INTEGRATION OF TRADITIONAL AND SCIENTIFIC ECOLOGICAL KNOWLEDGE FOR ASSESSING CHANGES IN THE SEMI-ARID LANDSCAPE OF MAASAI STEPPE, NORTHERN TANZANIA

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By

Philbert Simon Nyinondi

A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Art (Information Studies) of the University of Dar es Salaam

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CERTIFICATION

The undersigned certify that she has read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: ***Integration of Traditional and Scientific Ecological Knowledge for Assessing Changes in the Semi-Arid Landscape of Maasai Steppe, Northern Tanzania,*** in fulfilment of the requirements for the Degree of Master of Art (Information Studies) of the University of Dar es Salaam.

....

Prof. J. Nawe

(Supervisor)

Date: 22.09.2011

DECLARATION

AND

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1, **Philbert Simon Nyinondi** declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

Signature ------------------------------------

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I am grateful to my loving parents, whom I shall always remain greatly indebted to for their untiring moral, love, advice material support and for laying down concrete foundation of my education, I say, "thank you mum and dad". Moreover, I thank my brothers and sisters whose prayers, love and care have always been a source of inspiration and encouragement.

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DEDICATION

To God, my loving wife Dorice, my son Nyinondi, and daughter Nandi who have been my companion and very trustful friends. To my beloved father Simon Nyinondi and Mother Allodia Nyinondi who laid the foundation of my education.

ABSTRACT

This study aimed at developing methodological framework for integrating Traditional Ecological Knowledge (TEK) and Scientific Ecological Knowledge (SEK) for promoting local co mmunities' participation in the implementation of the Convention on Biological Diversity (CBD) at local community levels. The study specifically observed how TEK and SEK are used in assessing environmental changes in the semi-arid landscape; identified traditional and scientific indicators used for landscapes assessments; and developed a model for assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania. Data were collected through interviews, observation, content analysis and joint field assessment; and analysed using Microsoft Excel Spreadsheet, QGIS tool. The study findings show that the Maasai herders, like ecologists, have qualitative systematic approach of assessing landscape changes and synthesise the changes in relation to various ecological and anthropogenic factors. Maasai herders use multiple indicators such as livestock productivity, landscape grazing potential, vegetation and soil characteristics to monitor and assess landscape conditions. Maasai TEK on landscape classification, species identification, landscape conditions, and adaptive management strategies can be scientifically validated, and can be integrated with SEK. Based on the study findings, systematic framework to integrate TEK and SEK for assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania was developed. The study recommends the use of framework that integrates TEK and SEK to achieve CBD global goals through participation of local communities in their areas.

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LIST OF ABBREVIATIONS

AWF	African Wildlife Foundation
CBD	Convention on Biological Diversity
CCD	Convention on Combating Desertification
CD-ROM	Compact Disc Read Only Memory
FAO	Food and Agricultural Organisation – United Nation Agency
GIS	Geographical Information System
GPS	Global Positioning System
MA	Millennium Ecosystem Assessment
NASA	National Aeronautics and Space Administration
SEK	Scientific Ecological Knowledge
SRTM	Shuttle Radar Topography Mission
TANAPA	Tanzania National Park Authority
TEK	Traditional Ecological Knowledge
UNCED	United Nation Conference on Environment
UNWCED	United Nation World Commission in Environment and Development
USGS	United States Geological Survey
WISP	World Initiative for Sustainable Pastoralism

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Traditional Ecological Knowledge (TEK) has been progressively recognized as essential in management of environment and natural resources (Desta and Smithson, 2010). Brosius (2006) characterized TEK of the landscape as an integral part of local knowledge systems for environmental classification, assessment and management. It is built around human environmental perceptions and historical knowledge of resource use. Such knowledge systems are common among pastoralists worldwide (Fernandez-Gimenez, 2000; Roba and Oba, 2008). Pastoralists like other indigenous people possess a rich vocabulary for describing landscape and an extensive knowledge of places in their environment (Brosius, 2006).

The management of arid and semi arid environments of East Africa, to a large extent, depends on pastoralists' TEK (Mapinduzi, 2001; Roba and Oba, 2009). Earlier, Parkipuny (1991) emphasized the importance of TEK in semi-arid environment of East Africa by stating that "it is not a mere accident of history that many of the most spectacular wildlife protection areas in East Africa were carved out in territories previously part of Maasailand". This is supported by the magnificent wildlife in Tarangire, Lake Manyara, Ngorongoro and Serengeti National Parks, and currently grazed area, the Maasai steppe.

Despite the recognition of the role of TEK in assessing environmental changes and management worldwide, it has been surpassed by scientific knowledge. Western countries and their formal education systems promoted Scientific Ecological Knowledge (SEK) over TEK for environmental assessment and management. For example, the establishment of protected areas in Maasai landscape between 1920s and 1980s were based on SEK, which required the removal of Maasai from their local environment. The process undermined the fact that the same Maasai have historically managed the landscape and lived in harmony with wildlife.

Generally, in the 19th century, the assessment and management policies of the Maasai semi-arid environment were dominated by fears of a 'tragedy of the commons' scenario. In this sense Maasai land use systems were perceived to be inappropriate, assumed to cause land degradation, desertification, drought and disaster (Lamprey, 1983; Sinclair and Fryxell, 1985). However, the introduction of SEK based management intervention to semi-arid environment of East Africa created intellectual debate on its effectiveness (Roba and Oba, 2008).

The debate centred on general applicability of the 'tragedy of the commons' and of classic equilibrium models of environmental degradation in arid and semi-arid rangelands (Oba, 2003; Briske *et al.*, 2003). These models suggested privatising the land, promoting western ranching system and carrying out environmental restoration to arrest land degradation (Oba, 2003). Many scholars criticised these models, which had assumptions more suited to equilibrium conditions, but in the environments better described as non-equilibrium (Sandford, 1983; Ellis and Swift, 1988; Behnke *et al.,* 1993; Oba *et al.,* 2000a). Opposing scholars contended that eco-systems in semi-arid or arid environment are continually shifting between multiple alternative vegetation states. The main driver is climate and no any long-term trend of environment deterioration under pastoralists land use. This school of thought supported the traditional land use systems that depended on TEK for assessing and managing environment. The evidence provided by Oba *et al.* (2000a) in support of Behnke and Scoones (1993) findings, emphasised communal ownership of landscape, mobility and flexibility in response to spatial and temporal distributions of pasture and habitat types.

The new paradigm on semi-arid environment management proved the weakness of SEK. The United Nation World Commission in Environment and Development (UN-WCED), in recognition of new paradigm and the importance of TEK, devoted attention to indigenous people. Agenda 21 which was adopted by 160 states at the United Nation Conference on Environment and Development in 1992 marked the world's turning point (UNCED, 1992). The UNCED (1992) consented to protect and use indigenous knowledge. The United National Convention on Biological Diversity (CBD), which was also pioneered by agenda 21, emphasized integration of both TEK and SEK in the assessment and management of local environment. Tanzania was among the early countries to sign CBD and ratified in 1996.

The integration of TEK and SEK in the assessment and management of local landscape was then set as the way forward. However, it lacked the practical model for its implementation.

1.2 Statement of the Problem

Despite the fact that Tanzania ratified CBD in 1996, its implementation has been constrained by lack of a model to integrate TEK and SEK for assessing environmental changes in the arid and semi-arid landscapes. The situation has not changed, fifteen years after CBD ratification. Assessment and monitoring of environmental changes in arid and semi-arid landscapes continued to be the role of scientists, who use exclusively scientific ecological methods and indicators. This is contrary to the convention condition of active participation of indigenous people. A local based integrated methodological approach is needed to address environmental degradation in semi-arid landscapes of Tanzania, especially those that are associated with changes in land use and outcome of SEK based interventions.

According to Roba and Oba (2008) this problem is not unique to Tanzania. Lack of integration model is a challenge to most countries in sub-Sahara, which are signatory to CBD. The same problem is also faced by other countries around the world (Scoones, 1999; Fernandez-Gimenez, 2000; Huntington *et al.*, 2004; Bart, 2006). Several scholars, for example Oba *et al.* (2008) attested that among the factors that hinder indigenous people to participate in the implementation of CBD is a lack of integration of TEK and ecological methods. The integration of TEK and SEK for assessing change in the semi-arid environment is fundamental to improve the understanding of the mechanisms behind changes in biodiversity and climate at local scales (Mapinduzi *et al.*, 2003; Bart, 2006).

Therefore, this study contributes to the national and the world efforts, which seek a model of integrating TEK and SEK for assessing environmental changes in the semi-arid landscape.

1.3 Research Objectives

1.3.1 Main Objective

The main objective of this study was to develop a model for integrating TEK and SEK for assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania.

1.3.2 Specific Objectives

Specific objectives were to:

i. Establish how TEK and SEK are used in assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania,

ii. Identify ecological and traditional indicators used for landscape assessments in the semi-arid landscape of Maasai Steppe in Northern Tanzania, and

iii. Develop a model for assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania.

1.3.3 Research Questions

The research questions which guided this study were:

i. How TEK and SEK are used in assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania?

ii. What are ecological and traditional indicators of identifying environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania?

iii. Which model can be used to integrate TEK and SEK in assessing environmental changes in the semi arid landscape?

1.4. Significance of the Study

The study adds knowledge on the role of TEK on arid and semi arid landscapes management. The findings and recommendations of this study can be used for increasing local communities' participation in local landscape management and creating linkages between research and development agenda. Information created can be used by different actors like World Initiative for Sustainable Pastoralism (WISP) and United Nations Food and Agricultural Organisation (FAO) in building knowledge system, and their development programme in semi-arid regions. More important, the study findings confirmed some aspects of previous studies and increase the understanding of TEK, and thus promote implementation of CBD, which emphasises the integration of TEK and SEK in assessing changes in local landscape. Therefore, it creates awareness on how best landscape managers and planners can involve local communities in sustainable management of the environment. The proposed approach of involving herders in environmental change assessment of Maasai Steppe (if put in practice) can improve the existing management strategies.

1.4.2 Scope and Limitations of the Study

The study was conducted in only three wards located in the Maasai Steppe, Northern Tanzania. The geographical coverage of this study was determined by set time and available funds. Language and culture were the main challenges for this study, where by most respondents speak Maa instead of Swahili and English, which are Tanzania's official languages. Hence, one of the Maasai 'Moran' was recruited for translation and assisting the researcher to familiarise with Maasai culture.

1.5 Operational Definitions of Basic Concepts

The following are definitions of basic concepts as used in this study.

Integration: The term integration is used in this study to connote collective use of indigenous and SEK methods and indicators to understand environmental change. Indigenous people use TEK, process and situational indicators, while ecologists use ecological methods and ecological indicators to understand the environmental trends. The integration of the two systems of knowledge complements each other and improves understanding of environmental change. Therefore, integration is a process that creates a common forum for sharing information and appreciating different perceptions, by indigenous communities and by scientists.

Environmental change: In general environmental change encompasses changes in biophysical environment due to natural process or human activities. These may either manifest at the global scale (systemic change) or at local scale but that can widespread as to be a global phenomenon (cumulative change). The global environmental changes in land cover and soils, atmospheric composition, climate variability and means, water availability and quality, nitrogen availability and cycling, biodiversity, sea currents and salinity, and sea level.

Assessment: Assessment is term used to express observation of the status of various indicators that measure environmental health. It involves appraisal at one point in time to generate baseline data on vegetation and soil physical characteristics. According to Roba and Oba (2008), herders assess the grazing landscape more frequently to ensure an acceptable quality and quantity of fodder for multiple livestock species. In science, ecological assessment of grazing ecosystems is less frequent and on limited spatial scales. Observations are usually made at a series of sampling transects and plots in order to generate data that are used to generalize the status of grazing resources. However, in this study assessment describes activities conducted by herders and ecologists to determine the suitability of Maasai Steppe to support different land uses on short-term and long-term basis.

Landscape: Landscape comprises the visible features of an area of land, including the physical elements of landforms, water bodies, living elements of land cover including indigenous vegetation, human elements including land uses, buildings and structures, and transitory elements such as lighting and weather conditions.

Land/ landscape degradation: The concept land degradation or landscape degradation has no universal definition. The concept is defined differently depending on the context of use. Barrow (1991) defined land degradation as the loss of utility or potential in relation to biological organisms as well as changes in the physical environment that would alter the functions of natural systems. This was divergent to Abel and Blaikie's (1989) definition, which considers land degradation as a permanent decline in land for the yielding of livestock products under a given system of production. Later scholars described land degradation as decrease in plant productivity or unfavourable changes in species composition that can be temporary or permanent (Dodd, 1994). Herders define land degradation in relation to livestock productivity. A degraded environment, according to herders, does not support livestock productivity at optimal levels due to the loss of important fodder species (Mapinduzi *et al.,* 2003; Roba and Oba, 2008). This study adopted a general understanding that land degradation process and the situation is considered to be reversible with suitable management approaches.

Tragedy of the commons: The "tragedy of the commons" is the concept introduced by an ecologist Garrett Hardin (1968) to illustrate how human deeds turn into environmental catastrophes. Hardin (1968) introduces an imaginary example of a pasture shared by local herders, which he referred to as “commons”. In that share or communal grazing herders are assumed to wish to maximize their yield, and so will increase their herd size whenever possible. The utility of each additional animal has both a positive and negative component. The positive utility is all gained by herder from each additional animal, while the negative aspect is slight degradation of pasture due to each additional animal.

In Hardin’s point of view, division of costs and benefits is unequal, because the individual herder’s gains all of the advantage, but the disadvantage is shared among all herders using the pasture. As a result at every stage an individual herder rational course of action is to continue adding animals to his or her herd. Eventually, overgrazing with immediate losses occurs, and degradation of the pasture that may be its long-term fate. Because this sequence of events follows predictably from the behaviour of the individuals concerned, Hardin describes it as a “tragedy” (Hardin, 1968). This hypothetical examples and suggested solution influenced landscape management policies and strategies in 20th century.

Cattle complex: An American anthropologist Melville Herskovits (1926) introduced the term "Cattle Complex" to describe the system of values that governed native cattle ownership in a large part of East Africa. Herskovits (1926) used the term to clarify how and why cattle ownership was crucial to the acquisition of prestige and authority in a number of East African societies, beyond the apparent economic significance of owning cattle. The term quickly politicised and vulgarized among white settlers in East Africa as a way of denigrating such societies, *vis viz* western ranching system which the main goal is economic gain.

Traditional Ecological Knowledge (TEK): The TEK has been defined by Turner *et al.* (2000) as "a cumulative body of knowledge, practice and belief, evolving by adaptive process and handed down through generations by cultural transmission about relationship of living being with one another and with their environment". According to Fernandez-Gimenez (2000) TEK consists of biophysical observation, skills, technologies as well as social relationships such as norms and institutions that structure human environmental interaction. This study adopted broad definition of TEK, in an understanding that it is an attribute of societies with historical continuity in resource use practices; by and large, these are non-industrial or less technologically advanced societies, many of them indigenous or tribal.

Scientific Ecological Knowledge (SEK): SEK is accumulated systematic study and organized by general principles. The scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses. This knowledge is also termed by other scholars as western knowledge and/or western science.

Boma: *Maasai Bomas* - The Maasai people live in the kraal which is commonly known as *boma* in Swahili. The *boma* which means *enkang'* (singular) and *inkang'itie* (plural) in the Maa language is a compound within which are houses or rather huts covered by manure. The arrangement of a *boma* or kraal is normally in a circular fashion. The fences are made by men using branches of trees. These *bomas* are generally shared by more than one family. However, due to the reduction of land and land ownership systems, *bomas* are increasingly occupied by a single family.

1.6 Organization of the Dissertation

This study is divided into five chapters. Chapter one covers the background and context of the study, statement of the problem, objectives of the study, research questions, significance of the study and definition of operational terms. Chapter two deals with the review of the relevant literature and theoretical/conceptual framework while chapter three covers methodological aspects: sample and sampling techniques, methods of data collection, instruments used, data analysis, data quality control and ethical issues. Chapter four presents the research findings and discusses them while the last chapter covers conclusions, recommendations and suggestions on areas for further study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section reviews literature on integration of TEK and SEK for assessing environmental changes in arid and semi arid landscapes worldwide, with special reference to Maasai Steppe in Northern Tanzania, and establishes the research gap. The sources reviewed cover the period between 1960 to date. The work is organised in three subsections, starting with the global study on integration of SEK and TEK, followed by the landscape history, and lastly theories of semi-arid management and conceptual framework.

2.2 Convention on Biological Diversity

The Convention on Biological Diversity (CBD) was signed in 1992 at the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro and ratified in 1993. Tanzania ratified CBD in 1996. The CBD is a comprehensive, binding agreement covering the use and conservation of biodiversity. It requires countries to develop and implement strategies for sustainable use and protection of biodiversity, and provides a forum for continuing international dialogue on biodiversity-related issues through the annual conferences of the parties (COPs).

Article 8(j) of the CBD obligates member states like Tanzania to harness traditional knowledge, innovations and practices. The article 8(j) state that:

"Each contracting party shall, as far as possible and as appropriate: subject to national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge innovations and practice".

The implementation of CBD in this context is as well reflected through participation of local communities and appreciation of their traditional knowledge. This entails the innovations in terms of integrating scientific and traditional knowledge.

2.3 Integration of TEK and SEK

Integration and the use of indigenous ecological knowledge with the scientific methods in assessing and monitoring effects of management on land degradation has been proposed in recent years by Oba and Kotile (2001) and Mapinduzi *et al.* (2003). However, developing empirically sound methods for integrating local knowledge and formal methods of natural resource assessment is constrained by the lack of guidelines in spite of the recent advances (Fernadez-Gimenez, 2000; Oba and Kotile, 2001; Mapinduzi *et al.*, 2003). Despite the provision for participation of local peoples in strategies for combating desertification given in chapter 12 of *Agenda* 21, integration of TEK and scientific methods for monitoring the impacts of the implementations of the conventions have not been done.

The participatory research that integrates TEK with scientific methods meet the demands for involving local communities in implementation of global environmental conventions (UNCED, 1992) such as Convention on Biological Diversity (CBD) and Convention on Combating Desertification (CCD). Integration of herder knowledge with scientific methods for assessing and monitoring landscapes could provide important methodological bridge between science and management that may improve the understanding of the mechanisms behind land degradation at local scales (Mapinduzi *et al.*, 2003).

