ECONOMIC VALUATION OF RANGELAND MANAGEMENT PRACTICES IN THE PASTORAL SYSTEM OF TANA RIVER COUNTY, KENYA

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DEDICATION

This thesis is dedicated to my family for the moral support they gave me throughout my studies.

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ACRONYMS AND ABBREVIATIONS

ASAL:	Arid and Semi-Arid Land
CBA:	Cost Benefit Analysis
CVM:	Contingent Valuation Method
DCE:	Discrete Choice Experiment
FAO:	Food and Agriculture organization of the United Nations
FGD:	Focus Group Discussion
GoK:	Government of Kenya
IGO:	Inter-Governmental Organization
ILRI:	International Livestock Research Institute
IPCC:	Intergovernmental Panel on Climate Change
IRR:	Internal Rate of Return
IRR:	Internal Rate of Return
IUCN:	International Union for Conservation of Nature
KCSAP:	Kenya Climate Smart Agriculture Programme
MNL:	Multinomial Logit Model
NDMA:	National Drought Management Authority
NPV:	Net Present Values
PSA:	Participatory Scenario Analysis
RPL:	Random Parameter Logit Model
RUT:	Random Utility Theory
SWAT:	Soil Water Analysis Tool
TCM:	Travel Cost Method
TEV:	Total Economic Value
TEV:	Total Economic Value
UK:	United Kingdom
UON:	University of Nairobi
WRUA:	Water Resource User Association
WTA:	Willingness to Accept
WTP:	Willingness To Pay

ABSTRACT

Economic valuation of rangelands has been recognized as an important tool that can help decision-makers evaluate the tradeoffs between the social welfare losses of inaction and the net welfare gains of alternative actions against rangeland degradation. This points to the need to consider natural capital in decision-making on rangeland use. Both market value and simulated market approaches were used to emphasize the economic value of rangeland-based ecosystems and highlight the economic benefits of sustainable rangeland management in Tana River County, Kenya. The study focused on the economic analysis of pastoralists' preferences for rangeland management practices, the economic values attached (welfare impacts) to the preferred rangeland management practices, and the determinants of their adoption, as well as the socio-economic factors influencing the willingness to pay for sustainable rangeland management.

The findings of the study indicate that pastoral communities derive positive utility from connected systems that enable reciprocal access to resources in both wet and dry seasons. Pastoralism adapts to the spatial and temporal variability of pasture and water through herd mobility; hence, the positive utility derived from practices that contribute to the availability of adequate water and pasture across the seasons. Interventions aimed at achieving sustainable rangeland management should therefore consider enabling mobility as a management strategy. The results show that pastoralists would prefer to have a rangeland system in which: there are adequate water pans to harvest and store water; there is a dry season grazing reserve; overgrazing is limited to avoid degrading the grazing fields; and there is enough forage yield and water for the animals. Because livestock production is a viable source of livelihood for pastoralists in tropical rangelands, they were willing to pay more to have enough water and pasture for their animals. Membership in community groups, income, and the main source of livelihood had a higher influence on the willingness to pay.

Regarding the adoption of various sustainable rangeland management practices, such as soil and water conservation practices, the results demonstrate that the adoption process has a social element and involves collegial interactions. Pastoralists require technical know-how and skills, capital, and organizational support for the successful adoption and use of water harvesting systems. It is therefore important to design and develop alternative, effective policy instruments and mechanisms, strong institutional options for extension services, technical assistance, training, and capacity building that will facilitate the adoption of rangeland practices through participatory practices to ensure a better fit to the needs of pastoralists.

These findings demonstrate that ecosystem services, despite typically being outside of markets, have a significant economic value in the rangelands. As a result, analyses of the benefits and costs of the rangeland options are biased toward development over conservation, and planning efforts miss potential win-win areas and associated opportunities to finance conservation of rangeland resources in innovative ways. It is therefore important to ensure that both ecosystem services and biodiversity conservation are incorporated into decision-making to an extent that is commensurate with their importance. This would provide concrete arguments as to why stewardship of rangeland biodiversity is crucial to pastoral livelihoods, thereby reducing rangeland degradation.

Not all factors were, however, included in the economic valuation and assessment of this study due to limitations of time, capacity, and capital. For example, the value of rangelands in carbon sequestration was not included, although this is an important ecological service. However, the valuation of carbon sequestration requires time series data and not a static data set, which would not have been possible during the short period of the survey. These estimates need to be included in the economic valuation of rangelands and remain a key area in need of further research.

