0		IMBIRIKANIAIDS	0.0
LORETRAHCODE	0.0		LYFAT	0.0
EWANGANWUADVG	0.0		ANPCANKENYA	0.0
CONCERNWORLD	0.0		APHIAII	0.0
GERMANAGRO	0.0		LORETRAHCODE	0.0
ABANTUDEVT	0.0		EWANGANWUADVG	0.0
FPFK	0.0		CONCERNWORLD	0.0
MAAOUTREACH	0.0		GERMANAGRO	0.0
MaasaiLionTrust	0.0		ABANTUDEVT	0.0
KARI	0.0		FPFK	0.0
HCDA	0.0		MAAOUTREACH	0.0
Wingsfor Earth	0.0		KARI	0.0
HOPE	0.0		HCDA	0.0
ICIPE	0.0		Wingsfor Earth	0.0
KEFRI	0.0		HOPE	0.0
AMIRAN	0.0		AMIRAN	0.0

Appendix 8c: Calculated brokerage for both current and netweaved social structure for Loitoktok community.

Brokerage opportunities for actors in Loitoktok social structure				
Actor	**Original Network**		**Actor**	**Netweaved Structure**
DKWS	764		DKFS	1429
DAO	729		DKWS	1318
DLG	426		DAO	971
Tourists	241		DLG	669
DSdO	236		DLO	646
DLO	189		HerbalistCGs	534
GameScouts	156		DSdO	450
DWO	130		DWO	377
DKFS	87		GameScouts	350
DHO	66		DHO	258
DEdO	17		EnvCGs1	254
CYEDF	12		CouncilElders	236
EquityBank	6		Tourists	190
SNV	6		CulturalBsAmboseli	174
HospInv	6		PastG1	127
CWEF	6		ICIPE	94
BeadWorkCGs	4		DEdO	88
CulturalBsAmboseli	4		CYEDF	66
WRMA	4		WaterPGs1	58
HerbalistCGs	4		CWEF	40
FG1	2		FG1	18
PastG1	2		HealthHIVCGs	16
AmboseliSerena	2		DIO	14
AmboseliSopa	2		ACC	13
OltukaiLodge	2		ENSDA	8
TawiLodge	2		AmboseliSerena	8
TortilisCamp	2		AmboseliSopa	8
PoriniCamp	2		OltukaiLodge	8
CampiKanzi	2		TawiLodge	8
ShompoleLodge	2		TortilisCamp	8
OlDonyoWuasLodge	2		PoriniCamp	8
ChyuluConservancy	2		CampiKanzi	8
OlkeriSanctuary	2		ShompoleLodge	8
KimanaSanctuary	2		OlDonyoWuasLodge	8
EnvCGs1	2		ChyuluConservancy	8
WaterPGs1	2		OlkeriSanctuary	8
YGs1	2		KimanaSanctuary	8
WGs1	2		WRMA	6

Brokerage opportunities for actors in Loitoktok social structure				
Actor	**Original Network**		**Actor**	**Netweaved Structure**
EducateCGs	2		LWC	6
HealthHIVCGs	2		KVaccinePI	4
FGMCGs	2		HospInv	4
AWF	1		WWF	4
AMREF	1		SFS	4
FARAJATRUST	1		MaasaiLionTrust	4
LEWETKENYA	1		BeadWorkCGs	2
AgriBD	0		KEFRI	2
KenyaSeed	0		AgriBD	0
NCPb	0		KenyaSeed	0
ENSDA	0		NCPb	0
KEPHIS	0		KEPHIS	0
TOPServe	0		TOPServe	0
Bayer	0		Bayer	0
AgroSolutions	0		AgroSolutions	0
CityFarming	0		CityFarming	0
Syngenta	0		Syngenta	0
Mavuno	0		EquityBank	0
SMEP	0		Mavuno	0
IlkisonkoSacco	0		SMEP	0
AFC	0		IlkisonkoSacco	0
DorcasAid	0		AFC	0
DOREP	0		DorcasAid	0
RedCross	0		DOREP	0
ICPAK	0		SNV	0
SACDEP	0		RedCross	0
ALLPRO	0		ICPAK	0
KVaccinePI	0		SACDEP	0
CouncilElders	0		ALLPRO	0
ATE	0		AWF	0
ACC	0		ATE	0
ATGRCA	0		ATGRCA	0
USAID	0		USAID	0
ParksCanada	0		ParksCanada	0
WWF	0		AMREF	0
SFS	0		WRUA1	0
WRUA1	0		UNICEF	0
DIO	0		YGs1	0
LWC	0		WGs1	0
UNICEF	0		WelfareCGs	0
WelfareCGs	0		SelfhelpCGs	0