Pastoralists use acquired knowledge of the landscape and resource assessment to determine grazing and monitor the status of the grazing resources at landscape scales (Fernandez-Gimenez, 2000; Mapinduzi *et al.*, 2003). Oba *et al.* (2000b) argue that, unlike ecologists, herders measure changes associated with land degradation not only in terms of changes in plant species composition but monitor the changes using livestock production performance. Therefore, the central understanding of the processes of land degradation in the Maasai Steppe is an important step toward achieving community participation.

2.4 Landscape History

According to Scoones (1999) the process of landscape change over time and across space is a function of complex interaction between social and environmental factors and hence environment at different scale is both a product and mirror of human actions. Thébaud and Batterbury (2001) were of the opinion that there is need to understand land use histories and interaction of social, institutional, political and economic process over time. The role played by local practices in influencing environmental dynamic is of great value. Warren (1995) argued that application of environmental history in ecological studies will elucidate the contribution of man's action in ecosystem dynamics against the theory of balance of nature and stable ecological community. A hybrid model that employs indigenous ecological knowledge through oral narratives and ecological analyses will become handy in such studies (Warren, 1995).

According to Oba and Kotile (2001), indigenous communities monitor such changes quite closely as they associate them with livestock performance and also through close observation of physical changes in landscape. Bolling and Schulte (1999) added that changes such as displacement of nutritious grass species with less nutritious ones are easily observed as they affect livestock production. Furthermore, Fernandez-Gimenez (2000) explained changes such as those brought about by occurrence of prolonged drought, major shift in resource utilization pattern, migration of other population into the area which might have impacted negatively on the environment are all contained in the local people's environmental perception.

Through oral narration of environmental history from elderly and informed members of the community; past trends in the processes of environmental degradation can be captured. Such local perceptions can be related to a range of ecologist's knowledge on environmental degradation. The change in the vegetation type reported can further be compared with interpretations of past aerial photos and satellite imagery to give a clear picture of past trends of land degradation. By combining aerial photograph interpretations, oral history, historical timelines on environmental history during the past three to four decades can be reconstructed.

2.5 Theoretical and Conceptual Framework

2.5.1 Theoretical Models

Conflicting ecological theoretical models have been used to describe processes of land degradation: the dominant equilibrium and the new non-equilibrium models. The equilibrium-grazing model characterizes landscape production with stability (Behnke, 1995). In the equilibrium system, such as those of semi-arid environments, livestock population is controlled by density dependent factors where changes in stocking density create predictable changes in plant composition (Oba *et al.*, 2000a). The model links livestock population to the problem of land degradation when the carrying capacity is exceeded (Lamprey, 1983). Most of the past development interventions in African landscape were designed based on this model (Niamir-Fuller, 1999). The equilibrium model fails to describe crucial aspects of the arid land ecology where the main drivers are unpredictability and variability of rainfall inducing opportunism in traditional land use (Niamir-Fuller, 1999; Oba *et al.*, 2000a).

The non-equilibrium model has been suggested for the arid ecosystems. Ellis and Swift (1988) suggested that in the arid landscape ecosystems the principle drivers of the system are biotic factors rather than density-dependence. The non-equilibrium model emphasizes the unreliability of rainfall both in temporal and spatial distributions (Behnke, 1995; Oba *et al.*, 2000a). The non-equilibrium model is appropriate for describing the traditional systems of land use where livestock uses mobility in response to spatial and temporal distributions of forage resources (Behnke and Scoones, 1993; Niamir-Fuller, 1999). In this system livestock responds to the boom and burst forage productions (Fernandez- Gimenez and Allen-Daiz, 1999).

The non-equilibrium model has been criticized recently because of the role played by scale effects and the assumptions that the arid and semi arid environments respond to grazing impacts, with grazers playing a crucial role in ecosystem processes (Illius and O'Connor, 1999; 2000; Briske *et al.*, 2003). Studies show that the response to grazing, which is coupled with plant production, may vary depending on whether the reference is to the key resources like semi arid areas or non key resources such as arid environments. Thus, in arid and semi-arid ecosystems characterized by high variability of primary productivity, localized and intensified herbivore plant interactions tend towards equilibrium behaviour (Illius and Connor, 1999). A new suggestion is on the equilibrium-non-equilibrium continuum as opposed to discrete systems (Briske *et al.*, 2003, Fernandez- Gimenez and Allen-Daiz, 1999). According to Oba *et al.* (2003) the application of the models to understand effects of grazing pressure without stating the scales at which the opposing models operate is questionable. It appears, therefore, that the different ecological models have varied explanations for land degradation.

The debate on landscape degradation and desertification reveals lack of universal definition of phenomena. The term land degradation was defined by Blaikie and

Brookfield (1987) as reduction in landscape production. This definition can be interpreted in different ways. In this study, land degradation is defined as processes of land cover changes. The changes are manifested in reduced species diversity and vegetations coverage. This study was guided by the conceptual framework that allowed the use of both TEK and SEK to establish environmental changes (Figure 1 on page 19).

The ecological models have not clearly explained how the different perceptions of land degradation can be verified by hypotheses testing. The most controversial view is the concept of reversibility and scale. According to Spooner (1982) localized over use of resources through overgrazing and overexploitation of vegetation is more likely to accurately describe the processes, contrary to Lamprey's (1975) idea of progressive expansions of the desert margins. Hence, in that context land degradation is mirrored by ecological and social factors at local scales (Stocking, 1987, Thomas and Middleton, 1994). In this case applications of equilibrium model to explaining the geographical scales may be less informative than the local scales processes that could be verified by targeted research.

The non-equilibrium model explains degradation as a spatial and temporal variability that distinguishes natural from human induced land degradation processes. For example, the existence of bare areas alone could not be used as indicators of permanent change in arid and semi-arid ecosystems where rainfall is variable between years. Thus, in such systems, changes in species composition caused by overgrazing may be reversible. At regional scales, climatic variations explain the spatial-temporal variability of the productivity of the landscapes (Oba *et al.*, 2001). However, at local scales, degradation might disclose complex interactions between anthropogenic disturbances and climatic variability (Oba *et al.*, 2003).

The SEK as expressed in ecological models has shaped the way semi arid landscape degradation and management of African pastoral environment has been perceived over the years. The complex nature of degradation calls for interdisciplinary approach to assess anthropogenic impacts. Landscape degradation has mainly been measured as the end product of the biological resources such as vegetation cover with little emphasis on the production system. A more inclusive approach is to view degradation as net outcome of interactions of management (both positive and negative interventions) and the natural variability associated with climate variability and ecosystem diversity (Blaikie and Brookfield, 1987).

The equilibrium and non-equilibrium ecological models lack explanation for the social dimension of landscape change. Scoones (1999) made an important attempt to examine the theoretical shifts in light of the debates within the social sciences. The review raised some fundamental issues related to the spatial and temporal variability and scale effects from the perspectives of anthropological ecology, which is central to the human ecology hypothesis. He suggests an important role of the environment-people relations and their motives and behaviours that shape the cultural environment. Blaikie and Brookfield (1987) have also convincingly argued the issues in a currently emerging social-ecological disciple of political ecology. The ideas grounded in different schools are difficult to reconcile. Yet, the links between environmental-people knowledge is fundamental to explaining the role indigenous ecological knowledge plays in describing ecosystem behaviour (Berkes *et al.*, 1998). The current study considered an interdisciplinary approach for integrating TEK of herders and ecological methods for discussing the roles played by environmental history in analyzing processes of land degradation in Maasai Steppe, Northern Tanzania.

2.5.2 Conceptual Framework

In order to understand how TEK and SEK could be integrated to assess and monitor environmental changes in the Maasai Steppe of Tanzania, the study assessed the methods and indicators used by herders (TEK) and ecologists (SEK) disjointedly (Figure 1). Non-biological indicators (soil condition), biological (vegetation status and trend) and anthropogenic indicators (land use pattern, perception on environmental degradation, livestock production, and environmental history) were identified and used to assess environmental changes. The joint survey (herders and ecologists) is assumed to improve understanding of the landscape, thereby creating landscape assessment knowledge base (Figure 1). Landscape knowledge base can be used by landscape managers, be herders and/or formal institutions at local scale to develop appropriate management strategies for sustainable management of local level landscape. Therefore, effective implementation of CBD article 8(j).

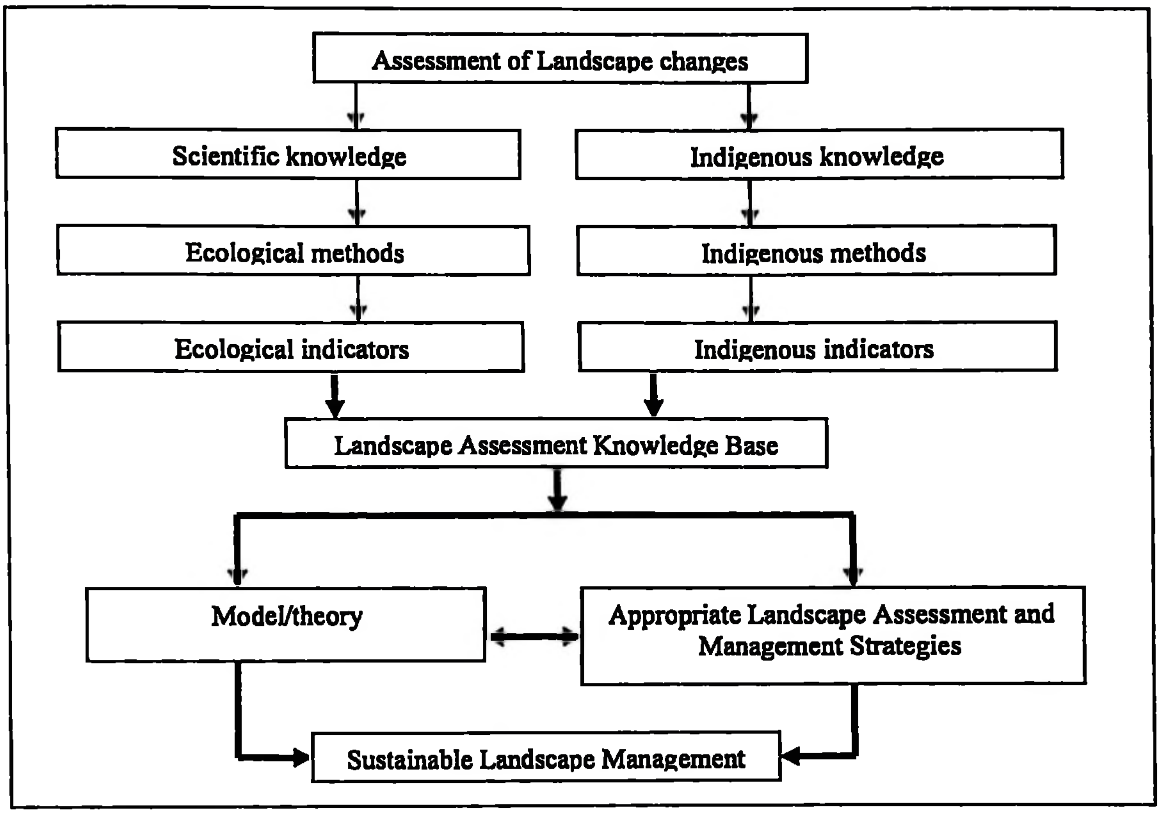

Figure 1: Conceptual framework of the study

Source: Developed by the researcher based on the works of Roba (2009), Oba *et al.* (2003) and Mapinduzi (2001).

2.5.3 Research Gap

Various studies have been documented on the use of TEK for assessment of landscape changes (Mapinduzi *et al.*, 2001, Roba, 2009). Furthermore, a number of studies have been carried out to assess Maasai semi-arid landscape changes (Oba *et al.,* 2001). In the same context various methodological models have been proposed for assessing Maasai Steppe landscape. However, based on the literature review, there are no well researched and established mechanisms on how TEK and SEK could be integrated in assessing semi-arid landscape, such as Maasai Steppe in Tanzania. This is a research gap which this study attempted to address.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The chapter presents the methodology and procedures used in conducting this study. The chapter covers methodological approaches in social research, research design, description of the study area, population and sample size and sampling techniques, data collection methods, research instruments, data analysis procedures and mechanisms used for quality control in data collection and analysis.

3.2. Methodological Approaches in Social Research

There are "three dominant methodological approaches to social research: quantitative (linked to posivitism), qualitative (linked to phenomenology or interpretivism), and participatory action paradigms (linked to critical theory)" (Babbie and Mouton, 2005:47-49). According to them, the choice of approach or approaches to be used in conducting any given study is dictated by the aims of the study, the nature of what is being studies and the underlying theory or expectations of the researcher.

3.3 Research Design

A research design is the strategy for a study, as well as a plan by which the study is to be carried; it specifies the methods and procedures for collection, measurement and analysis of data. This study adopted an action research approach for the purpose of practically developing the research protocol in the field (Krishnaswami, 1993). A combination of quantitative (ecological survey) and qualitative (Transect walk and observations) research methods were used. Three phase approach was used to implement this research model. The first phase involved interviews of knowledgeable elders who lived in the area for long time. The second phase involved selecting five knowledgeable elders to carry out assessment (Plate 1).

Plate 1: Maasai Herders Involved in Joint Landscape Assessment in Cluster I

Joint assessment ecologists and Maasai elders' (here referred to as Maasai herders) and then systematically compared the results. While Maasai herders and ecologists assessing the landscape the researcher was observing, asking question and recording. The second phase enabled the researcher to identify ecological and anthropological indicators of determining landscape changes applied in TEK and SEK. The third phase involved in-depth interview with key informants and the general community to validity the results and information given during transect walk and field assessment. Both primary and secondary data were collected, analysed and communicated back to the community for verification and validation. Finally, the results were related to available literature, discussed and propose the model for integrating TEK and SEK for assessing semi-arid landscape.

3.4 Study Area

3.4.1 Location

The Maasai Steppe is formed by six districts namely Monduli, Kiteto, Kondoa, Babati and Longido. The Maasai Steppe is located in Northern part of Tanzania and lies within the Eastern Rift Valley zone. The area plays a key role in conservation, encompassing Tarangire and Lake Manyara National Parks, Manyara Ranch, and potential wildlife migratory corridors. It is also keystone to pastoral economy in Tanzania, and attracting local and foreign investments in agriculture, tourism and mining sectors. The area elevation arises from about 1,000m in the south-west to 2,700m in the north-east. The Maasai Steppe is estimated to cover between 20,000 and 35,000 km2 (Borner, 1985 cited in Kshatriya *et al.*, 2007). The large part of the area is flatland (75%), hilly (3%), and the rest 22% is rolling to moderately dissected (Kshatriya *et al.*, 2007). However, this study concentrated in Makuyuni Division, one of the three divisions of Monduli District. The study formed two sets of village clusters for the purpose of assessing environmental changes. Cluster I was composed of five villages namely Losirwa, Majengo, Migombani, Barabarani, Mto wa Mbu, while cluster II included Makuyuni, Mswakini Juu, Mswakini Chini and Naiti. These villages were once grazing areas of livestock and wildlife and are fairly located in the proximity of protected areas. (Figure 2).

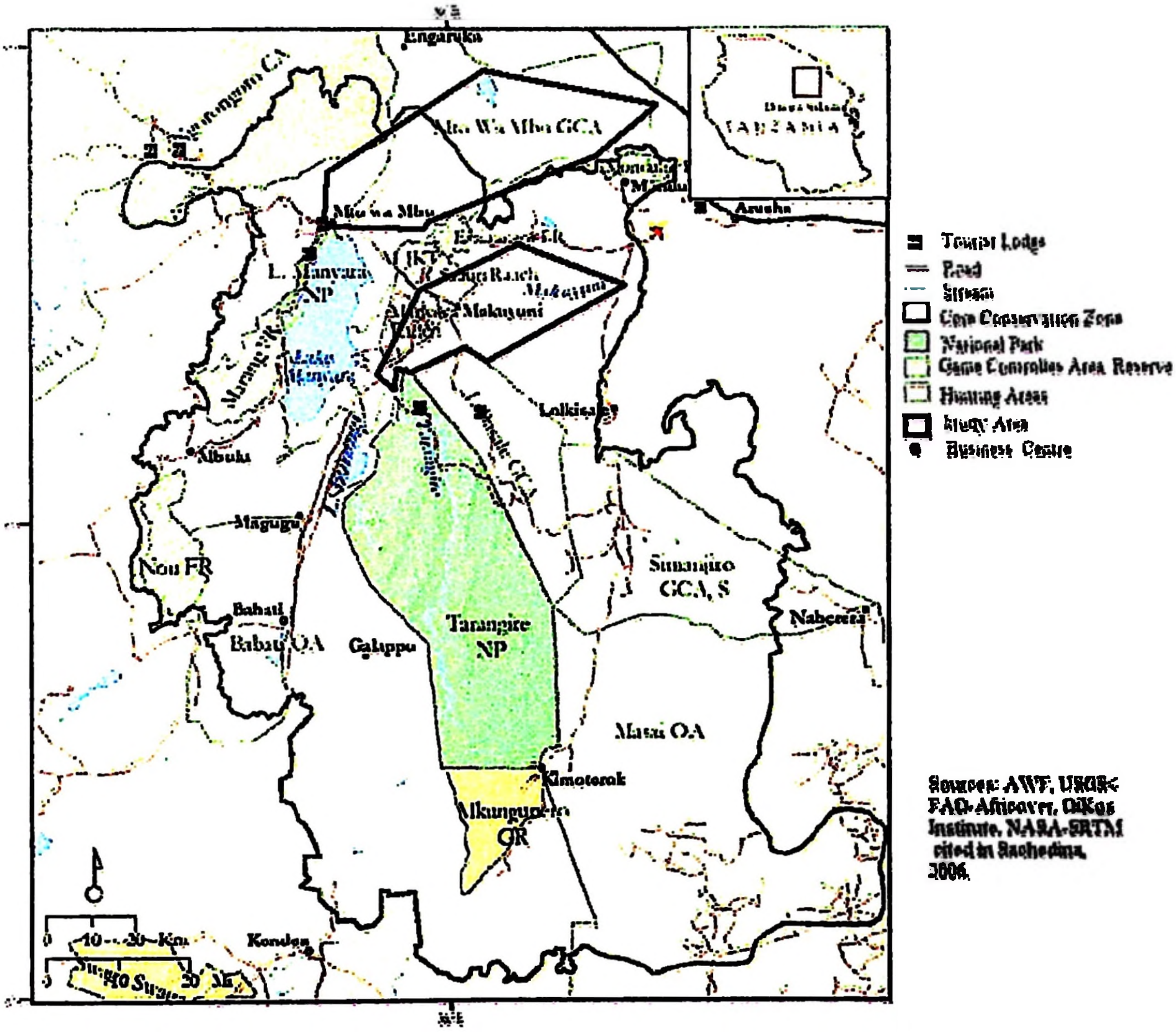

Figure 2: The Map Showing Location of Study Area in the Maasai Steppe

3.4.2 Climate and Drainage

Forage distribution, wildlife and domestic animals movement in the Maasai Steppe is driven by rainfall and drainage systems. Human economic activities are also influenced by both temporal and spatial distribution of rainfall, soils characteristics and accessibility (Kshatriya *et al.*, 2007). Standardised annual rainfall pattern in the area is bi-modal with short rains occurring between November to December followed by a dry spell, January and February, and by a longer period of rain from March to May (Kshatriya *et al.*, 2007; Figure 3). The study area is semi-arid featured with unreliable and very unpredictable rainfall trend. Rainfall trends show high temporal variation (Figure 4) as well as spatial variation. According to review and analysis of Kshatriya *et al.* (2007), the study area's mean maximum temperature is 27°C and minimum temperature is 16°C. The extreme minimum is 4°C in July and the highest maximum 40°C in January.