CHAPTER ONE:

INTRODUCTION

1.1 Background information

The inherently unpredictable rainfall and frequent droughts in the tropics have resulted in the deterioration of rangeland resources, leading to forage and water shortages that negatively impact the livelihoods of pastoral communities (Western et al. 2021). The situation is compounded by the rising demand for products from rangelands and a shrinking natural resource base, orchestrated by factors such as land tenure, land use changes and conflicts. The result is rangeland degradation that is made worse by climate change, leading to a loss of services from land and land-based ecosystems that are necessary for pastoral livelihoods and economic development in these areas (Western and Mose, 2020). Communities in the rangelands are dependent mainly on pastoralism, small-scale crop farming, and ecotourism (Muricho et al. 2017). Pastoralism, which is characterized by extensive livestock production, is highly dependent on the availability and accessibility of water and grazing resources, which are sparsely distributed within such expansive areas. Crop production, on the other hand, is highly sensitive to weather and climate-related hazards, including drought and floods, which contribute to soaring food insecurity (IPCC, 2014).

Rangelands face various land resource management challenges, all of which have an impact on their capacity to adapt to the effects of climate variability and change (Mugo et al. 2020). These challenges stem from a combination of policy, governance, and economic factors that have gradually resulted in a land tenure context where uncoordinated and unsustainable land-use practices are currently being observed. When combined with the effects of climate change, these threaten the future of sustainable management of resources and livelihoods in the rangelands. Food production, water availability, energy security, and other services provided by intact ecosystems are jeopardized by the ongoing loss of rangeland and soil productivity. Climate change adds another layer of risk to this precarious situation. Its impacts threaten to exacerbate the existing land degradation problem and add to the vulnerability of the drylands' inhabitants unless significant measures are taken to improve management of the natural resource base. To restore the degraded rangelands and enhance their productivity, it is important to maintain their ecological resilience and the stability of rangeland ecosystem services while providing sustenance and diverse livelihoods for the pastoral communities. The context of sustainable rangeland management practices is constantly shifting with changing environments, populations, and demands. A proper understanding of the economic value of rangelands, complemented with an understanding of the drivers of rangeland degradation and the enabling environment, can inform the development of policies and incentives to identify and support positive practices that can be adopted. Despite the increasing knowledge on the biophysical contexts of rangeland degradation, such as the mapping of the extent of degradation occurrence, it has been known that there is a significant knowledge gap about the environmental and economic benefits generated from the adoption of sustainable rangeland management and the value of rangelands as well (Constanza et al. 2016).

Valuing rangeland services requires an understanding of two main things: the rangeland components, functions, and processes that produce valuable services and how these services translate into benefits (Westerberg, 2016). Therefore, valuing various approaches to sustainable rangeland management not only helps to reveal the benefits of rangeland management practices but is also crucial in guiding policies, decisions on development intervention, and resource allocation. Valuing sustainable rangeland management in the drylands further provides information on the sustainable practices that support pasture production and livestock productivity, which both have a direct bearing on the livelihoods of the populations living in these areas (Keeler et al. 2012).

Economic valuation involves the process of recognizing rangeland goods and services, quantifying them, and valuing their multi-functionality (Pagiola et al. 2004). Therefore, the exclusion of socio-cultural and non-market economic services in the valuation of rangeland ecosystems normally results in an underestimation of their economic importance (Favretto et al. 2016). It is therefore important to evaluate the social and economic facets of the rangeland ecosystem that are impacted by various management practices implemented in rangelands to understand their economic value. Economic valuation of rangeland practices helps assign monetary value to goods and services provided by various rangeland management interventions. This involves the use of market prices for resources with direct use that are traded in markets, as well as derived prices for the indirect uses and functions of rangelands (Kelemen et al. 2014).

Although there is extensive literature on the economic importance of rangelands, very little includes the valuation of both the use and non-use values of rangelands. Where it does appear, rangelands tend to be undervalued, mainly due to three reasons. One is the fact that most analyses are restricted to a specific sector, most commonly livestock production; secondly, some analyses are biased towards one marketed product, such as milk, beef, or pasture; and lastly, some analyses are limited to use values, which mostly have a market price. This results in an undervaluation of rangelands that may lead to inappropriate policy recommendations and prescriptions for rangeland management.

Several studies have assessed the total economic value of extensive or mobile pastoralism in national (Nyariki and Amwata, 2019; Casas Nogales and Manzano Baena, 2007), regional, and global (Davies and Hatfield, 2007) economies, focusing on both market and non-market values. Research at the regional or sub-national level has used discrete choice experiments to assess the values attributed by respondents (pastoralists and local stakeholders) to different land uses (Mazzocchi and Sali 2019). Other studies have used data from surveys to compare the economic performance of different extensive and intensive production systems using a variety of methods and metrics, such as technical efficiency (Shomo et al. 2010), benefit-cost ratios (Qtaishat et al. 2012), and relative profitability based on partial budget analyses (Legesse et al. 2005). Findings from these studies offer mixed evidence on the economic benefits of rangelands. They focus only on goods and services that can be merchandised in the market and have quantifiable costs, disregarding rangeland services and functions for which markets do not exist. For those products from the rangelands whose markets exist, there is often undervaluation (Favretto et al. 2016). Besides, the market price of some traded rangeland goods may not reflect all the costs incurred in their production (Constanza et al. 2016).