Brokerage opportunities for actors in Loitoktok social structure				
Actor	**Original Network**		**Actor**	**Netweaved Structure**
SelfhelpCGs	0		EducateCGs	0
BusinessCGs	0		FGMCGs	0
SCILO	0		BusinessCGs	0
CHILDFUND	0		FARAJATRUST	0
PACTKENYA	0		SCILO	0
NOOMAYIANAT	0		CHILDFUND	0
NIA	0		PACTKENYA	0
CATHOLICNGONG	0		LEWETKENYA	0
FRIFATSUPGRP	0		NOOMAYIANAT	0
SONSHIPFOUND	0		NIA	0
IMBIRIKANIAIDS	0		CATHOLICNGONG	0
LYFAT	0		FRIFATSUPGRP	0
ANPCANKENYA	0		SONSHIPFOUND	0
APHIAII	0		IMBIRIKANIAIDS	0
LORETRAHCODE	0		LYFAT	0
EWANGANWUADVG	0		ANPCANKENYA	0
CONCERNWORLD	0		APHIAII	0
GERMANAGRO	0		LORETRAHCODE	0
ABANTUDEVT	0		EWANGANWUADVG	0
FPFK	0		CONCERNWORLD	0
MAAOUTREACH	0		GERMANAGRO	0
MaasaiLionTrust	0		ABANTUDEVT	0
KARI	0		FPFK	0
HCDA	0		MAAOUTREACH	0
Wingsfor Earth	0		KARI	0
HOPE	0		HCDA	0
ICIPE	0		Wingsfor Earth	0
KEFRI	0		HOPE	0
AMIRAN	0		AMIRAN	0

Appendix 9: T-Test results for significance between the original Loitoktok network and the netweaved social structure.

BOOTSTRAP PAIRED SAMPLE T-TEST Number of bootstrap samples: 5000					
Original Loitoktok network density	0.0294	**Netweaved Loitoktok structure density**	0.0697	**Difference in density**	-0.0403
Estimated bootstrap standard error	0.0060	**Estimated bootstrap standard error**	0.0109	**Bootstrap standard error of the difference**	0.0125
Classical standard error of difference:				0.0028	
Classical t-test (indep samples):				-14.1808	
95% confidence interval for the difference:				[-0.0648, -0.0158]	
bootstrap t-statistic (indep samples):				-3.2291	
Bootstrap SE for the difference (paired samples):				0.0073	
95% bootstrap CI for the difference (paired samples):				[-0.0546, -0.0260]	
t-statistic:				-5.5183	
Average bootstrap difference:				-0.0396	
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Appendix 10: Table showing the proposed afforestation strategy using commonly used medicinal plant species in Loitoktok district**. Source:** Compiled by the author

Zones	Location	Relevant location examples in the district	Medicinal plants
1	Highland areas	Slopes of Mount Kilimanjaro	*Ficus sycomorus*
			Rhamnus stado
			Annona Squamosa
			Mondia whytei
2	Dryland forest	The fragmented Acacia woodlands	*Rhamnus prinoides*
			Lannea welwitschii
			Azadirachta indica
			Olea europaea
			Moringa oleifera
			Mondia whytei
3	Savannah/grassland	The widespread Athi Plains	*Acacia mellifera*
			Kigelia pinnata
			Erythrina abyssinica
			Warburgia ugandensis
			Acacia nilotica
			Salvadora persica
			Olea europaea
			Moringa oleifera
4	Riparian (Near water)	Along the main rivers and springs supplying water to the community	*Rhamnus prinoides*
			Ficus sycomorus
			Tamarindus indica
			Kigelia pinnata
			Albizia anthelmintica
			Balanites aegyptiaca
			Salvadora persica
			Moringa oleifera
			Annona Squamosa
5	Disturbed areas	Areas supplying material for infrastructure construction e.g. quarries, road sides and overgrazed areas.	*Lannea welwitschii*
			Ajuga remota
			Physalis peruviana
			Warburgia ugandensis
			Moringa oleifera

SHORT RESUME

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Representative publications

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