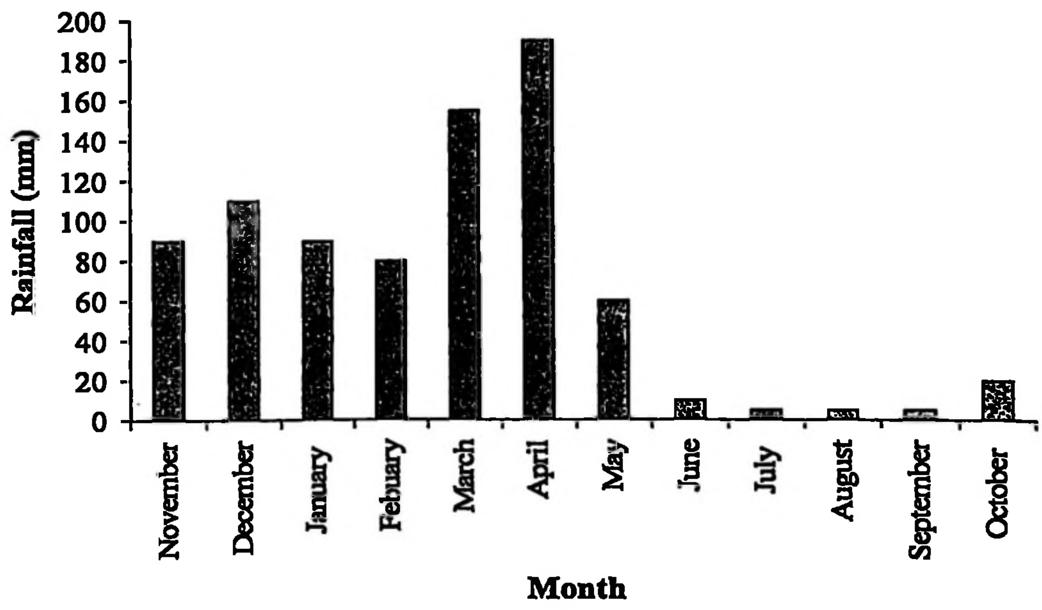

Figure 3: Showing Standardised Monthly Rainfall Pattern in Maasai Steppe

Maasai steppe is drained by seasonal and perennial rivers. The area which is located in Monduli district is drained by the Makuyuni river system of seasonal streams, which enter the northern end of Lake Manyara. The plain part of the Monduli District is also drained by Tarangire River. The seasonal and perennial streams including Mto wa Mbu, Simba and originate from the highlands to the north-west of the basin and enter the lake on the northern part. Rivers are fed by both surface run off and ground water recharge (Mwalyosi, 1999).

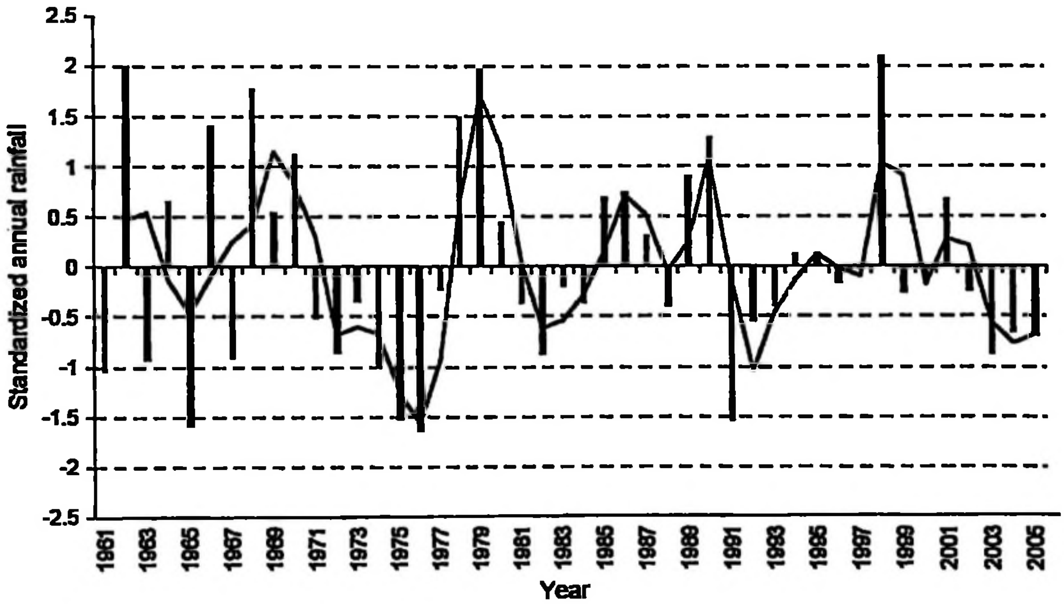

Figure 4: Standardise Annual Rainfall Pattern in the Maasai Steppe

Source: Kshatriya *et al.*, 2007

3.4.3 Inhabitants

The inhabitants of these areas are the Maasai named after their language "Maa". The Maasai are pastoralists keeping different species of livestock, in particular cattle, camels, sheep, goats and donkeys. Like other pastoralists in Africa and around the globe, Maasai lifestyles revolve around livestock. They are nomadic in nature, and keep moving from one place to another in search of water and pasture. The human population of Monduli district and the newly formed Longido district were 71,756 people in 1978 which increased to 109,006 in 1988. According to the 2002 Tanzania National Census, the population of the Monduli District was 185,237. The current growth rate in this district is 3.8% (NBS, 2003). However, the annual population growth rate varies. It ranges between 3.1 % and 22.8%. This has contributed to changes in resources uses. The growth is to a greater extent contributed by the immigrants who are mainly agriculturalists. According to Yanda and Maduhu (2003) the main factors for immigration include availability of land, availability of pasture and grazing areas, social services, and business opportunities. According to the District Veterinary Officer, the current total population of pastoralists that inhabit the Maasai Steppe is estimated to be 350,000, owning about one million cattle (Personal communication).

3.5 Rationale for Selection of the Study Area

Maasai Steppe was selected as a study area because the villages located in it provide a good experimental scenario to test the possibility of integrating TEK and SEK in assessing environmental changes in the landscape. This is because landscape changes reflect and shape social values, which in turn influence the way landscapes are assessed, monitored and managed (Mills *et al.*, 2002). Maasai have lived and grazed their livestock in the area for centuries. For that reason they have acquired knowledge to develop a well-defined grazing system and codes to govern resource use in the landscape (Oba and Kaitira, 2006).

Unfortunately, traditional systems of land use were interrupted and transformed by colonial and post-colonial public policies of wildlife conservation, expansion of cultivation and discouraged traditional communal land use in favour of private ranches (Rohde and Hilhorst, 2001; Kshatriya *et al.*, 2007). The new landscape managers and decision makers undermined Maasai TEK and exclusively used SEK. Tanzania has to implement CBD Article 8(j) which requires the use of TEK and SEK to complement each other. This literally means the use of Maasai TEK together with SEK in assessing, monitoring and management of Maasai Steppe landscape.

Against this background the Maasai Steppe landscape which is semi arid but managed as humid environment, Maasai who are ethnic user of the landscape, and recent paradigm shift in landscape management at national level makes the setting suitable to evaluate the consistency of herder landscape assessments methods (TEK) using empirical field data. This environment provides conditions for establishment of practical model of integrating TEK and SEK of assessing environmental changes in the semi arid landscape.

3.6 Population, Sampling Strategy and Sample Size

Population refers to all things or people with similar characteristics that the researcher intends to study within the context of a particular research problem while a sample is a small group of respondents drawn from a population from whom the researcher is interested in getting information from. A sample is part of the population which is being studied for the purpose of making inference to the whole population (Rwegoshora, 2006).

3.7.1 Sampling Strategy

In this study, both probability and non- probability sampling designs were used. In the field non probability sampling was used to select knowledge individuals in terms of TEK. A combination of purposive and snowball non-probability sampling techniques were used in selecting the sample. The purposive sampling technique was used to select the first respondent that is particularly informative (Newman, 2000). Then, snowball sampling technique was used to select other respondents; until saturation point was reached (Saunders *et al.*, 2007).

Probability sampling was used to select the starting point of transect line while following lines were established systematically. The technique is referred as systematic sampling. Sample plots were laid along transects. Along each transect and nested plots were fixed using a Global Positioning System (GPS). This enabled sampling flora and fauna diversity using 10 m x 10 m plots in areas with bushes and thickets, while bare ground and erosion indices (i.e. wash, gullies and rills) were assessed in 1 m x 1 m plots.

3.7.2 Sample Size

The sample size depends on the nature of study, time and funds available (Saunders *et al.*, 2007). Due to the difficulty in finding the current list of all knowledgeable Maasai herders in the study area, snowball sampling technique was used to select a sample. According to Saunders *et al.*, (2007) a sample size of 30 usually results in a sampling distribution that is very close to the normal. In this study the sample size was determined by the saturation point of respondents' answers. It is important to note that the saturation point was reached with sample size of 23 people, however the study continued to a sample size of 48 people. In the third phase, the study evaluated TEK in the general community, regardless of age and gender. Thus, the sum total sample size was 69 respondents. Purposive sampling was also used to select 2 graduate ecologists to assess the landscape in joint with the 5 Maasai herders.

Respondents were selected based on the researcher's own sense of judgment on who is more informative and knowledgeable in TEK, for the purposes of fulfilling the research objectives. The question of gender was taken into consideration to reduce gender bias, but to a large extent was limited by the Maasai culture which prohibits women to disclose TEK to outsiders.

3.8 Data Collection

Collection of data was done in three phases. Phase one concentrated on collection of secondary data found to be necessary for familiarizing with the area, grounding the study and for developing appropriate research instruments. Phase two involved collection of primary data in the field and phase three, that is post field work concentrated on data cleaning, coding data analysis and report writing. Both secondary and primary data were collected using various methods of data collection.

3.9.1 Secondary Data

Secondary data were gathered from various secondary sources including publications such as books, journals, conference proceedings, topographical maps, aerial photographs and relevant unpublished reports. These were used to identify land units and land cover. Aerial photographs were very helpful in providing information on topography, soils, drainage and vegetation.

3.9.2 Primary Data

Primary data were collected mainly through transect walk and non-structured in-depth interviews and field observations because the study was qualitative in nature. Questionnaires were mainly used to capture socio-economic data.

3.9.2.1. Transect Walk

A group of 5 Maasai herders assessed changes on the landscape along transect, while a researcher observed and asked questions, using transect walk observation guide (See appendix 1). A group of 5 people was considered reasonable to openly discuss and give responses. Maasai herders proved to have memory of landscape history and described changes which occurred over time as presented in section 4.2.

3.9.1.2. Unstructured Interviews

In-depth face to face interviews were held with 69 people in a period of two months. The interview guide (See appendix 2) guided the interview sessions. The sessions lasted for one to two hours. The interviews were held at their *bomas* (homestead). The first part of interview guide captured socio-economic data, the second part captured data on TEK. Generally, unstructured interview complemented transect walk.

3.9.1.3. Observation

A close observation was made to compare what is on the ground with responses of the interviewees on how TEK and SEK are used in the field. Images were captured when felt necessary. This process helped in identification of indicators used for assessing environmental change.

3.9.1.4 Field Assessments

Joint assessment of landscape environmental change by Maasai herders and ecologists was done. The Maasai herders participated in narrating landscape change, reflecting their knowledge in terms of changes in land cover, land use, vegetation composition, species loss, uses of different species and livestock grazing preference in relation to productivity. The aim of this exercise was to establish the consistency of TEK and indicators of assessing landscapes versus SEK.

3.9.1.5 Content Analysis

The researcher used content analysis guide that served as a tool to interpret phrases, terms, expressions used by the Maasai in responding to the questions and discussions to examine and make conclusions on integration of traditional and scientific ecological knowledge for assessing changes in the semi-arid landscape of Maasai Steppe. The same guide was also used for synthesising information gathered from secondary sources.

3.10 Research Instruments

In order to obtain valid and reliable data (cross-checking data), different data collection instruments were used. This study mainly used interview and observations guides to collect data.

3.11 Data Analysis

This research applied a heuristic process of phenomenological analysis (for qualitative data) which went through various stages. These include immersion, which according to Moustakas (1990:56) involves researcher's "full presence, to savour, appreciate, smell, touch, taste, feel, and know without concrete goal or purpose". At this stage the data (interview transcripts and field notes) were checked to ensure that they were all in place. This stage was followed by incubation, a time of quiet cognition and reflection on experiences, opinions and attitudes expressed in order to identify, code, and categorise the primary patterns in the data obtained from primary (interaction with the Maasai informants and experts) and secondary data based on the analysis of the literature reviewed (Aerial photography and previous ecological surveys which covered the study were reviewed and analysed to establish temporal land cover changes between 1960 and 2005). These experiences and opinions were then contextualized; that is, the different meanings were examined and the relevant meanings construed in terms of the study objectives.

Ecological data were computed by using Excel spreadsheet. The descriptive statistics were computed to establish comparable results in some cases. Both the qualitative and quantitative data were then synthesised for drawing a model for integration of traditional and scientific ecological knowledge for assessing changes in the landscapes.

The summary of results was presented to the community gathering to assist in verification. Comments were then incorporated in the results.

3.12 Data Quality Control

3.12.1 Pre-Testing of the Research Instruments

The research instruments were pretested in local setting using 3 Maasai herders and 2 ecologists. Few modifications were made which involved the use of Foot-step to estimate metre instead of tape measure.

3.12.2 Triangulation

Triangulation reduces biasness and ensures that quality data are collected. In this study, combinations of four research instruments were used to collect data. According to Baker (1999) the use of more than one method of collecting data enhances the quality of the data.

3.12.3 Rigorousness and Seriousness in Procedure

The researcher ensured that the study was conducted rigorously and seriously to ensure quality, validity and reliability of data obtained. The summary of results was presented to the community gathering to assist in verification.

3.13 Ethical Issues

Research permit for this study was issued by the Vice Chancellor, University of Dar es salaam (See appendix 3). The permit was presented to Arusha Administrative Regional Officer for approval. The administrative procedures were followed during the fieldwork and thereafter (See appendices 4, 5, and 6). Furthermore, Maasai elders in person were requested to take part in the study. They were assured that the study was strictly for academic purposes, and will not be used for any unethical reasons. Respondents were also assured confidentiality of their answers. During data collection, before taking any photography, the consent of respondents was sought first. It is important to note that in most cases respondents refused to be photographed, and/or mention their names, although freely agreed to answer other questions.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter is divided into six main sections. In order to put the study into perspective, section two present characteristics of the studied population. The third section presents environmental history of Maasai Steppe in northern Tanzania, to show the changes and their causes. Section four presents comparison of how TEK and SEK are for assessing environmental changes. The fifth section presents potential indicators of assessing landscape changes by herders and ecologists. The sixth section presents the proposed model for integrating TEK and SEK for assessing environmental changes in semi-arid landscape of Maasai Steppe.

4.2 Household Characteristics

A total of 69 respondents were interviewed in the selected households from the 8 villages within Maasai Steppe. Their population characteristics are shown in Table 1. The age set of the respondents was essential character for this study, the Korianga who formed 33% of respondents are the active responsible people for landscape assessment. All age set where represented in this study. Maasai women are culturally prohibit to disclose information about landscape, consequently more respondents were drawn from males (80%) compared to female (20%). While key informants had never been to school (29%), majority of respondents have either some primary schools years or completed primary school (70) and only one respondent attended secondary school. See Table 1 for details.

Table 1: Attributes of the respondents in Maasai Steppe

Attribute		Frequency (N=69)	Percentage
Age set	Layoni	16	23
	Korianga	23	33
	Landisi	2	3
	Ikishumu	2	3
	Iseuri	2	3
	Makaa	10	15
	Yeyo	14	20
	Total	**69**	**100**
Sex	Female (Yeyo)	14	20
	Male	55	80
	Total	**69**	**100**
Education	None	20	29
	Primary school	48	70
	Secondary	1	1
	Total	**69**	**100**
Occupation	Pastoralists	69	100
Households size	1-5	19	28
	6-10	36	52
	10-15	12	17
	16 and above	2	3
	Total	**69**	**100**
Livestock	Cattle	69	100
	Sheep and goats	69	100
	Donkey	8	12

All respondents were pastoralists as the study specifically targeted Maasai herders. All respondents kept cattle, sheep and goats, and a few (12%) kept donkeys. The numbers of livestock were reported to fluctuate depending on forage and rainfall. However, the reported figure ranged from 50 to 3000 for cattle and 100 -1800 for goats and sheep per household. There was a relationship between household size and size of livestock. The large the households had more livestock than the small households.

4.3 Environmental History and Drivers of Changes of Maasai Steppe

Maasai pastoralists had moved into the Maasai Steppe area by the 18th Century. The whole Maasailand in the 18th Century extended from the today known Mkomazi through the southern foothills of Mount Kilimanjaro (Pare plains); runs northward between Mount Kilimanjaro and Mount Meru. To the West the Maasai took in the whole of Maasai Steppe and to the extreme westerly limit of Serengeti, as shown in Figure 5 (Kivasis, 1953; Fosbrooke, 1972). It is this land, which has experienced a great change in the 19th and 20th century. Traditional grazing lands of the Maasai pastoralists were converted into blocks of exclusive wildlife reserve under the name of conservation, private and government-owned lands for ranching, agriculture and other monetary geared economy (Figure 6).