The economic value of any resource is measured in terms of what the consumers of that resource are willing to pay for it, less the costs incurred to supply it (Kelemen et al. 2014). However, in most cases, the costs of supplying rangeland resources are close to zero, so the consumers' willingness to pay for the rangeland resource (goods or services) is ordinarily considered its net value (Constanza et al. 2016). The basic principle behind this is that ecosystem services can have either a positive or negative value and may arise intentionally or unintentionally from the various management practices (Favretto et al. 2016). Understanding the economic and social values of ecosystem services from management practices in rangelands is therefore central to making investment decisions and determining the feasibility of management practices. This study focused on the economic value of management options that sustainably enhance the delivery of essential ecosystem goods and services in pastoral systems. The aim was to estimate the economic value of rangeland management practices by specifically analyzing pastoralists' preferences for rangeland management practices, the economic values attached to effective rangeland management practices and determinants of their adoption, as well as the socio-economic factors influencing the willingness to pay for rangeland management.

1.2 Statement of the problem

The arid and semi-arid lands in Kenya are experiencing increasingly unpredictable rainfall and frequent droughts, attributed to climate change. This has resulted in feed and water shortages, which negatively impact livestock productivity and therefore undermine food and income security in pastoral areas. Various management practices have been put in place to address rangeland degradation and promote sustainable rangeland use options. However, typical tools traditionally used for assessing rangeland use options or the consequences of changes in rangeland use with a view of informing policymakers, such as land use planning and environmental impact assessments, do not take ecosystem services and the costs and benefits associated with them into account. Other forms of assessment have also focused on physical rather than monetary changes.

Rangelands have long been valued solely for the market price of pasture, livestock, or similar commodity-based market values. Yet, the services that rangeland ecosystems provide are now understood to include not only those that have market values but also those that have non-market values that contribute to the rangeland economy and social well-being of pastoral communities, albeit in less direct ways such as flood control and ecotourism. Including non-market valuation is critical to inform decisions on resolving rangeland degradation through economic tools, as many of the rangeland benefits do not have a direct market value. Using objective metrics like economic values provides a way to compare the trade-offs of alternative future options or scenarios and thus deliberate on rangeland issues from an equally informed position.

Therefore, information on the economic analysis of pastoralists' preferences for rangeland management practices and the welfare impacts of the preferred rangeland management practices is crucial in guiding policies, decisions on development intervention, and resource allocation. Precise appraisal of rangeland goods and service values permits the integration of unquantified values into principal decision-making frameworks, such as cost-benefit analysis and impact assessments, along with the costs and benefits that are easily quantifiable financially. The findings of this study therefore make it easier to discern the value of various practices by determining their benefits as well as costs, which can improve the effectiveness of decisions about the proper use of rangelands.

1.3 Justification of the study

The ecosystem services of rangelands are usually undervalued, and the potential economic contribution of range management practices is underestimated (Favretto et al. 2016). More often, only those goods and services that are traded in the market and have quantifiable costs are considered in the valuation of the importance of rangeland practices (Kelemen et al. 2014). This shows a disregard for those services and functions for which markets do not exist (Lambert, 2003).

The failure to include social and economic non-market values in decision-making processes often leads to underestimating their net benefits and, therefore, inappropriate allocation of resources and investments in the management and conservation of natural resources (Loomis et al. 2000). Assessments of land use and changes in land use in Tana River County, as well as landscape-level inventories of ecosystem services, have led to a review of current grazing and rangelands management practices and how they affect ecosystem services related to water, forage, and biodiversity (ILRI, 2016). The characterization of grazing management practices in Tana River County has not been done to economically assess trade-offs associated with different ecosystem practices, their services, and human well-being. This study analyzed the impact of rangeland management practices on the pastoral community by conducting an economic valuation of range management practices geared towards improving livestock production among pastoral communities.

Information on the economic value of rangeland resources not only provides incentives for these values to be incorporated into decision-making processes but also assists in generating additional financing for conservation by identifying significant gainers from rangeland conservation. Incorporating economic analyses into local and watershed-level decision-making could improve decision-making and management to enhance ecosystem services from rangelands. The characterization of rangeland practices and the determination of pastoral preferences for them provide information on rangeland management practices that are acceptable, ecologically suitable, and therefore appropriate for the welfare of pastoral communities.

Furthermore, this contributes to the knowledge of pastoral ecosystems and livelihoods in Africa and the diverse interactions between human activities and the natural environment. Sustainable land management is emphasized in objective 15 of the Sustainable Development Goals (SDGs), which aim at achieving land degradation neutrality as well as the integration of ecosystems and biodiversity values into national and local planning. On an international level, the United Nations Convention to Combat Desertification (UNCCD) was appointed as the custodian agency for SDG 15.3, and by developing economic arguments, this study complements the work of the scientific and technical committee of the Convention.

1.4 Broad objective

The general objective of the study was to evaluate the economic value of rangeland management practices in pastoral systems to inform sustainable rangeland use and management at local and landscape scales in Tana River County.

1.5 Specific objectives

The specific objectives of this study were to:

1. Characterize the existing rangeland management practices in pastoral areas of Tana River County.
2. Analyse the economic value attached to the rangeland management practices by pastoral communities.
3. Determine factors affecting the adoption of sustainable rangeland management practices.
4. Determine the socio-economic factors that influence the willingness to pay for rangeland management practices by pastoral households.

1.6 Research questions

The study provided answers to the following research questions.

1. What are the existing rangeland management practices in pastoral areas?
2. What are the economic values derived from sustainable rangeland management practices?
3. What factors determine the adoption of sustainable rangeland management practices in pastoral ecosystems?
4. What are the socio-economic factors that influence pastoralists' willingness to pay for sustainable rangeland management?

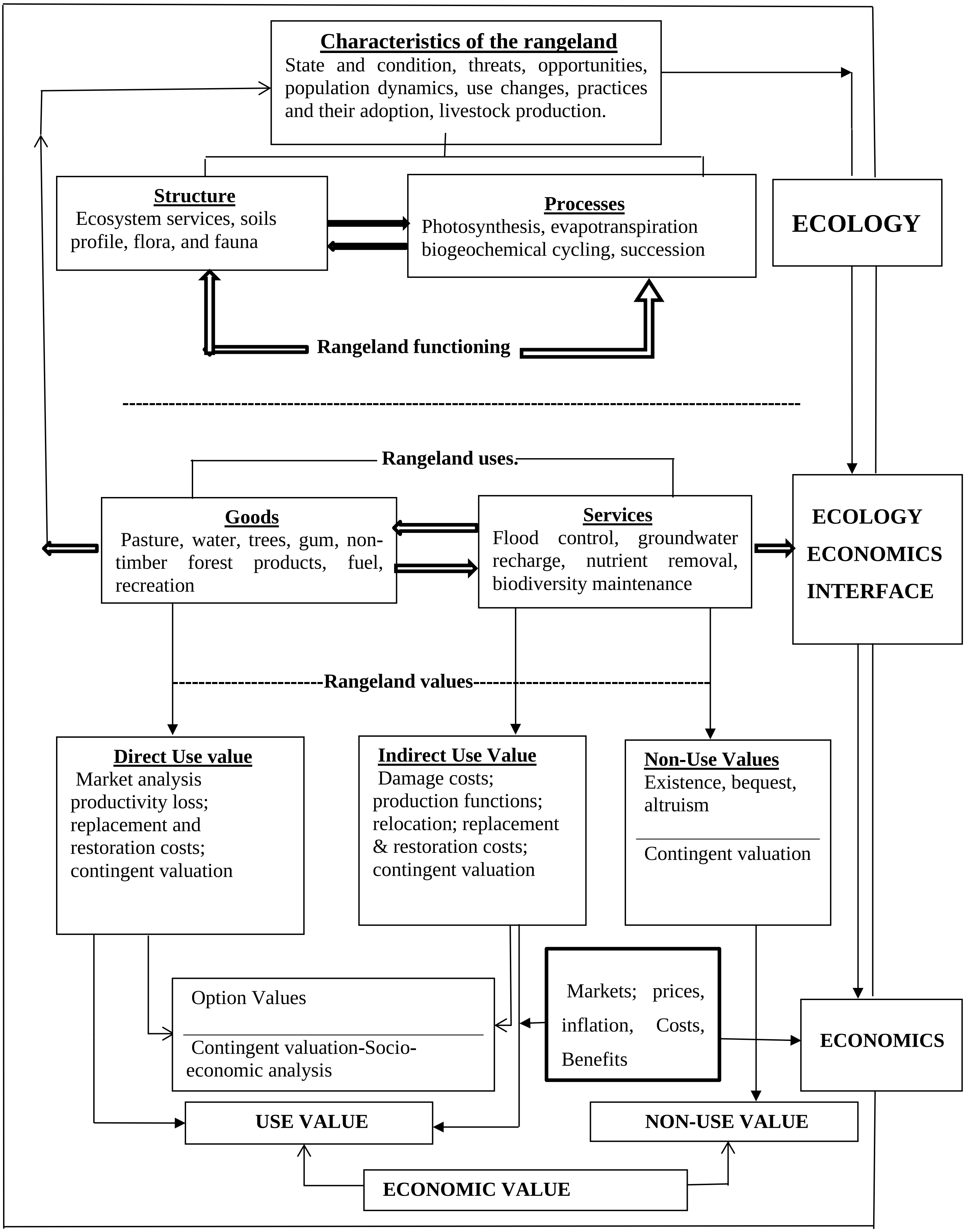
1.7 Conceptual framework

The most used framework for identifying, categorizing, and valuing environmental goods and services is the Total Economic Valuation (TEV) framework shown in Figure 1 (Lambert, 2003; Hirji et al., 2002). Total economic valuation is an important method of assessing the value of rangeland goods and services in monetary terms. According to Lancaster's consumer theory, a good is valued by the package of its attributes (Lancaster, 1966). A TEV framework helps to identify the different attributes of rangeland goods and services and their use values, such as providing forage and water, as well as their non-use values, such as providing habitat for various plants and animals, as shown in Figure 2.According to Fromm (2000) and Wasonga (2013), the total economic value framework ensures that all use and non-use values of rangeland practices are recognized, which prevents double counting of values in empirical analysis whenever multiple valuation methods are used. The TEV approach is also suitable for valuing ecosystem-based adaptation options, specifically where cost-benefit analysis (CBA) is a challenge in determining the ecosystem-based adaptation options to be selected. In this case, TEV complements CBA by highlighting the productivity of an ecosystem in economic terms.

It is important to capture the total value of the benefits generated by various practices to quantify them in monetary terms and compare them against the costs associated with them (Chiuta et al. 2002). The TEV takes into consideration the ecological functions, subsistence, and non-market values of rangeland goods and services. Besides, TEV discloses the economic costs associated with rangeland degradation (Emerton, 2003).

The total economic value of any rangeland management practice has two main values: use values and non-use values (Brander et al. 2006). The use values are derived from the actual use of goods or services and are composed of direct use values, indirect use values, and option values (Favretto et al. 2016). The non-use values are divided into three components: the bequest values, the altruism values, and the existence values (Carlsson et al., 2003; Emerton, 2003).