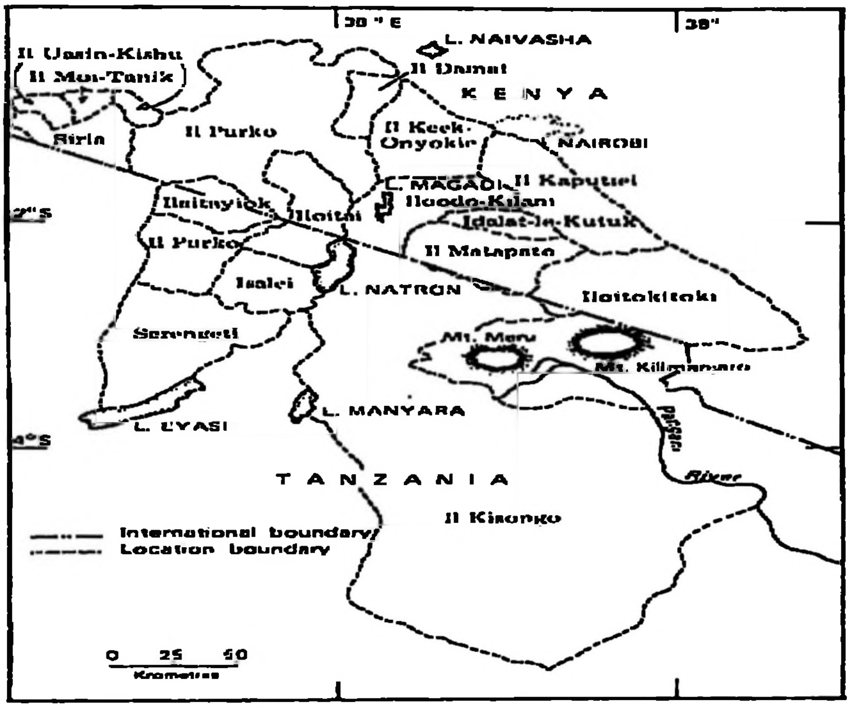

Figure 5: Map Showing Maasailand in 18th Century

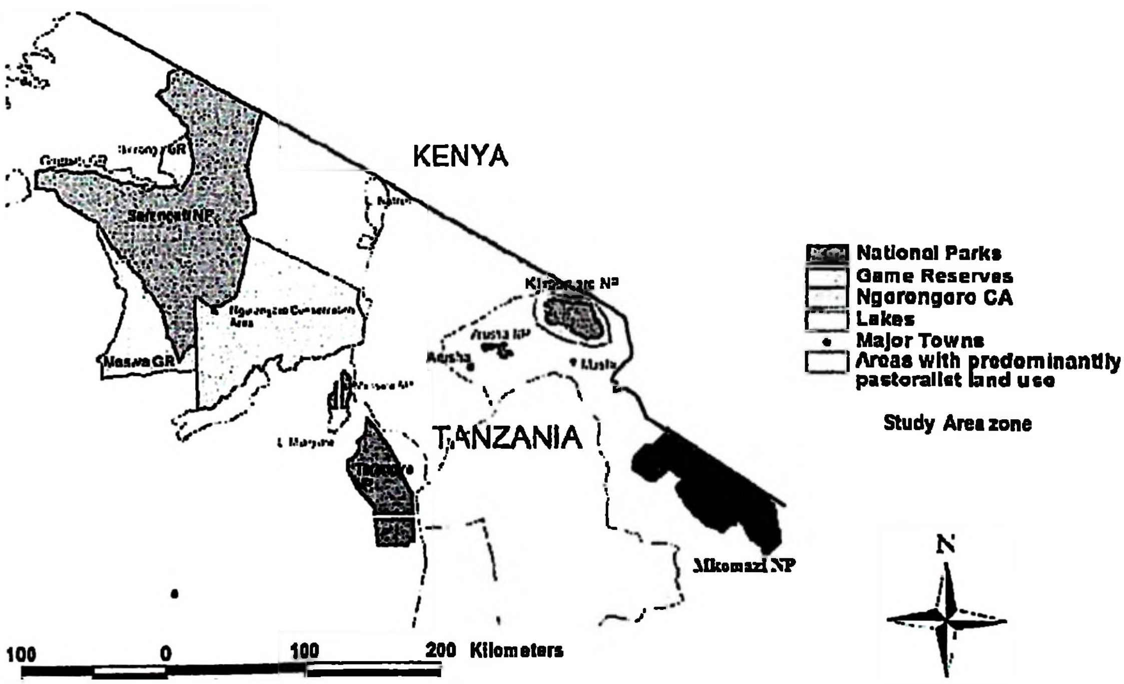

Figure 6: Map Showing Main Land Blocks Created in Maasailand in 19th and 20th Centuries

The prevailing situation in the Maasailand started with the German colonial policy, which condemned the Maasai for being primitive and wanderers, who were to be developed and modernised to prevent land degradation. This was a founding step towards the chain-process of Maasai land alienation which disrupted communal land ownership (Keiwua, 2002). The Germans went ahead to implement the policy by endorsing Adolf Siedentopf and Friedrich Siedentopf to grab land in the Ngorongoro Crater and set aside the Serengeti for sheep farming (Parkipuny, 1975). However, the Maasai were lucky because the two brothers failed to overcome wildlife while trying to create a room for farms in the Crater (Grzimek, 1960). Also, the Maasai from the plains of Mount Kilimanjaro and Meru were forced to move to the Maasai Steppe and Ngorongoro as Germans established numerous farms in the area.

In the Maasai Steppe the German settlers went as far as Lepurko and Losimingori where they established ranches. It is around the same time when the present Manyara and Saburi ranches in the Maasai landscape were established (Figure 2). British took over Tanganyika in the early 1920s following the defeat of the Germans in the First World War. The British policy encouraged peasants to migrate and cultivate the land perceived to be waste and underutilized by Maasai pastoralists (Parkipuny, 1975). The construction of the road from Mto-wa-Mbu in Maasai Steppe to Mbulumbulu around 1926 and to the crater in 1932 increased the prospect of agriculture and trade (Fosbrooke, 1972). This was followed by the intensification of wildlife carnage and marginalisation of the Maasai.

Tanganyika got independence in 1961. The independent government adopted the colonialism views towards Maasai and their land. New policy makers and administrators positively accepted the theory of "tragedy of the commons" and cattle complex towards scenarios. More lands from the Maasai Steppe were alienated in the name of public interest, and given to state organs like the army and prison services without consultation of the Maasai (Shivji, 1998). This way, the present vast land owned by Oljoro National Service, Tanzania Military Academy, and Makuyuni National Service were acquired. Additionally, wheat farming in Monduli juu and Loliondo were established, as the government promoted small-scale cultivation in *Ujamaa* villages. Consequently, peasants' immigration to Maasai landscape was enhanced. Massive land exclusive for wildlife conservation such as Tarangire and Lake Manyara National Parks were created and dry season grazing reserves of the Maasai were grabbed.

The impacts of changes on land use systems have not affected Maasai pastoralists only, but also caused land cover changes and degradation of Maasai Steppe. The land cleared for agriculture in the Maasai Steppe, appeared insignificant during Germans colonial era, but expanded drastically in 1980s to 2000s. Agricultural fields have replaced natural land cover (Figure 7).

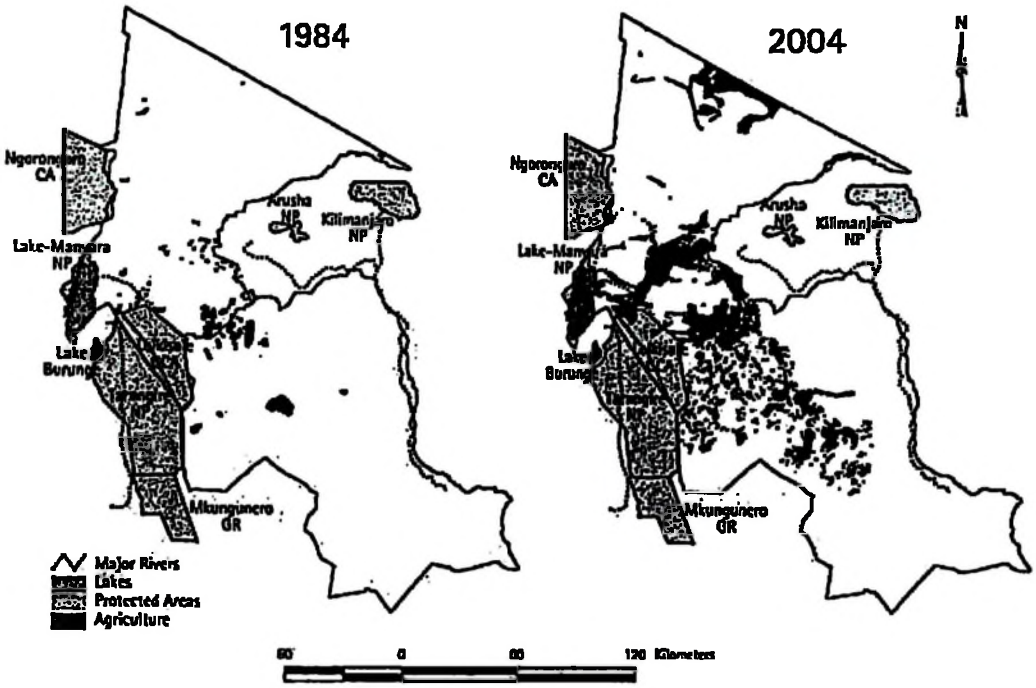

Figure 7: Maps showing agriculture in relation to protected areas in 1984 and 2004

Source: FAO, 2009

Along agriculture, temporary Maasai *bomas* in the steppe were replaced with immigrants' permanent houses (Plate 2). In fact the photo (See Plate 2) shows a typical land uses changes from traditional grazing pastures of Maasai pastoralists to conservation, agriculture, human settlement and on margin remaining grazing pastures for Maasai, but yet under high pressure of completing land use forms.

Plate 2: Aerial Photo Showing 1. Part of Lake Manyara National Park, 2. Agricultural Fields/Irrigation Scheme 3. Remaining Grazing Grounds 4. Mto wa Mbu Business Centre

In the study area, for example, with the exception of Losirwa village in Cluster I, Majengo, Migombani, Barabarani, and Mto wa Mbu have been transformed into agricultural fields and permanent residences. In cluster II, Naiti village has experienced expansion of small-scale agriculture from less than 5% of total village land in 1984 to almost 50% in 2000 (See Figure 8). Trends are not different in Mswakini Juu village (Figure 9). Meanwhile, Makuyuni is now a growing township with modern social services, and can hardly be considered to be once occupied by Maasai pastoralists.

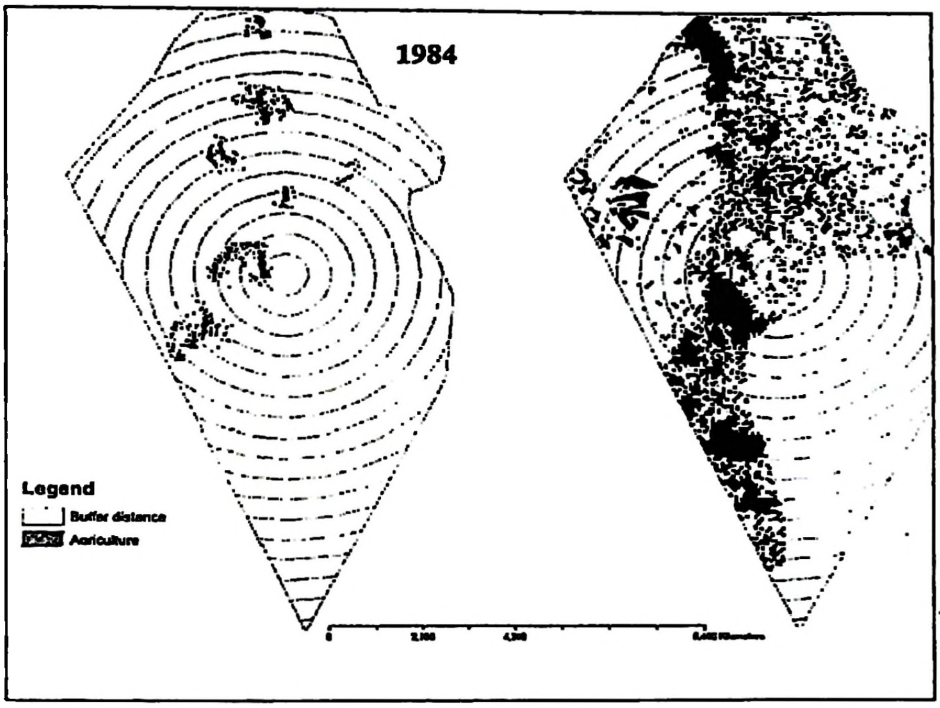

Figure 8: Maps Showing Agriculture Area of Naiti Village in 1984 and 2000

Source: Kshatriya *et al.* 2007

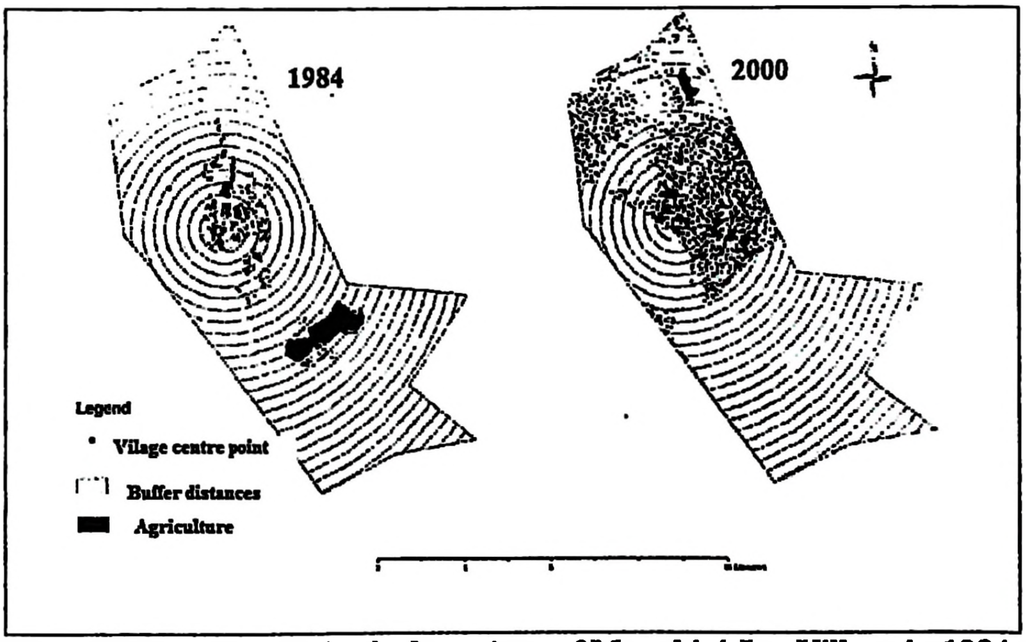

Figure 9: Maps Showing Agriculture Area of Mswakini Juu Village in 1984 and 2000

Source: Kshatriya *et al.* 2007

Changes of semi-arid landscape of Maasai Steppe are not only due to land alienation but also complex socio-economic issues. German and British colonial periods, politics after independence, histories of war, disease, famine and the spread of tsetse flies caused radical demographic change and social disruption (See Appendix 7). These processes of pastoral dispossession and colonisation have had negative impacts on landscape (Plate 3).

Plate 3: Photo Showing Gully Erosion at the Outskirt of Makuyuni Village

The Maasai Herders at Makuyuni associate the gully erosions in landscape (Plate 3) declining fertility and deforestation with total exclusion from landscape management, rapid population change due to migrants, pioneered settlement, cultivation and conservation. Cautiously, the Maasai herders attributed degradation of the landscape to increased number of livestock. There is now inadequate land for reasonable transhumance.

Several scholars with "tragedy of the commons and cattle complex theories" in mind blame the Maasai pastoralists for Maasai Steppe degradation. For example, Mwalyosi, (1992) reported that the grasslands of the Maasai plains are overstocked by 177%, leading to "ongoing overgrazing and mismanagement of rangelands".

Overgrazing is considered to be important cause of forest degradation in Tanzania. Chamshama (2010) argued that overgrazing is mainly "due to large herds of cattle arising from unwillingness among livestock owners to de-stock and the fact that most of the forests/woodlands are open access (not reserved). The consequences of overgrazing have been land degradation (soil compaction, broken soil crust and erosion) as well as reduced species diversity and density". Maasai herders normally de-stock their livestock when there is compelling situation. This is because the livestock acts like their banks and/or shock absorbers during difficult times. However, Chamshama's (2010) conclusion, as is the case with most Tanzanians scholars, is driven by the cattle complex theory (Herskovits, 1926).

The government policies and position, unquestionably consent to scientific scholars' inference, and out rightly rejects the Maasai herders' reasons for movement and overstocking. For example, the National Agricultural Sector Development Strategy

(2001) acknowledges Maasai seasonal movements of livestock to be an important coping mechanism in times of drought. Yet, take the stand of Hardin's theory of tragedy of the commons by arguing that Maasai practices cause land degradation because they lack sense of ownership of the grazing lands, and occasional conflicts between crops and livestock farmers (URT, Agric. Sector Dev. Strategy, 2001). Furthermore, the most recent Presidential directives to the Ministry of livestock and fisheries proves that Tanzania has not changed the colonial view on Maasai pastoralists, and is not implementing the Convention on Biological Diversity (CBD), article 8(j), fifteen years after its ratification (Box 1).

Box 1: Tanzania Government view on pastoralists' traditional life style

"*It is high time that we shun from traditional livestock keeping styles where people move around many kilometres in search of pasture and water. Pastoralists are going about their duties using rudimentary methods, moving through jungles in search of pasture and water for their livestock. We can only put a halt to these movements if we help them with well developed pastureland where their herd will graze and have access to water*" President Jakaya Kikwete on 29th March 2011 as quoted by state owned Daily Newspaper.

This section presented the temporal interruption and its impact to traditional Maasai Landscape. It also discussed how the continual policy and government interventions drive changes into this landscape. The next section will present what the government and scientists intentionally or unintentionally miss out. Consequently, blame the Maasai herders to be conservative and drivers of negative changes of their landscape.

4.4 TEK and SEK for Assessing Changes in Semi-Arid Landscape

4.4.1 TEK for Assessing Environmental Changes in Semi-Arid Landscape

"*If you real want to learn how we monitor and assess our landscape, come and live with us. After several months, you will gain experience and knowledge on livestock herding, searching for pastures and interact with wild animals. You won't learn a lot by asking questions or just a week with elders demonstrating how to do it*" (Shakwai – A Maasai Moran).

In the Maasai perspective the knowledge is acquired through interacting with nature, livestock and other people. To have a good idealised landscape in mind that suits the Maasai needs, and be able to monitor and assess existing situation, one has to go through Maasai's way of doing things and live with them. This is consistent with western understanding that landscape value depends on personal and subjective assessment of aesthetic satisfaction derived from a landscape type (Jacques, 1980).

The Maasai traditional knowledge is typically narrated in the form of folktales, songs, stories, poetry, and chants. It contains a wide-scope of knowledge about grazing practices, landscape history, landscape ecology, livestock management, traditional medicine, wild animals' behaviour and gathering of wild plant foods. TEK among the Maasai is the combination of locally developed experience and knowledge acquired from other sources. The knowledge pertains to individuals or groups of individuals of distinct gender, age, role and experience.

Traditionally, Maasai communities assign roles and authority to individuals based on their gender and age-group. The role of landscape assessment is generally for men, while each age-group has a different role and authority to practice (Table 2). The males' age-group in Maasai Steppe include *layoni*, *morani*, *landisi*, *ikishumu*, *iseuri*, and *makaa* (Table 2).

Table 2. Age Set of Maasai Male and Their Role on Landscape

Age set	Age (years)	Role on landscape
Layoni	Below 18	Grazing calves
		Grazing goats and sheep
		Helping morani to herd cattle
Morani	18-25	Survey for pasture and water (landscape assessment)
(Korianga)		Cattle herding
		Security of livestock (cattle, goats, and sheep) and *boma*
		Animal treatment
Landisi	25-45	Overseer of development activities
		Decide where to graze
		Local herbs or modern drug use adviser
		De-stoking
Ikishumu	45-50	Force behind all current changes
		Participate in development activities
Iseuri	50-65	Advise on all socio-cultural issues
		Overseer of all activities in the boma and setting.
Makaa	70 and above	Advise on all socio-cultural issues

Each age-group has a leader known as *laigwenan*. The *boma* heads usually make decisions unless communal consent is necessary, in particular where decisions by an individual affect the whole community. It is important to note that 75% of the respondents in this study, mentioned *Morani* as active age-group exercising landscape assessment. *Morani* reports to senior age-groups, who normally, visit the landscape for verification before making decision on use or reservation of available resources.

The roles and knowledge of women and young girls on landscape are particularly on resources use, such as tradition medicinal plants, tree for building *manyatta*, and firewood. Although, they are not allowed to make decisions or disclose any information on landscape to strangers, their knowledge on local natural resources availability and use is worth investigation.

The first research question is how TEK and SEK are used in assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania. The findings of the study show that Maasai herders have good understanding of the landscape and resources found. More important with TEK, Maasai herders were able to describe landscape divided into 14 micro-landscapes based on landform, dominant vegetation, and soil colours (See appendix 8). The systematic criteria used by Maasai herders to classify the landscape in the study area are landforms, dominant vegetation, soil colour, and land use type (Table 3).

Table 3. Criteria and Names of Micro-Landscape in the Study Zone

Criteria	Name of Micro-landscapes	Number of Micro-landscape
Landform	*Ayarata engeju, Engusero ondinyika, Engusero losteti, Nembirika, Engusero, Orng'arua, Ololukoti, and Oloudo*	8
Dominant vegetation	*Oit ekituma, Omeserani, and Loseye*	3
Land use type	*Olalili Orng'arua, and Olalili Ololukoti*	2
Soil colour	*Arukung'o*	1

In most cases topographic features of landscape dominates the naming of micro-landscape and landscape at large scale, for example Serengeti or "*Serengit*" is the Maasai name to a large scale landscape, which means "Endless Plains", while Ngorongoro means "the great or big hole". Similarly, dominant vegetation is used to name micro-landscape and large scale landscape, for example the Lake Manyara National park. The name "Manyara" is altered Maasai word "*emanyara*", which refers to a euphorbia species, scientific known as *Euphobia tirucalli*. The species was dominant in the areas and is grown into a hedge around some Maasai *boma*. The micro-landscape set aside exclusively for certain use, according to Maasai traditional rules may be named for that particular land use type, for example "*Olalili*" or called "*Alalele*" refers to calve pasture reserve. The criterion of soil colour is used when the area is bare or rocky. Generally, the Maasai name use binomial system to name a landscape or micro-landscape when it has two or more dominant physical features and monomial when the landscape has or micro-landscape have prominent common features (See Appendix 8).

The traditional system of landscape classification reflected herder familiarity with their environment (Oba and Kaitira, 2006; Roba and Oba, 2009). According to Oba and Kaitira (2006) cultural values and personal experiences is expressed on landscape classification. They further argued that the Maasai use two types of names for landscape classification, which are locality specific names and the general landscape names. The names are used for ecological and landscape management purposes (Oba, 1994).

Maasai herders are reported to use their experience on local landscape and knowledge to assess the micro-landscape and/or the whole landscape before planning for livestock movements. This is done to ensure maximum utilisation of temporal and spatially distributed resources in the landscape. The followings are the key indicators reported by Maasai herders.

i. Landscape Tolerance to Grazing Pressure

Maasai herders use system similar to scientific experimental research to detect change in their landscape. The degree of landscape sensitiveness to the grazing pressure is established, after long-time observations of soil and vegetation response to grazing. Inference on the type of landscape/micro-landscapes under observation thus made. This inference is passed to generations through story telling and practical instructions. Using the study area, Maasai herders categorized the landscapes sensitive to grazing pressure as degradable (*orpora*) or resilient that is non-degradable (*orkojita*). Degradable landscape are characterised with soil which are vulnerable to erosion due to grazing pressure, while vegetation are seasonal or annuals, which dry-off during dry season (See Plate 4).

Plate 4. Photo Showing Degradable Micro-Landscape "*Orpora*"

Non-degradable landscapes are charactrised with stable soil due to perennials and resilient plant species. In this case, Mr. Leura (Maasai elder of about 75 years old) presented his family calve pasture reserve (*alalele*) estimated at 10 acres as non-degradable. Reasons given are stable black soil and presence of forage around the year. The dominating resilient plants in the pasture include: ***Emirua (Cynadon dactylon)***, ***Omuluwa (Cynodon plectostachyus)***, ***Ologoriang'oki*** *(*Unidentified*)* and scattered ***Endepesi (Accacia Spp*** (Plate 5).

Plate 5: Photo Showing Section of Non-Degradable Micro-Landscape Managed As Calve Pasture Reserve "*Alalele Orkojita*"

This system of landscape categorisation enables herders to set wet and dry seasonal grazing pastures. According to Maasai herders degradable landscapes are grazed during wet season and non-degradable during dry season. Therefore, the issue of carrying capacity is not applicable in the Maasai landscape resource use and management; instead emphasis is on timing temporal resources that will otherwise shrink depending on weather.

ii. Forage Plants

The Maasai herders are very sensitive to changes in the composition of key forage species in the landscape. TEK on plant identification, biomass, cover, nutrition value, quality and quantity of grazing of the key species, are used as indicators to monitor changes in their landscape. The group of Maasai herders in the study area were able to identify 106 key plant species (See appendix 9). Like the way rangeland scientists categories forage as increasers, stable or decreasers, or palatable and non-palatable, Maasai herders also use the same system. According to Maasai herders, decreasers are those species that fatten livestock and improve their body condition such as "*Olonyoro*" and those that increases milk production such as "*Omuluwa*". This implies that identification and classification of species depends on the feedback reflected on livestock health and yield. Therefore, Maasai herders observe forage composition as an important criterion of assessing landscape change. The discussion with Maasai herders revealed that TEK of forage plants is particularly useful in identifying: dominant plant species, desirable and non-desirable species, and degraded landscape.

Furthermore, Maasai herders described the micro-landscape as degraded because key desirable species have declined or non-degraded when forage composition has few increasers. For example, Baraka sub-village was classified as degraded because the key species that once were dominant in 1970's have disappeared or declined considerably. Decline and/or disappeared species include: *laikuhinyo, endasikon, ilaikopi, orng'oting'oti (Vigna frutescens), alakalei, inyoroo, ilopit, arng'anayo loongisho, irikuloriti, osiyamali, oltukai (Phoenix reclinata), olmesera (Adansonia digitata), elerai (Acacia seyal), engamai aandare, engamai oongisho, olremit (Salvadora persica), olmukutani (Ekebergia capensis), endemelwa, and engoki.*

The reasons for forage composition change and degradation, as openly discussed among Maasai herders are associated with forced settlement, agriculture and restriction on livestock movements. The quotation of Lengeno, a man from Losirwa village of about 70 years old qualifies that view.

> *"I have lived here [Losirwa village] before operation vijiji. Grass was tall enough to cover the calf, lion were roaming here, and wild beast grazing and the whole land were occupied by four bomas. We had a system of grazing in the plain and in the mountains. Livestock numbers were not a problem, never caused landscape change. Later, government set restriction for livestock movement, were allocate a piece of land [village] and more Maasai brought here. The government promised for free veterinary services, schools, and water, which they never did. The other parts of our land were occupied by immigrant, who cleared our pasture and turned it into crop production".*

Maasai herders are of the view that the government policies disrupted traditional land uses systems by causing restriction on wet-dry season pastoral grazing movements, promoting crop production, allocating piece of land to many herders (Plate 6). Consequently, more competition over grazing land and limited time for forage recovery, causing disappearance of some plant species and decline in livestock population. The plant species reported by Maasai herders to have disappeared or decreased considerably are those sensitive to grazing pressure, and trees that are used as fuel wood like *olmukutani (Ekebergia capensis)* and construction of *manyatta* and *boma* like *accasia sp.*

Plate 6: Photo Show the Preceding Maasai Traditional Pasture Fenced, With Warning Sign "*It is Prohibited for Cattle to Cross Here*"

iii. Weather

Weather is the most important aspect affecting forage and livestock production for the Maasai. Extreme rainfall and drought in the landscape are the most natural threat to Maasai and their livestock. The major drought seasons that 80% (N= 20) of Maasai elders have memorized are those which caused drastic change of livestock (on their opinion). These include the following year range: 1933-35, 1948-50, 1953-56, 1964-67, 1973-76, 1983-87, 1990-94, 2002-2005, and 2009-2010. Rainfall means high productivity while droughts imply trials for Maasai herders. Makuyuni

Ward Exuctive Officer estimated about 3000 cattle to have been exterminated by short drought in year 2009/10. Because of such drought and rainfall impact on Maasai livelihood, weather becomes one of their key indicators of landscape assessment and management. Maasai herder linked weather and landscape changes in the following words "Dry season usually is associated with wind and the landscape has no grass; winds carry away good soil called "*engulukoninado*" and leave the sand soil called "*oloibo lusunyai*", such soil makes landscape poor; [on the other hand] grass grow during rainy time; livestock get enough folder [and] increase production''. These descriptions validate the argument that Maasai are aware of causes for landscape degradation, and natural process for landscape restoration.

iv. Water

Water is a scarce resource in the Maasai Steppe especially during dry season. Available water is monitored and managed for livestock and human consumption. While the Maasai herders searching for suitable pasture, water holes are also assessed. No matter how scarce the water resource, it is still communally owned and managed. Observant Maasai herders utilize the available water very efficiently. Three major strategies are used by herders to deal with water shortage: livestock are split and sent herds to different water holes, water livestock in alternate days, and migrate as last strategy (Table 4).

Table 4: Strategies for Dealing with Water Shortage

Most frequently reported Strategies	Frequent (N=69)	Percentage
Split the herds and send to different water holes	49	71
Water livestock on alternating days	55	79.7
Migrate when no more water	63	91.3

Nevertheless, descriptive statistics show not all herders employ all three strategies. It is only 70.4% of herders who spilt their herds and 79.5% water livestock on alternating days. Although, when the landscape is dry, 90.9% resort into moving their animals. The differences on responses to water shortage among the herders were associated with animal species, number of animals herders own, and willingness to pay agriculturalists to use part of their irrigation farms. The herders with more than 100 herds of cattle spilt their herds and water at different holes, the rest may not. Furthermore, those with less than 100 heads of cattle are also required to water on alternating day option. Again, significant numbers of herders who own goats do not follow the agreed upon cattle schedule, because goats use less water than cattle. When there is drought, livestock are sent to dry season grazing reserves. Few herders (9%) have few animals, and do not use distance dry range for grazing, instead enter into agreement with immigrants who own irrigation farms, and use the left over and water from the irrigation channels.

iv. Animal Performance

Livestock performance is used as indicator of landscape degradation. Maasai herders suggest that livestock productivity changes as landscape resources change. In their view landscape degradation is directly proportional to reduced livestock productivity. Herders pointed out that change in landscape causes low livestock productivity associated with change in forage composition, weather, diseases, water quality and nutritional value of the forage.

The Maasai assess the overall grazing quality on the basis of quick animal gut fill, plant cover and the animal's condition. With a good grazing quality, the animal belly is usually full within short-time, there is an increase in milk production and the animals are healthier. The Maasai assess livestock performance using several attributes such as body condition, milk production, posture and gait, skin coat and fur, mating or birth frequency, cow dung texture and colour. Generally, the Maasai herders use livestock condition and productivity as early warning indicators of land degradation in the Maasai Steppe.

v. Landscape Conditions

The TEK among the Maasai was evaluated using three key questions, which all respondents regardless of age and sex had equal chance to answer. The test questions were (i) how do you assess the landscape condition? (ii) What criteria do you use for the mentioned classification? and (iii) how is livestock movement regulated in the landscape?

The majority of the respondents based on content analysis classify the landscape as good, average and bad (Table 5). The main ecological basis for landscape conditions are livestock performance and productivity in terms milk yields, weight, mating frequency and health is good; others are water availability, soil, vegetation cover/forage, and vector and diseases incidences. The livestock satisfaction and dissatisfaction is used to tell the condition of landscape in a single day.

Table 5: Major landscape conditions as classified by Maasai herders

Classification	Description	Frequent (N=66)	Percentage (N=66)
Good Landscape	Enough forage, adequate water, good soil, short distance to grazing, less vector and disease.	56	84.8%
Average Landscape	Adequate forage, long distance to water, few diseases, incidences, less vector and disease.	51	77.3%
Bad Landscape	Inadequate pasture, acute shortage of water, high disease incidences.	52	78.8%

The ranking of Maasai criteria for assessing landscape conditions as per Maasai elders shows that livestock or animal performance to be most considered and least is soil type (Table 6).

Table 6: Rank of Criteria for Assessing Landscape Condition

Criteria	Rank
Livestock/animal performance	1
Forage composition and availability	2
Water quality and availability	3
Vector and diseases	4
Soil types	5

The Maasai keep multi-species livestock, which comprised cattle, sheep and goats, and donkeys for few *bomas*. Multi-species of livestock are kept in response to unpredictable rainfall. This was also alluded to by (Mapinduzi *et al.,* 2003). Based on the animal species and rainfall trend, the movements are designed to rotate to most possible key grazing resources, while taking into consideration landscape type and conditions. The Maasai herders decide the direction of movements and grazing at distinguished micro-landscapes at local scale, and in wholeness at large landscape. The grazing transhumance as observed by Mapinduzi *et al*., (2003) is organised between the hot arid (*orpukel-lengolol*), the semi-arid (*orpukel le-supuko*) and the cool sub-humid (*osupuko*) eco-climatic zones. At the landscape level, grazing transhumance depends on diverse micro-topography, similar to the wet–dry season grazing movements ((Mapinduzi *et al.,* 2003). In special cases, the Maasai reserve pastures for calves and sick animals called "*Alalele*" near the homestead. The Maasai herders do not basically move aimlessly as many scholars presume. There must be a compelling reason(s) to decide to move from one locality to the other, which otherwise they will loose significant number of livestock, human death or altogether.

4.4.2 Joint Survey Using TEK and SEK for Assessing Environmental Changes

Maasai herders and ecologists' joint survey aimed at understanding the consistency of Maasai herders' TEK of environmental changes, particularly changes in forage composition in comparison to ecologists' field empirical data. Ecologists were also interested to verify Maasai herders' claim on disappeared or declined plant species at landscape scale (section 4.4.1. ii).

The joint survey shows that species which were reported by Maasai herders to have disappeared such as *laikuhinyo, endasikon, ilaikopi, arng'anayo loongisho, irikuloriti, osiyamali, oltukai, elerai, engamai aandare, engamai oongisho,* and *engoki* were not present at landscape scale. The absence of the previous key species at landscape scale confirms the reliability of Maasai TEK on plant species composition changes. In this case Maasai herders can serve as benchmark for assessing biodiversity loss and degradation of landscape. Furthermore, plant species which Maasai claimed to have considerably decline such as *orng'oting'oti (Vigna frutescens), olmesera (Adansonia digitata), olremit (Salvadora persica), olmukutani (Ekebergia capensis)* were found at low frequencies at landscape scale (Table 7). In most cases cited plants were not captured at micro-landscape scale. Though, ecologists argued that low frequencies of species at landscape scale do not provide scientific basis, to infer significant decrease of the plant species as claimed by Maasai herders, unless there is comparable benchmark data. Yet, the Maasai Steppe provides setting environment to ascertain the consistency of Maasai claim. This could be done by carrying out similar joint study in other landscapes such as

Tarangire and Lake Manyara national parks, which share geographical features with the study area.