Direct use values are derived from direct use activities, and they can be easily traded on the market, hence having a market value. Indirect use values are derived from indirect uses such as carbon sequestration, reduced sedimentation and erosion, and low evapotranspiration. Option values result from the choice of using a good or a service sometime in the future, either directly or indirectly. Altruism and bequest values stem from the desire of a person to have a good or a service for others to benefit from it, even if the person professing the value does not use the goods or services themselves (Costanza et al. 2016, Kelemen et al. 2014). In the case of altruistic values, the desire is for others in the current generation to benefit from the resource, while bequest values reflect the preference for future generations to benefit from the resource. Existence values are depicted when a person has no actual or planned use of the resource or for anyone else but would want to maintain the existence of that good or service. In the context of rangelands, this often relates to the protection of rare or endangered species of flora and fauna provided by rangelands as habitat (Lambert, 2003). For a holistic valuation of rangelands, it's important to consider other aspects affecting rangeland productivity, such as the state and condition of the rangelands, threats to the productivity of rangelands, and socioeconomic aspects affecting the adoption of some of the sustainable practices.



Source: Adapted from Lambert, 2003

Figure 1 Conceptual framework for economic valuation of rangelands

CHAPTER TWO

LITERATURE REVIEW

2.1 Rangeland ecosystems

2.1.1 Extent and importance of rangelands

Rangelands include all those environments in which natural ecological processes predominate and where values and benefits are based primarily on natural resources that have not been intensively developed for primary production (Nielsen et al. 2020). Rangelands make up about 41.3% of the world's land surface and 43–45% of Africa's land surface (Mgalula et al., 2021). They provide critical ecosystem services in primary production, soil carbon storage, and nutrient cycling (Sankey et al., 2021).

The arid and semiarid ecosystems occupy approximately 30% of the global terrestrial land (Provencher et al., 2023) and are predominantly used for livestock production, mainly through pastoralism. In sub-Saharan Africa alone, 25 million pastoralists and 240 million agro-pastoralists depend on livestock for their primary income (FAO, 2009). Rangelands, though professed by many as of low significance, have supported people's livelihoods, which has resulted in the rising recognition of their contribution to global food security (Roche, 2021).

In terms of ecological significance, rangeland vegetation protects fragile soil profiles, is a catchment for major rivers, and provides habitat for wild animals and plants (Angerer et al., 2023). Besides the above-ground carbon stored in grasses, trees, and shrubs, rangelands stock up to thirty percent of the global soil carbon (Mgalula et al., 2021). Due to the spatial-temporal variability of rainfall and other climatic factors, crop production is not a sustainable economic activity in the rangelands, making livestock production the main viable source of livelihoods in these ecosystems (Bolo et al. 2019). Despite the economic and ecological contributions of rangelands, there is considerable undervaluation of rangeland resources due to a lack of knowledge of these resources, which have indirect uses and non-marketed services (Maher et al., 2021). This has resulted in inadequate investment in the conservation of rangelands (Constanza et al. 2016; Kelemen et al. 2014).

The foregoing literature points to the need for information on the economic and social value of rangelands to be incorporated into decision-making processes at the policy level in support of rangeland conservation. This will provide information on the sustainable practices in the rangelands that support pasture production and livestock productivity, which have a direct bearing on the livelihoods of the populations living in the rangelands.

2.1.2 Challenges in pastoral production systems

Pastoralism is a low-external-input subsistence system based primarily on livestock production. The system is grounded in the strategic exploitation of resources that are not uniformly distributed in space and time (Nyariki and Amwata, 2019). The spatio-temporal variability in water and pasture availability influences the mobility and settlement patterns of pastoral communities, leading to the development of pastoralism as the most suitable livelihood in arid and semi-arid areas (Sobania, 2019).

Pastoralists are confronted with a variety of risks that constantly disrupt their livelihoods and devastate their assets (Wasonga, 2016). These risks, coupled with limited and increasingly ineffective risk management options, underlie vulnerability in pastoral systems. Some of the challenges facing pastoral communities include land tenure changes, land fragmentation, heat stress, pests and diseases, a diminishing grazing resource base, and frequent droughts that undermine pasture and livestock productivity (Mwangi et al. 2020). The movement of livestock herds is a central component of rangeland management (Sobania, 2019). However, mobility has been compromised due to declining access to rangeland resources occasioned, among others, by the loss of grazing land to agriculture, poor watering point management, conflicts and insecurity arising due to the breakdown of traditional institutions, and social change necessitated by changing human aspirations and economic needs (Janzen, 2020). These challenges undermine rangeland productivity and therefore the ability of pastoral communities to cope with the challenges of complex and dynamic ecosystems (Liao et al. 2020).

For a long time, pastoralists have used various adaptive and flexible risk management strategies and resilience enhancement mechanisms to maintain their lifestyle (Ndiritu, 2021). Some of these strategies include pasture deferral which includes grazing restrictions near water points during the wet season by having wet and dry season grazing areas, maximizing stocking densities to ensure biomass threshold below which grazing is not allowed to avoid overgrazing, livestock species diversity which involves keeping mixed species of animals such as browsers and grazers to maximize the scarce resources, splitting of herds into satellite herds that graze and browse far away from the homesteads and home-based herds which involve lactating animals and young ones that graze within homesteads, and livestock redistribution among friends and relatives as an insurance (Oba, 2012; Wasonga et al. 2016).

Having proper management of water points, preventing degradation and overgrazing, and preserving dry season grazing areas has a positive effect on biomass yield and water storage capacity, which traditionally benefit the community across the seasons (Huho et al. 2011). Unfortunately, due to changes in policies, increases in human population, and changing lifestyles, a number of these strategies are becoming increasingly constrained, thus affecting the pastoral production system (Liao et al. 2020). For the proper management of rangelands, studies have shown that it is therefore important to understand the topical issues affecting rangelands and how the challenges faced by the rangelands can be handled through proper rangeland management.

2.2 Economic valuation of management options

Economic valuation of rangeland resources can be defined as the process of quantifying the goods and services that rangelands provide in monetary terms (Barbier, 2007). Valuing rangeland services requires an understanding of the rangeland components that produce valuable services and how these services translate into benefits (Westernberg, 2016). Precise appraisal of the value of rangeland goods and services permits the integration of unquantified values into principal decision-making frameworks such as cost-benefit analysis and impact assessments, along with the costs and benefits that are easily quantified financially (Lambert, 2013). This makes it easier to discern the value of various practices by determining their total costs and benefits, which results in more effective decisions about the proper use of rangelands (Favretto et al. 2016).

While there has been an increasing tendency to determine the economic value of rangelands' goods and services, there remain data gaps in the valuation of non-market goods and services, which results in an incomplete valuation of the costs and benefits associated with various management practices. Most studies involved in the economic valuation of rangeland practices have been short-term and therefore have not been able to exhaustively evaluate the economic benefits resulting from these practices (Kelemen et al. 2014). According to Xie et al. (2016), there are similar challenges in assessing the costs and benefits of adaptation practices, specifically with regards to ecosystem-based adaptations and their associated benefits.

One of the challenges faced in the economic valuation of rangeland resources is that attaching monetary value to natural resources is a complex process because most of them do not have a structured market for those services and benefits, which complicates the process. This has resulted in the undervaluation of rangelands, especially for services that are not traded in markets and are therefore not considered in the decision-making processes of rangelands (Constanza et al. 2016). Valuation methods start with utility—the satisfaction that one gets from the ecosystem goods and services provided by rangelands (Torell et al. 2013). In the valuation of preferred management practices, dynamic cost-benefit models are used to estimate the economic value of goods and services that are not traded on the market but are important to human welfare (Westernberg, 2016).

The dynamic cost-benefit models determine the economic and financial benefits over the period of existence for the preferred practices (Mukama, 2010). The resultant measures used in appraising the preferred practices are the net present value (NPV) and the internal rate of return (IRR) (Entem, 2013). The net present value is used to determine the feasibility of a management practice by adjusting the costs incurred and the benefits accrued to the effect of time and the opportunity cost of capital (Gollier, 2010). The internal rate of return, on the other hand, is the discount rate at which the net present value is equal to zero. Therefore, should the NPV be negative, and the IRR be less than the discount rate, then the rangeland management practice is considered non-viable compared to the next best alternative, but when the IRR is greater than the discount rate, then the practice is more appropriate to capitalize on (Pritchett, 2013).