Table 7: Plant Species Composition in the Study Area

Maa Name	Scientific Name	Life Form	Frequency (%)
Alaisai	*Sericocomopsis spp*	Shrub	24
Alaisai II	*Sericocomopsis spp*	Shrub	18
Aripalakai	*Brachiaria deflexa*	Grass	12.7
Armagiririani	*Acacia brevispica*	Shrub	12.6
Arpakwa	*Brachiaria deflexa*	Grass	11
Aringabol	*Ficus sycomorus*	Tree	3.1
Asangari	*Digitaria diagonalis*	Grass	38
Eiti	*Acacia mellifera*	Tree	5.2
Embereepapa	*Asparagus africanus*	Shrub	7.1
Emborokwai	*Melhania sp.*	Shrub	23
Emborokwai ekop	*Melhania sp.*	Shrub	17
Emborokwai engujenebo	*Melhania sp.*	Shrub	12.9
Emirua	*cynadon dactylon*	Grass	34
Emurua ekopi	*Cynadon spp*	Grass	28
Endejani	*Cissus quadrangularis*	Shrub	22.1
Endepesi/ oit	*Acacia tortilis*	tree	15.7
Enderepenyi	*Setaria verticillata*	Grass	38.7
Endulele	*Solanum incanum*	Shrub	31.3
Endunduru	*Dicrostachys cinerea*	Tree	23.1
Engaiteteyai	*Commelina benghalensis*	Herb	69.3
Enguruishash	*Barleria eranthemoides*	Shrub	13.4
Erube	*Themeda triandra*	Grass	18.9
Esilale engailopai	*Commiphora schimperi*	Tree	4.7

Iring'onom	*Cyperus distans*	Herb	33.3
Lolondo	*Sida ovata*	Shrub	18.3
Magigilia	*Acacia brevispica*	Shrub	0.7
Olngaboli	*Ficus vallis-choudae*	Tree	0.9
Oldupai	*Echinochloa colona*	Grass	28.2
Olekitolee	*Scabdoxus multifluros*	Herb	2.3
Olosite	*Grewia bicolor*	Shrub	12.1
Oliamunywa	*Ocimum suave*	Shrub	3.9
Olingonomi	*Abutilon hirtum*	Herb	79.1
Olmesera	*Adansonia digitata*	Tree	4.2
Olmukutani	*Ekebergia capensis*	Tree	23.2
Olmukutani	*Albizia anthelmintica*	Tree	21.6
Ologoriang'oki	*Hyperrhenia colina*	Grass	5.3
Oloisijoi	*Tamarindus indica*	Tree	2.7
Oloisikirai	*Heliotropium steudneri*	Herb	9.1
Olonyoro	Failed to indentify	Grass	60.3
Olopito	*Glycine wightii*	Legume	31.6
Olremit	*Salvadora persica*	Tree/shrub	6.3
Omuluwa	*Cynodon plectostachyus*	Grass	62.9
Orkereyani	*Acrocerus macrum*	Grass	24.2
Orkojuto ionyoke	*Themeda Triandra*	Grass	75.6
Oseyei	*Scirpus maritimus*	Grass	7.3
Osinon	*Lippia kituiensis*	Shrub	12.7
Urukurusashi	*Barleria eranthemoides*	Shrub	11.7

The joint survey further established that scientific findings on landscape assessment can be provided with sound explanation from local people. For example, when the Maasai herders were asked to explain the phenomena shown by plant species (Table 7 and Figure 10) during results presentation meeting, the following was the response.

"What you see now in our landscape is different from that in 1960s and 1970s; here grasses were tall, lion and buffalo used to hide in grass; when cattle move to Tarangire [earlier dry grazing landscape], bushes used to be dense; we had to use fire to manage bush [woody plants] encroachment; now animals stay longer in this landscape; if no rain no grass at all, our goats browse on bushes; trees are sparse; grass do not grow tall and the ones you see [referring to the landscape] is due to December short rain; re-growing, may increase or decrease depending on rainfall trends "

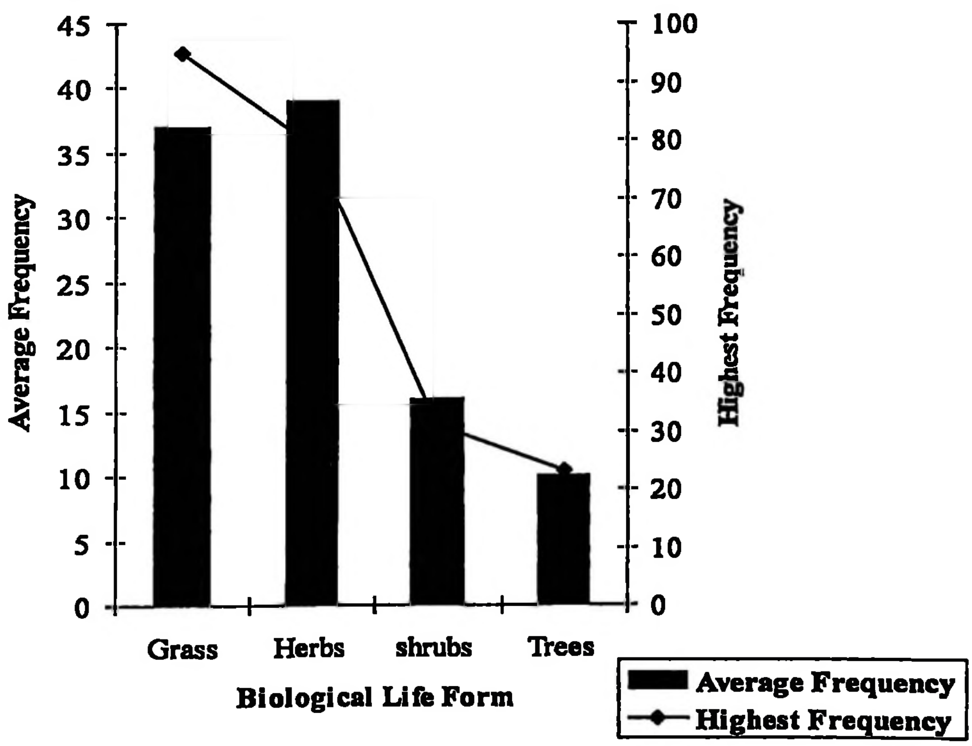

Figure 10: Average and Highest Frequencies of Plant Species Occurrence in Respective Biological Life Form

The Maasai herders' comments describe plant dynamics in the landscape, in their view, if the landscape is not managed bushes will cover the whole land, and there will be no grass for cattle and sheep (grazer). The main drivers of plant dynamics and changes are rainfall and livestock. Woody plants expand during drought season unless goats are left to browse them. Maasai herders contemplate Figure 10 as the outcome of drought season, otherwise the trend should be vice versa (Figure 11). Contrary to Maasai herders, ecologists perceive the phenomenon as the normal trend of ecological succession. This implies that the once degraded landscapes pave the way to grass colonisation, then herbs, shrubs and trees (Figure 12).

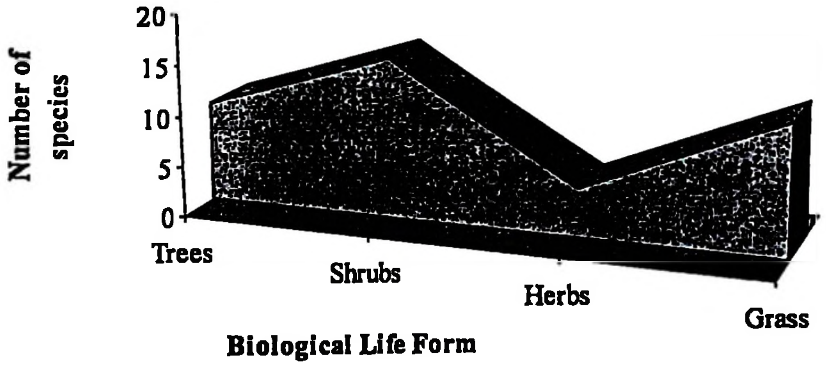

Figure 11: Show Maasai Herders' Interpretation on Plant Species Dynamics

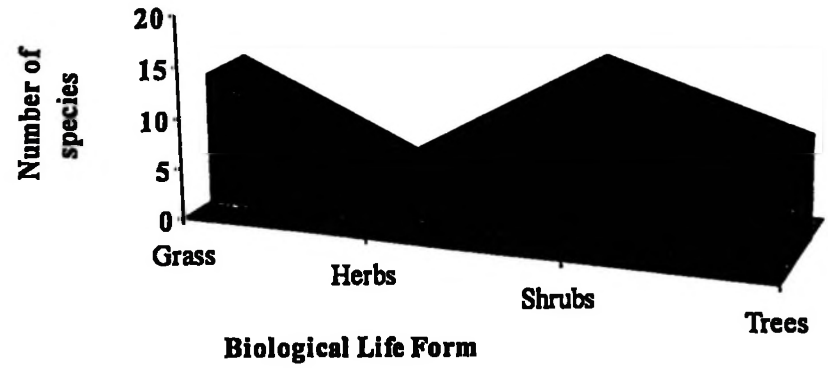

Figure 12: Ecologist Synthesise of the Plant Species Dynamics

The most interesting observation was the way Maasai herders work like ecologists in pilots measured on foot steps of 10 m x 10 m plots in areas with bushes and thickets, while bare ground and erosion indices of 1 m x 1 m plots. This epistemology gave comparable results between ecologists and Maasai herders.

4.5 Ecological and Anthropogenic Indicators Used to Assess Change in the Maasai Steppe

This study explored traditionally understood indicators for the assessment of changes in the landscape. The results show that Maasai herders similar to other pastoral communities use anthropogenic and ecological indicators simultaneously to assess changes in the landscape (Reed and Dougill 2002) (Table 8). Ecological indicators include vegetation/forage, soils, water, animal condition, and vector populations. Reed *et al.* (2007) in addition reported the use of animal behaviour while Goldman (2007) reported the use of wild beast migration trends as an indicator of rainfall and forage trends in Maasailands. Anthropogenic indicators used by Maasai herders is livestock productivity and animal performance in terms of milk yields, calving rates, mating frequency, body weight and general animal health. Maasai anthropogenic indicators are similar to those used by Borana in Kenya and Karamoja in Uganda (Roba, 2009, Oba, 2011).

In reference to the results presented in sections 4.3 and 4.4 above and literature review, the study further established that there are comparable evidences of indicators, used for assessing semi-arid landscapes in TEK and SEK (Table 8, and

Figure 13). Table 8 presents the indicators cited by Maasai herders (in scientific interpretation), and show evidence from the literature, which support the accuracy of the referred indicators. Similarly, Figure 13 provides the basis of overlaps between SEK and TEK, where by out of 24 indicators used by herders in combination to assess landscape change, 17 (70.7%) are scientifically acceptable, while the rest are either not yet validated or are in conflict with scientific evidence. For example, water logging due to decreased water infiltration rate, in science is considered to cause soil erosion and acidity, while for Maasai herders it serves as water source during rainfall and reserve for dry season pasture. Importantly, this study presents evidence that TEK and SEK to larger extent overlap, and can be integrated for the purpose of complementing each other.

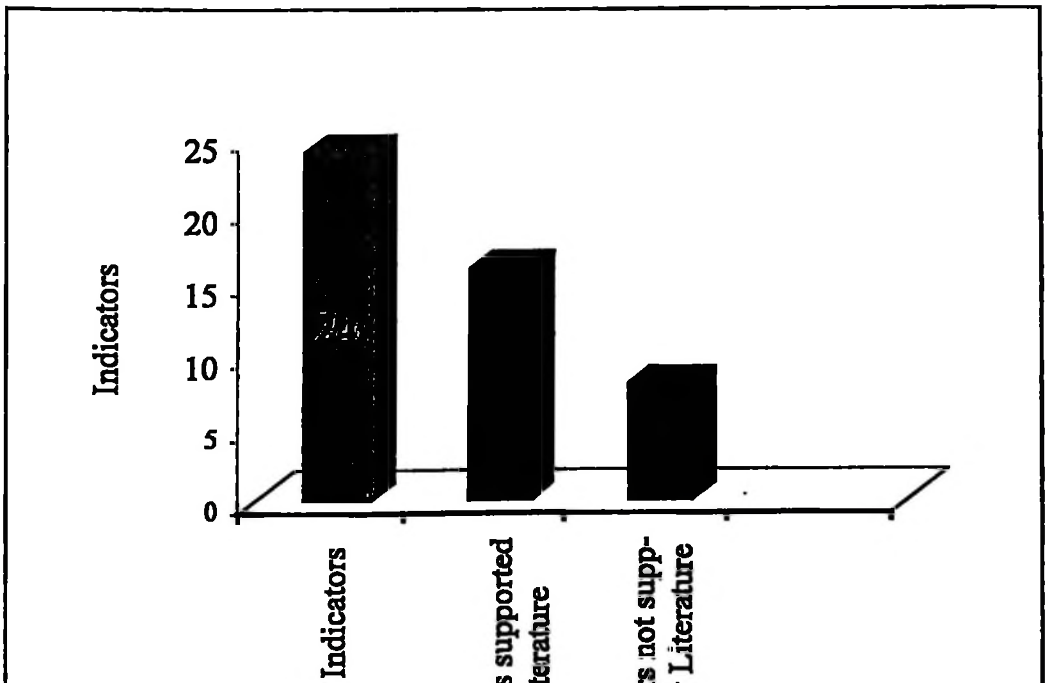

Figure 13: Showing the Extent of Overlap in TEK and SEK

This study supports Reed *et al.* (2007) arguments that local communities provide more meaningful interpretations of all indicators cited in the literature and those without scientific empirical basis. The Maasai indicators have been practiced and used in management decisions of local landscape for centuries. The indicators used by Maasai herders are simple and easy to measure, require short time and no laboratory works, analysis is done in individuals' heads, and inferences are discussed with fellows.

Table 8: Indicators Considered Accurate and Easy To Use by Maasai Herders in Maasai Steppe Showing Supporting Literature and In the Field

Indicator	Cited in literature	Cited by Maasai
Soil		
Increased litter cover	Tongway 1995	✔
Decreased water infiltration rate	x	✔
Decreased area affected by soil erosion features	FAO/UNEP 1984; Ottichilo *et al.* 1990; Tongway 1995; Krugmann 1996; Hamblin 1998.	✔
Decreased frequency and severity of wind dust	Reining 1978; Kassas 1987; Dregne *et al.* 1991; Krugmann 1996	✔
Increased incidence of cattle tracks	x	✔
Vegetation		
Increased above-ground and total biomass production	Keya 1998; DePietri 1995; Bellows 1995	✔
Increased vegetation cover	FAO/UNEP 1984; Reining 1978; Kassas 1987; Tongway 1995; Weixelman *et al.* 1997; Milton *et al.* 1998; Hamblin, 1998; de Soyza *et*	✔

	al. 1998; Whitford *et al.* 1998; Dahlberg 2000; DeSoyza *et al.* 2000a, 2000b; King *et al.* 2000; Manzano and Navar 2000	
Decreased unpalatable species abundance and increased forage quality	Reining, 1978; van Vegten, 1983; Kassas 1987; Ottichilo *et al.* 1990; Skarpe 1990a, 1990b; Ringrose *et al.* 1990; de Queiroz 1993; Kipuri 1996; Milton *et al.* 1998; Whitford *et al.* 1998; Desoyza *et al.* 2000a, 2000b	✔
Increase in specific palatable species	Van Zyl 1986; Krugmann 1996; Keya 1997; Weixelman *et al.* 1997	✔
Increased perennial grass abundance	Kerley and Whitford 2000; Whitford *et al.* 1998; Desoyza *et al.* 2000a	✔
Decreased annual grass abundance	DePietri 1995	✔
Decreased bush encroachment	Warren and Agnew 1988; de Ridder and Breman 1993; Quan et al. 1994; Dean and MacDonald 1994; Scoones 1995; Adams 1996; OwenSmith 1996; Hamblin 1998; Kerley and Whitford 2000; Weber *et al.* 2000.	✔
Increased biodiversity	Dregne 1976; Barrow 1991; Bellows 1995	✔
Specific plants and animals are able reproduce	Reining 1978; Kassas 1987	✔
Increased abundance of trees	x	✔
Wild animals		
Increased abundance of wild animals	Bellows 1995; Goldman 2007	✔
Increased abundance of Termites moulds	x	✔
Increase in vectors	x	✔

population		
Livestock		
Increased availability of livestock products (Milk)	Reining 1978; Kassas 1987; Abel 1993; Kipuri, 1996; Roba, 2009; Oba, 2011	✔
Increased livestock production (herd size and calving rate)	Reining 1978; Kassas 1987; White 1993; Kipuri 1996; Oba and Kaitara 2006	✔
Poor livestock condition/weight	x	✔
Increased incidence of livestock disease	x	✔
Livestock graze at increased distance from borehole	x	✔
Socio-economic		
Decreased distance to sources of fuel-wood and building material	Dregne *et al.* 1991; Ottichilo *et al.* 1990	✔

Source: Modified from Reed *et al.*, 2007; Field Survey 2011

NB: Authors cited in this table appear under the list of other reference consulted.

Furthermore, Maasai indicators encompass SEK indicators and non-technical, which makes it more broad and inclusive (Figure 14). For example, 9 out of 10 (90%) vegetation indicators used by Maasai herders are acceptable in SEK, and supported by in SEK literature (Table 8, Figure 14). Inclusiveness of Maasai TEK makes it more accurate in the local landscape.

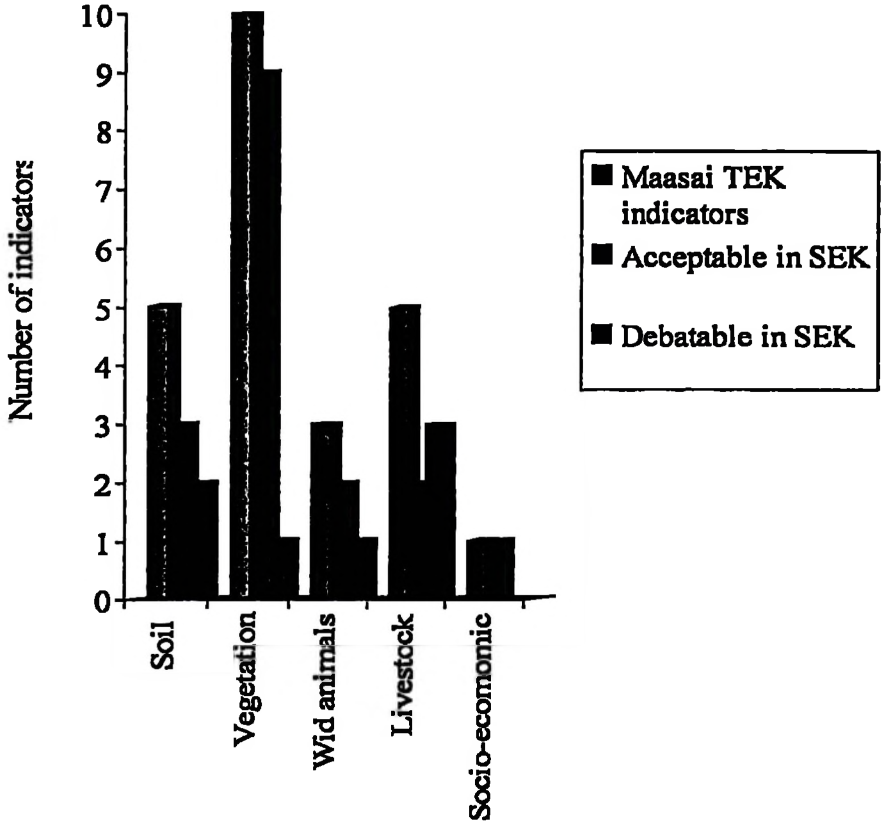

Figure 14: Proportional of SEK Indicators Used in TEK in the Maasai Steppe

4.6 Model for Assessing Environmental Changes in the Semi-Arid Landscape

4.6.1 Theoretical Framework for Integrating TEK and SEK

The integration of TEK and SEK is inevitable for those who want to develop common methodological approach for assessing environmental changes in the local landscape. Different knowledge systems should be synthesised and built into integrated framework supported by theories and practical field evidences, which ensures the efficiency in supporting implementation of global policies like CBD at local level, and actively involving technical and local people. Thus, based on literature review, field findings in Maasai Steppe and evidence presented from elsewhere, this study concurs with the theoretical framework for implementation of Global Environmental Conventions, as proposed by Roba (2009) (Figure 15).