According to Entem (2013), the dynamic cost-benefit models measure the efficiency of the projects over a given period. The analysis measures private returns for the project itself, those for the community alone, and those at the national level. Income from the perspective of the community is measured by subtracting the subsidies provided by the government and donor organizations from a cross-section of the cost-benefit models (Pritchett, 2013). The expenditures on the community financial analysis are calculated as the initial expenditures minus the subsidies on expenditures, resulting in the estimation of the community financial internal rate of return (IRR) and net present value (NPV), thus indicating the profitability or attractiveness of the investment from a community's perspective (Entem, 2013). The costs and benefits are subjected to foreign exchange and tax adjustments to derive the overall economic costs (Chee, 2004).

2.3 Methods for economic estimation of ecosystem goods and services

Approaches used for estimation of the value of goods and services to avert the challenges of market price distortions can be categorized into market value approaches, surrogate market approaches, and simulated market approaches.

2.3.1 Market value approaches

This refers to the non-demand-based methods that estimate the cost incurred from an increase or decrease in environmental quality. The increase in costs leads to a decrease in quantity supplies for a given demand associated with an increase in the economically optimal price. This means the market value approach measures the change in welfare associated with the change in the cost of provision. This includes replacement costs, damage costs avoided, mitigation costs, opportunity costs, and market prices.

The replacement costs approach applies when goods and services do not have actual market value but may have alternatives that can be purchased or sold, meaning that if the services are not available, they can be replaced by other means. These costs can be used as a proxy for rangeland resources and ecosystem values (Emerton, 2003). The mitigation or avertive costs approach involves the cost of restoring damaged resources to their original state or avoiding economic damage and is used as an indicator of costs avoided when rangeland resources are conserved. The value-added approach applies when the resource provides an input that does not have a price in the production process (Turpie et al. 2006). Therefore, it is possible to ascertain how much this input contributes to production at the local and national levels, the latter being gross domestic product, for example, the contribution of rangelands to livestock production.

2.3.2 Surrogate market approaches

This refers to the demand-based revealed preference methods that deduce value from market behavior. They do not involve changes in income levels and rely on existing payments or costs incurred. The surrogate market approaches mainly capture use values but not non-use values because they rely on existing surrogate markets. This includes the hedonic price and travel cost methods. The hedonic pricing method assumes that a difference in environmental quality can be valued through property prices (Hirji et al. 2002). This method assesses the differences in prices and wages between locations and isolates the proportion of this difference that can be attributed to the existence of the goods and services afforded by rangeland systems (Emerton, 2003). The method considers the observed prices contained in the characteristics of each good or service, which gives an insight into the implicit value placed on the characteristics that make up these services and goods. The travel cost method (TCM) measures the value of the resource through the travel costs and considers the people's willingness and ability to pay to use the natural resource (Hirji et al. 2002). The higher the amount the consumer is willing to spend on traveling to a certain site, the higher the value of that resource.

2.3.3 Simulated market approaches

These are the demand-based stated preference methods used to capture the value of environmental goods and services. They involve people directly stating how much they would be willing to pay for an increase in the provision of an environmental good or service or how much they would accept for a decrease in the provision of a good. The simulated approaches and stated preference methods can be used to capture both the use and non-use values of a good or service because they rely on people stating their preferences rather than expressing them in actual markets. They include contingent valuation methods and the choice experiment method.

The contingent valuation method (CVM) and direct market valuation are often used to value the use and non-use values of rangelands. The contingent valuation technique is used to determine the values of non-market goods and services resulting from rangeland practices. Contingent valuation surveys are used to determine the values of such services or goods resulting from management practices that give utility even when they are not sold in markets (Bartlett et al. 2002).

The CVM determines the maximum amount a person is willing to pay for a resource and the minimum amount they would be willing to accept (WTA) to forgo the resource (Loomis et al. 2000). CVM analysis examines this trade-off, considering an individual's underlying utility function. In neoclassical economic theory, the economic value of an ecological good or service is determined when people are willing to pay for it or accept compensation to forego it (Farber et al., 2002; Chee, 2004).

Using the utilitarian approach to ecosystem service valuation, willingness to pay reveals preferences for the good or service. The total willingness to pay for society is the aggregate WTP for everyone. This is usually also a measure of the total economic benefit of the practice (Chee, 2004). Different individuals in society may have different purchasing power and, hence, varying willingness to pay due to various socio-economic factors.