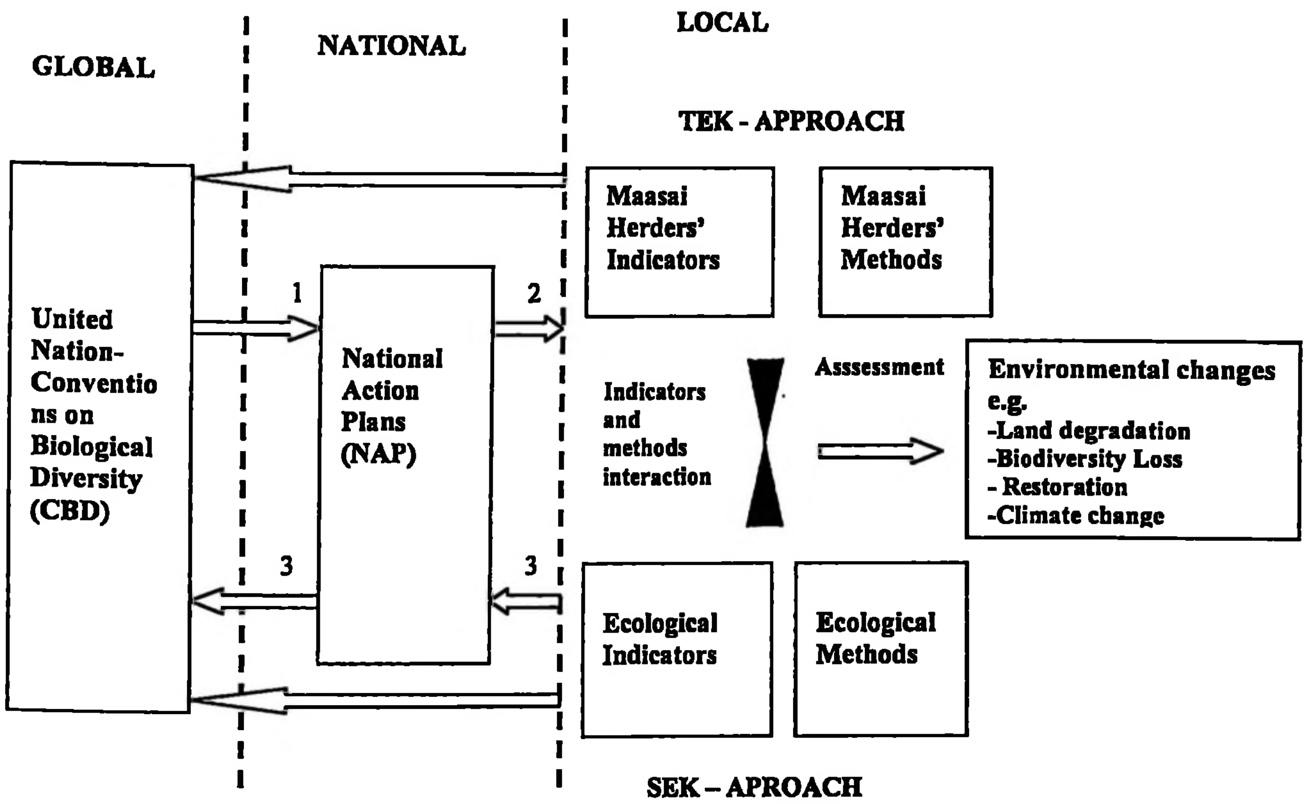

Figure 15. Framework for the Implementation of CBD Showing Integration of TEK and SEK for the Assessment of Environmental Change (Source: Roba, 2009)

Successful implementation of the Convention on Biological Diversity is linked to the activities at global, national and local levels. At the global level, the conventions are negotiated as part of collective global responsibilities. At the national level, each country implements the conventions according to meet its international obligations as stipulated in the protocol, usually the nations develop so called "National Action Plans", with this each country sets priorities and strategies. Implementation at the local level necessitates consideration of the diversity of ecological, production and social-cultural systems, and the use of local knowledge for resource assessment (Roba, 2009). The CBD at global level requires indigenous people to participate in developing implementation plans through national and local levels, as indicated in Figure 15.

Framework for the implementation of CBD has three linked stages, these are: Stage 1 is concerned with the global land degradation and biodiversity loss are described and discussed; Stage 2 of the framework is concerned with the implementations of NAP; and Stage 3 is concerned with local participation in the implementation of CBD (Figure 15). This study focused on Stage 3 where the mechanisms of integration of TEK and SEK for the assessment of environmental change so as to ensure effective local participation in global and national actions.

The strength of this framework is centred on the approach of selecting realistic and convenient indicators from SEK and TEK, which can be used either by ecologists or herders in the field. This is different from other bodies of scientific knowledge that have not shared indicators for assessing local landscape (Oba, 2011). The framework allows anthropogenic indicators to be used in reconstructing long-term impacts on pastoral landscape and livelihood, while the responses are in terms of management decisions by the herders at local level and basis for developing policies at national level. The framework combines the work of ecologists and the herders for selection of indicators. In this way, the framework promotes integration of traditional knowledge used by herders and the scientific ones used by ecologists.

Therefore, the framework provides methodological approaches which produce results that are likely to be acceptable at local, national and global level.

4.6.2 The Implementation Mechanisms of the Framework in Maasai Steppe

The integration of TEK and SEK entails joint research, which employs traditional and ecological methods simultaneously. There are different steps for integrating data collection, recording and data interpretation (Figure 16).

Step I: Interviews

Scholars must learn local environment and human communities under study. The initial step of doing this is to conduct interviews with local knowledgeable individuals, who can be identified with the help of target community. Conducting group discussions with herders about traditional systems of landscape management in general, landscape classifications, assessments and management strategies for coping with changes. Compilation of key words and concepts and the indicators that are frequently used is necessary. Most knowledgeable herders can be identified while conducting interviews. The herders' tales are descriptive, adapting the cultural contexts of the stories told on changes in community perceptions of grazing lands and impacts of droughts. According to Reid *et al.* (2000) historical reconstruction of land use change is based on herder memory against time lines of social institutions such as age sets, yearly calendar, and historical events. This way TEK can be realised and put in practice (Oba, 2011).

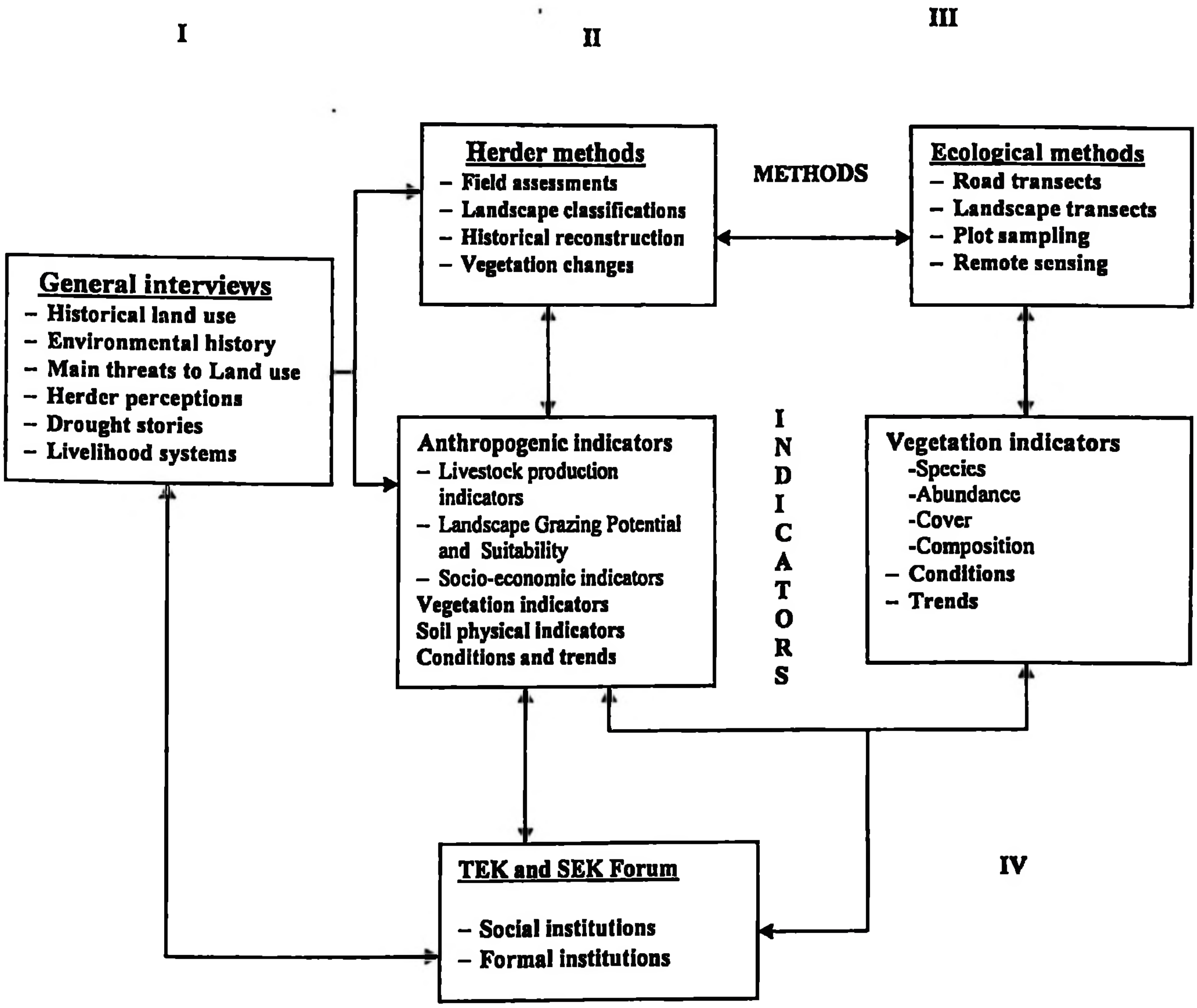

Figure 16. Systematic Framework for Integrating TEK and SEK

Step II: Learning Traditional Methods

The second step should focus on identifying and describing indicators and concepts used by the herders. Such surveys might include discussions with herders on indicator functions in relation to livestock production. The vegetation covers and forage species indicators would be applied at suitable scales (Coppolillo, 2000).

The relative severity of environmental change can be related to herder landscape classifications (Oba and Kaitira, 2006). Herders would describe the processes relative to livestock grazing suitability and forage availability in relation to grazing preferences and availability of forage species (Oba and Kaitira, 2006). Based on soils and vegetation indicators the grazing suitability and landscape grazing potential can be assessed. Plant and soil indicators and the corresponding livestock production performances influenced herder decisions. This may also influence spatial and temporal distribution of livestock based on species type. Similar to Oba's (2011) observation and conclusion, this study affirms that herders would also determine changes in the landscape in terms of disappearance of key forage species and extent of land cover. It is true that herders notice environmental changes that affect the livestock performance earlier based on day to day observation. Active involvement of herders benefits from narratives that provide the perspectives of local conditions inferred from past herding experiences (Roba and Oba, 2008). As results presented in section 4.4.2 confirm, herders are knowledgeable in vernacular taxonomy being able to identify plant species even without aid of floral parts, which ecologists seldom achieve. Furthermore, herders understand different uses of plant species varied from grazing suitability, medicinal, rituals, and food, making utensils and for building materials (Stave *et al.*, 2007). Using the type of knowledge, herders would reconstruct environmental changes.

Step III: Joint Environmental Changes Assessment

In the third step, ecologists would use road transect and landscape transects to assess changes in vegetation indicators. From the changes landscape indicators could be built, while the trends would be based on herder historical knowledge. Ecologists should learn to incorporate the different indicators and evaluate their performances (Mapinduzi *et al.*, 2003). The pre-condition of integrating ecological and anthropogenic indicators is participatory assessments (Shanley and Gaia 2002). Ecologists should also be able to systematically collect field data, conduct analysis and interpret the data. Descriptions of the methods for building integrated indicators should combine the ecological and indigenous knowledge. According to Yoccoz *et al.* (2001) the descriptions are necessary methods to be compared while working in different environments. Hence, comparable and effective joint environmental change assessment requires the research team to start with landscape transect walk. The objective of carrying out the survey should be made clear for everyone taking part in the exercise. The concepts and indicators identified in prior steps should be discussed in relation to the assessments exercise to be done. While ecologists use ecological methods, herders can be informed on rationing in order to use traditional methods. The scales of measurement can be plots, patches and landscapes (Oba, 2011).

Step IV: Forum

The fourth step is concerned with data analysis, information sharing and decision making. Local communities need to discuss collected and analysed data. Scientific interpretation should be presented to studied communities for them to accept or correct misapprehension. The herders should be able to express their views on the drivers of environmental changes. The forum should discuss roles that can be played by ecologists and herders in the implementation of biodiversity conservation at local landscape as stipulated in CBD. Ecologists and herders should share information as much as possible to reach a balanced and acceptable point of addressing so called reluctant or conservative local communities in implementation of CBD, by making rational decision in the local landscape.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study has established that Maasai Pastoralist have their traditional knowledge that is useful for management of the landscape. The maasai TEK is practical and adaptive to semi-arid landscape like Maasai Steppe. The Maasai TEK is not static but rather dynamics; it has components that are similar to scientific ecological knowledge. The maasai herders are aware that socio-economic changes, agriculture, continuous grazing, and rainfall influence the resources distribution in the landscape.

Furthermore, Maasai herders use multiple indicators such as livestock productivity, landscape grazing potential, vegetation and soil characteristics to monitor and assess landscape. Maasai knowledge on landscape classification, species identification, landscape changes management strategies are to large extent supported by literature. Some of Maasai herders' indicators on biophysical and anthropogenic indicators have been scientifically validated. Therefore, the study appreciates Maasai TEK along SEK by developing systematic framework to integrate both knowledge systems for the purpose of assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania.

5. 2 Conclusion

This study has achieved the main objective of developing a model for integrating TEK and SEK for assessing environmental changes in the semi-arid landscape of Maasai Steppe in Northern Tanzania. The model is presented in the form of a framework that interprets CBD protocol into practice through the integration of traditional and ecological methods of assessing landscape. The framework demonstrates how local participation in the implementation of the CBD could be achieved. Transformation of the convention articles into national and local actions involves developing appropriate methods and locally valid environmental indicators, while taking into consideration landscape history. Tradition or herders' indicators can be identified, coded and tested. In the Maasai Steppe herders' indicators proved to be sensitive to environmental changes, and detect change at a very early stage through livestock production performance. Herders and ecologists have comparable indicators that can be used to assess environmental changes in semi-arid landscapes. While ecologists view the landscape on ecological succession model, the herders view landscape on the basis of history and livestock grazing potentiality. Different views of landscape result in additional landscape indicators, which seem to be illogical to the opposing perception. With respect to Article 8(j) of CBD that required the nation to maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles, support the local people's view against ecologists. This empirical study in support of CBD concludes that Maasai herders have diverse TEK that can be integrated with SEK for assessing environmental changes in semi-arid landscapes. Therefore, it is indeed possible to involve local communities in the implementation of CBD at the local level.

5.3 Recommendation

This study confirmed that local communities have diverse knowledge in their landscape. It is recommended that such knowledge be used to assess environmental changes. Thus, the study recommends the use of systematic framework for integrating TEK and SEK in local environment where it was developed. In order to implement the CBD at local levels, it is recommended that biodiversity conservation agenda should be considered in line with local communities' utilitarian objectives of vegetation assessment, for the purposes of livestock management. Joint assessment for the implementation of the CBD may involve establishing an inventory of biological species that are found in local landscapes. The early inventories will serve as benchmark for future assessments.

5.4 Areas for Further Study

This study suggests three areas for further study. These include: First the tests of traditional indicators that are used by herders but not found in literature, and have not been scientifically tested. Second is similar study on non-Masaai pastoralists like Sukuma, Iraqw and Hadzabe who also live in semi-arid landscapes. The third important study should be carried out among agro-pastoralists who reside in semi-arid and humid landscapes. The comparable studies will provide the general trends on shared traditional indicators, and comparable TEK. Common traditional indicators can be used to develop integrated national indicators for assessing environmental changes at national level.

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APPENDICES

Appendix 1: Transect Walk and Observation Guide

Guiding theme:

1. Culture arts (folks, songs, dances, story)
2. Social organisation
3. Livestock Population
4. Weather pattern
5. Indicators
6. Ecological range suitability ranking in relation to forage plants
7. Indicators
8. Management of undesirable quality of pasture of grazing areas
9. Solutions to deal with resources shortage
10. Maasai soil classification and use
11. -indicators
12. Maasai criteria of range assessment
13. Ecological range rating
14. Decision making roles according to age sets
15. Traditional ranking of rangelands
16. Evidence of landscape covers change
17. Evidence of landscape degradation
18. Evidence and remnants of historical events

Appendix 2: Interview Guides

A. Socio-economic Data

i. Name of the respondent (optional)

ii. Sex of the respondent:

iii. Age:

iv. How long have you stay in this area?

v. Why did you migrate to this area?

vi. Do you keep livestock?

vii. Which type of livestock species do you possess?

viii. Why do you keep different species of livestock?

ix. How many livestock species did you possess before 1960, and in 1990s?

x. Are the numbers increasing or decreasing today? Why?

B. Assessing Landscape Changes

i. How do you classify your landscape?

ii. What are criteria for classification?

iii. What are key resources in this landscape?

iv. Why do you consider the resources mentioned in iii as key?

v. How do you assess the landscape condition?

vi. What are criteria used to classify landscape as good or poor?

vii. Think about Maasai steppe in the past, what would you see or not see that tells you this land is poor? In what ways is the rangeland differ now from the way it used to be in the past?

viii. What changes do you see in the landscape (1) vegetation; (2) soil; (3) livestock; (4) wild animals and insects; (5) people who use the land in this area?

ix. Are these changes degradation or drought indicators? Do you still find these indicators after it has rained?

x. What is the first thing you would see that would make you suspect that an area of land was going to decline/become poor/unproductive?

C. Biophysical and Anthropogenic Indicators

Weather/Climatic Characteristics

i. What do you know about the weather/climate?

ii. What are the major climatic factors affecting livestock production in this landscape?

iii. Which is the most critical factor?

iv. How do these weather elements affect rangeland quality and livestock productivity?

v. What is the rainfall pattern around the year?

vi. Think about Maasai steppe in the past, have you ever experienced prolonged drought season? Which year(s)?

Soil Characteristics

i. How do the following soil characteristics affect fodder availability and animal performance\ productivity? (Soil colour, texture)

ii. How do you evaluate soil fertility? (Plant vigour, size of the fruit, size and colour of the leave, forage production, crop yield, presence of a certain plant species)

iii. What do you do to overcome the problems caused by soil infertility?

Water Availability

i. What are the sources of animal water in your area?

ii. Do you face the problem of animal water scarcity?

iii. What are the indicators of water availability?

iv. Does water availability affect animal performance or productivity?

v. If yes why?

vi. What decision(s) do you make when there is water scarcity

vii. Do you experience water competition among Maasai, between Maasai and Non-maasai?

viii. If yes, what are the reasons and what time of year is this situation critical?

Vegetation Identification and Composition

i. Do you know the names of vegetation growing in this landscape?

ii. Which type vegetation type is dominant in each micro-landscape (botanical composition)? Why?

iii. Do you see any change in botanical composition due to either grazing intensity or climatic change?

iv. Are these changes positive or negative?

v. What do you do when the botanical composition changes?

vi. Do you face the problem of overgrazing in your area? If yes why and what are the indicators?

vii. How do you rate the landscape condition (Soil indicators, plant vigour, litter cover or animal performance)?

viii. What attributes do you use in assessing landscape condition (animal performance, forage availability, distance to water, diseases incidences, security?)

ix. What is the most important attribute of the above-mentioned indicators?

x. How do you ecologically rate the range suitability for livestock production?

Animal Productivity/Performance

i. How does botanical composition relate to

-Dietary requirement of different animal species

-Preferred plant species

-Poisonous plants

-Medicinal plants

-Fattening of livestock

ii. What are the attributes used in the assessment of animal performance? Rank them according to their importance?

iii. What are the factors affecting animal performance?

iv. How do you overcome each negative factor which causes poor animal performance?

v. How do you relate animal performance landscape conditions?

vi. How do you overcome harsh condition affecting your livestock (coping strategies)?

Management Options

i. How do you traditionally manage these different types of micro-landscape and why?
ii. How do you traditionally manage the micro-landscape for different grazing purposes?
iii. In case of any difference in management systems what is the reason for this?
iv. How do these different management systems affect livestock productivity and the environment?
v. How and when are these micro-landscape used?
vi. How livestock movements are regulated in the landscape?
vii. How can you prevent your landscape from becoming unproductive/poor?
viii. What can you do to make unproductive/poor micro-landscape productive again?
ix. Can you think of any traditional practices that could help protect or restore degraded lands?

Appendix 3: University of Dar Es Salaam Research Clearance

UNIVERSITY OF DAR ES SALAAM
OFFICE OF THE VICE-CHANCELLOR
P.O. BOX 35091 ♦ DAR ES SALAAM ♦ TANZANIA

Ref. No: AB3/12(B)
Date: 29th October, 2010
To: The Regional Administrative Secretary,
Arusha Region.

UNIVERSITY STAFF AND STUDENTS RESEARCH CLEARANCE

The purpose of this letter is to introduce to you **Mr. Nyinondi, Philibet** who is a bonafide staff of the University of Dar es Salaam and who is at the moment conducting research. Our staff members and students undertake research activities every year especially during the long vacation.

In accordance with a government circular letter Ref. No. MPEC/R/10/1 dated 4th July, 1980 the Vice-Chancellor was empowered to issue research clearances to the staff and students of the University of Dar es Salaam on behalf of the government and the Tanzania Commission for Science and Technology, a successor organization to UTAFITI.

I therefore request you to grant the above-mentioned member of our University community any help that may facilitate him to achieve research objectives. What is required is your permission for him to see and talk to the leaders and members of your institutions in connection with his research.

The title of the research in question is **"Integrating Indigenous and Scientific Knowledge for Assessing Changes in the Semi-Arid Land Scape of Maasai Steppe Northern Tanzania".**

The period for which this permission has been granted is **October, 2010** to **November, 2010** and will cover the following areas/offices: **Arusha-Manyara Region.**

Should some of these areas/offices be restricted, you are requested to kindly advise him as to which alternative areas/offices could be visited. In case you may require further information, please contact the Directorate of Research, Tel. 2410500-8 Ext. 2087 or 2410743.

VICE CHANCELLOR
UNIVERSITY OF DAR-ES-SALAAM
P.O. BOX 35091
DAR-ES-SALAAM

Prof. Rwekaza S. Mukandala
Vice-Chancellor

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Website address: www.udsm.ac.tz

Appendix 4: Karatu District Council Research Clearance

JAMHURI YA MUUNGANO WA TANZANIA

OFISI YA WAZIRI MKUU

TAWALA ZA MIKOA NA SERIKALI ZA MITAA

MKOA WA ARUSHA.
Simu Na: 2534032.
Fax Na.2534469

Unapojibu tafadhali taja:

Kumb. Na. DC/KAR/c.10/9/Vol.III/83

OFISI YA MKUU WA WILAYA,
WILAYA YA KARATU,
S. L. P. 5,
KARATU.

13/01/2011

Mkurugenzi Mtendaji,
Halmashauri ya Wilaya,
S. L. P. 190.
KARATU.

YAH: "UNIVERSITY STAFF AND STUDENTS RESEARCH CLEARANCE"

Rejea somo hilo hapo juu.

Pamoja na barua hii pokea kivuli cha barua Kumb. Na. FA.195/232/01A/263 ya tarehe 8 Januari, 2011 kutoka kwa Katibu Tawala wa Mkoa wa Arusha ambayo inajieleza.

Kwa kuwa wahusika wanatarajia kufanya utafiti huo katika baadhi ya Kata na Vijiji (kwa maelezo yao), nawaleta kwako na kukuomba uwapokee na kuwapa ushirikiano watakaouhitaji kutoka katika Mamlaka yako ili waweze kufanikisha utafiti huo.

Nakushukuru kwa ushirikiano wako.

P. N. Nducha
KATIBU TAWALA WA WILAYA
KARATU

KATIBU TAWALA WILAYA
KARATU

Nakala: Bw. Philibet Nyinondi.

Appendix 5: District Executive Director Karatu Research Clearance

HALMASHAURI YA WILAYA YA KARATU

(Mawasiliano yote yaandikwe kwa Mkurugenzi Mtendaji)

Simu: +255 27 2534047
Fax: +255 27 2534300

E-mail:
karatucouncil@bushlink.co.tz

Idara ya Elimu (W),
S.L.P. 190,
Karatu,
Tanzania

Unapojibu tafadhali taja kumbukumbu nambari:
KDC/DED/C.5/4/VOL.I/05

Tarehe: 19/1/2011

- Watendaji wa Kata
- Watendaji wa vijiji

YAH: PHILIBERT NYINONDI

Husika na suala ilivyotajwa hapo juu.

Mtajwa ni Mwanachuo wa Chuo Kikuu cha Dar-es-Salaam na ameruhusiwa kufanya utafiti juu ya "Intergrating Indigeneous and Scientific knowledge for assessing changes in the semi-Arid land scape of Maasai Steppe in Northern Tanzania katika Wilaya yetu kuanzia tarehe ya barua hii.

Kwa barua hii naomba apewe ushirikiano unaostahili katika maeneo yetu.

M.Hallu
Kny Mkurugenzi Mtendaji (w)
Karatu

DISTRICT EXECUTIVE DIRECTOR
KARATU DISTRICT COUNCIL

Appendix 6: Monduli District Council Research Clearance

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA WAZIRI MKUU
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

MKOA WA ARUSHA
Simu Na: 2538002/2538078
Unapojibu tafadhali taja:

DC/MON/R.9/188

OFISI YA MKUU WA WILAYA,
WILAYA YA MONDULI,
S. L. P. 6,
MONDULI

20/01/ 2011

Maafisa Watendaji Kata,
Mswakini, Esilalei na Makuyuni,
Wilaya ya Monduli.

YAH: **UTAFITI**

Tafadhali husika na somo tajwa hapo juu.

Namtambulisha kwako Ndugu Philibet Nyinondi mwanafunzi wa Chuo Kikuu cha Dar es Salaam ambaye kwa sasa anafanya utafiti kuhusu **"Matumizi ya ujuzi wa Kienyeji na Kisayansi, kutathmini mabadiliko katika ikolojia kanda ya Kaskazini mwa Tanzania"**.

Tafadhali mpeni ushirikiano anaouhitaji.

Vivian B. Willium,
KNY: **KATIBU TAWALA WILAYA – MONDULI.**

Nakala: Mkurugenzi Mtendaji,
Halmashauri ya Wilaya,
MONDULI

" Afisa Tarafa,
MAKUYUNI.

Ndugu Philibet Nyinondi. ✓

Appendix 7: Sequence of Events in the Maasai Steppe

Era	Time	Major event in the landscape
Pre-colonial	< 18^{th} C	– Maasai pastoralists had moved in Maasai Steppe
	1880s	– Maasai at greatest extent – Maasai practiced communal land tenure system
Colonial (Germany)	1890s	– German colony (1884) – Outbreak of rinderpest devastating the Maasai herds – Outbreak of small pox and pleuro-pneumonia which killed many Maasai – Weaken Maasai raid by ancient enemies – Game Hunting law introduced in the land
	1910s	– World War I – Maasai regained livestock
(British)	1920s	– British colonial rule – Land Ordinance- all land belong to the Queen of England – Establishment of Game department (1921) – Tsetse expanded into the Maasai Steppe – Collapse of pastoral economy – Bush encroachments
	1940s and	– World War II – The law excluded pastoralists and their herds

	1950s	from the reserves, which resulted in loss of dry seasonal grazing land and watering points for livestock. – Wheat cultivation across the upper Makuyuni sub-catchment. – Colonial tsetse eradication programme involved clearance of bush and forests – In-migrating of Maasai from Serengeti – Establish of Serengeti National Park and Ngorongoro crater 1951 – Tarangire Game reserve established in1957 – Tanzania National Parks Ordinance (1959) cap 412
Post colonial (Independent)	1960s	– 1961 Tanganyika independent – Lake Manyara National Park gazetted – Arusha Declaration
	1970s	– Nation-wide programme of villagisation- Operation Vijijini and Maasai Range Development Project restricted dry-wet grazing system forcing the Maasai into village ranching.
	1980s to date	– Liberalisation in the economic – Population growth due to immigrants and expansion of agriculture.

Appendix 8: The Maasai Traditional Landscape Classification in the Study Area

Landscapes name	Descriptions	criteria
i. *Ayarata engeju*	*Ayarata* are narrower dry river valleys characterized by shallow soils. The main cause of soil erosion is water runoff. The *engeju* are deep valleys usually found on the banks of major seasonal river valleys. In maa, *engeju* means 'an arm' attributing this to the branching of the main valley, which feeds into the latter during the rainy season. The landscape is subjected to vertical erosion, forming gullies with shallow soils.	Landform
ii. *Engusero ondinyika*	The name means the valley of arid scrub, grazed during wet season.	Landform
iii. *Engusero losteti*	The landscape is located in the valley of the river Losteti and is grazed during dry season. Indigenous vegetation includes: Orkujitaibo and Esilalei.	Landform
iv. *Olalili Ololukoti*	This is the calf pasture reserve for settlements located at the bottom of the western Rift wall. The landscape is set aside for calf grazing during the dry season.	Land use
v. *Oit ekituma*	The name of the landscape means a forested patch dominated by Oit (Acacia spp). The landscape is grazed during the dry season. Indigenous vegetation includes: Oit, Esilalei, Olkilorit, Engapur and Orkujitonyokie.	Dominant vegetation
vi. *Olalili*	This is a calf pasture reserve in the swampy area. The	Land use

Orng'arua	landscape is used in dry seasons only. Indigenous vegetation includes: Olndiolo, Oseyai and Engaiteteya.	
vii. *Omeserani*	This is an upland landscape dominated by Baobao plant species. The landscape is grazed year-round and includes a livestock corridor to and from water points. Indigenous vegetation includes: Orkujitaibor, Baobao, Esilalei, and Orkujitonyokie.	Dominant vegetation
viii. *Nembirika*	The landscape shaped like a basin and grazed during wet seasons.	Landform
ix. *Arukung'o*	The landscape refers to the crest of the undulating terrain characterized by the presence of brownish soils called *orukokoto engulkok*. The soils subjected to constant downwash during rain seasons.	Soil colour
x. *Engusero*	The *engusero* micro-landscapes appear as troughs formed by seasonal river valleys or stagnating rainwater. The landscapes are characterized by deep (usually black or dark brown) loamy soils called *engulkok narok*. The areas support thick bush cover and may serve as depositional sites for the eroded materials from the surrounding hills.	Landform
xi. *Orng'arua*	The name of the landscape implies a swampy area. The soils are greyish in colour with high salt content. Indigenous vegetation includes: Orng'osua and Oloigoroing'ok. This area is used during dry seasons	Landform

	only.	
xii. Ololukoti	The name means a high table land. The landscape is used both for grazing and settlement.	Landform
xiii. Loseye	The landscape is dominated by Oseyei grass species and grazed during dry season by both livestock and wild animals. Indigenous vegetation includes: Oseyei, Enyaru, Oligoroing'ok and Orpau.	Dominant vegetation
xiv. Oloudo	The landscape name means upland and is grazed during dry season. Indigenous vegetation includes: Olaisikirai, Olonyoro and Olaisai	Landform

Appendix 9: Alphabetic List of Key Plant Species in the Maasai Steppe Landscape: Identified By Maasai Herders

S/No	Maa Name	Scientific Name
1.	Alaisai	Sericocomopsis spp
2.	Alaisai II	Sericocomopsis spp
3.	Alamereruani	
4.	Alemele rwagi	
5.	Alovara	
6.	Alumla	
7.	Aramanyalai	
8.	Arasekerai	Heliotropium steudneri
9.	Aripalakai	Brachiaria deflexa
10.	Armagiririani	Acacia brevispica
11.	Arpakwa	Brachiaria deflexa
12.	Aringabol	Ficus sycomorus
13.	Asangari	Digitaria diagonalis
14.	Ebisa/oloyapasei	Aspilia mossambicensis
15.	Eimimi	Indigofere erecta
16.	Eiti	Acacia mellifera
17.	Elikalie	
18.	Embalababa	Brachiaria deflexa
19.	Emborokwai	Melhania sp.
20.	Emborokwai ekop	Melhania sp.
21.	Emborokwai engujenebo	Melhania sp.
22.	Emberepapa	
23.	Emirua	cynadon dactylon
24.	Emurua ekopi	Cynadon spp
25.	Endejani	Cissus quadrangularis
26.	Endamejoi	
27.	Endamunywa	
28.	Endemerwa	
29.	Endepesi	Acacia tortilis

30.	Enderepenyi	Setaria verticillata
31.	Endulele	Solanum incanum
32.	Endunduru	Dicrostachys cinerea
33.	Enemela	
34.	Engaisijoi	
35.	Engaiteteyai	Commelina benghalensis
36.	Engalduu	
37.	Engapumbu	
38.	Engapuru	
39.	Engarishiriti	
40.	Engasee munyi	
41.	Engoju	
42.	Enguruishash	Barleria eranthemoides
43.	Enjani bosi	
44.	Erikaru	
45.	Erube	Themeda triandra
46.	Esilale engailopai	Commiphora schimperi
47.	Esilale	Commiphora Africana
48.	Esube	
49.	Ilugalu	
50.	Iring'onom	Cyperus distans
51.	Lekihi	
52.	Lekiushi	
53.	Leluhesidai	
54.	Lesekerai	
55.	Lolondo	Sida ovata
56.	Lubehe	
57.	Magigilia	Acacia brevispica
58.	Moswai	
59.	Nyatwata	
60.	Oindiang'ohom	
61.	Olngaboli	Ficus vallis-choudae

62.	Oldupai	Echinochloa colona
63.	Oleduarai	
64.	Olekikereta	
65.	Olekitolee	Scabdoxus multifluros
66.	Olemuran	
67.	Olesite	
68.	Oliamunywa	Ocimum suave
69.	Oliboboli/olibolibo	
70.	Olikile yabore	
71.	Olingonomi	Abutilon hirtum
72.	Olipileidong'oe	
73.	Olkalei	
74.	Olmesera	Adansonia digitata
75.	Olmukutani	Ekebergia capensis
76.	Olmukutani	Albizia anthelmintica
77.	Ologoriang'oki	Hyperrhenia colina
78.	Ologoroeng'oleo	
79.	Olohondo	Cyphostemma serpens
80.	Oloinori kipa	
81.	Oloisijoi	Tamarindus indica
82.	Oloisikirai	Heliotropium steudneri
83.	Olokikidomile	
84.	Olonyoro	
85.	Olopiki donkoye	
86.	Olopit/ olonyeyeni	
87.	Olopito	
88.	Oloswa	
89.	Oloyenai	
90.	Olremit	Salvadora persica
91.	Olupadule	
92.	Omuluwa	Cynodon plectostachyus
93.	Ondorko	

94.	Onyoki	
95.	Orgoronyoko	
96.	Orikitario	
97.	Oring'eriandosi	
98.	Orkereyani	Acrocerus macrum
99.	Orkitario	
100.	Orkojuto ionyoke	Themeda Triandra
101.	Orperesi	Aspilia mossambicensis
102.	Oseyei	Scirpus maritimus
103.	Osinon	Lippia javanica
104.	Urukurusashi	Barleria eranthemoides