Table 2.1 Quantitative evaluation methods, their applications, and constraints

No.	Valuation method	Types of values estimated	Application	Constraints
1	Market Price Method	Direct Use values	Value derived from law of supply and demand	Market imperfections (subsidies, lack of transparency) and policy distort the market price.
2	Damage Cost Avoided, Replacement Cost or Substitute Cost Method	Indirect Use Values: avoided erosion, pollution control, water retention	The value of animals that would be lost due to feed shortages, value of supplements to be bought (substitute cost). The value of disease control if migrations would occur (damage cost avoided).	It is assumed that the cost of avoided damage or substitutes match the original benefit. But many external circumstances may change the value of the original expected benefit and the method may therefore lead to under- or overestimates.
3	Hedonic Pricing Method	Some aspects of Indirect Use, Future Use and Non-Use Values	Used when values influence the price of marketed goods. Large surface of water or forage increase will increase grazing permits fee	Captures people's WTP for perceived benefits only. If they are not aware of the link between the environment attribute and the benefits to themselves, the value will not be reflected in the price.
4	Contingent Choice Method	For all goods and services	Estimate values based on asking people to make trade-offs among sets of ecosystems or environmental services.	Does not directly ask for WTP as this is inferred from trade-offs that include cost attribute.
5	Contingent Valuation Method	Non-Use Values	Asks people directly how much they would be willing to pay for specific environmental services.	Various sources of possible bias in the interview techniques. Controversy over whether people would pay the amounts stated in the interviews.
6	Benefit Transfer Method	Ecosystem services in general and recreational uses in particular	Estimates economic values by transferring existing benefit estimates from studies already completed for another location or context.	Extrapolation can only be done for sites with the same gross characteristics
7	Productivity Method	Specific goods and services: water, soils, humidity	Estimates the economic values for products or services that contribute to the production of commercially marketed goods	Only works for some goods or services

Source: Adapted from Lambert (2003); Barbier (1996); King and Mazzota (1999)

The market price will therefore just be the total measure of the benefit from the good or service less the consumer surplus, which is indicated by the total amount that consumers are willing and able to pay for a good or service less the total amount that they do pay at the market price (Amigues et al. 2002; Loomis et al. 2000).

The gross willingness to pay is therefore the market price plus the consumer surplus. Investments in natural resource improvement depend on the nature and magnitude of the social and economic benefits the investment brings to society and individuals. Willingness to pay (WTP) has therefore been used as a proxy indicator for the incentives accruing from social benefits. Studies have shown that social benefits provide the incentives for public and private investments in natural resource management as well as public and private goods and services (Alemu-Mekonen, 2000; Grebitus et al., 2013). Table 2.1 presents a summary of the most common quantitative evaluation methods used and their constraints and limitations.

2.3.4 Choice experiment

Studies such as Birol et al. (2006), Rolfe et al. (2000), Sayadi et al. (2005), Zander and Straton (2010), Scarpa et al. (2008), Layton and Brown (2000), and Poirier and Fleuret (2010) have used discrete choice experiments to value environmental goods and services. According to Ruto et al. (2009), discrete choice experiments (DCE) are based on stated preferences since they bring about information regarding individuals' preferences of environmental goods and services through the construction of a hypothetical, but realistic, market relating to the development or deterioration of rangeland conditions rather than on preferences of goods and services revealed from the actual behaviour of individuals. In discrete choice experiments, respondents are presented with several choice sets containing different alternatives relative to rangeland management options (Hanley et al. 2001). They are then requested to select their preferred alternative from the choice sets. A discrete choice experiment allows for the use of combinations of either qualitative or quantitative attributes (Otieno, 2011). The flexibility in the use of attributes of different natures is the main advantage of using discrete choice experiments in the economic valuation of rangeland practices (Kuhfeld, 2005).

A baseline or status quo scenario, which shows the conditions as they are on the ground without any intervention, is often incorporated in the choice set as an alternative; this allows those who want the change in the intervention to retain the current situation to choose no change. This baseline scenario allows those respondents who are satisfied with the status quo to select neither of the proposed alternatives without being forced to change (Hanley et al. 2001), which helps the results obtained in the analysis to be more consistent with demand theory (Ruto et al. 2009).

The advantage of using discrete choice experiments is the possibility of estimating the economic value for each attribute of the grazing management rather than estimating the values for the whole grazing management regime. The contingent valuation method (CVM) gives a single value for a whole grazing regime, while discrete choice experiments provide values for every attribute of the grazing management regime (Louviere et al. 2000), therefore making it possible to estimate the value of each individual attribute for grazing management practices.

Discrete choice experiment methods allow the estimation of the values of different goods that share a common set of attributes to be put together using the results of a single multinomial logit model (Alpizar et al. 2003). It is therefore a cost-effective method that allows for the estimation of both use and non-use values, especially when numerous alternative proposals need to be measured. According to List et al. (2006), the discrete choice experiment helps to solve the problem of using contingent valuation methods that result in 'yea saying' and lexicographic responses, which occur when individuals do not make trade-offs between the attributes and choose based on only one attribute. The 'yea saying' occurs when the respondents appear to accept what the interviewer says even when they have their own true opinions and views, which leads to biased estimation of value and reduced sensitivity to scope. CVM is not also suited for multiple options (Otieno, 2011), as a typical CVM presents respondents with only two alternatives to choose from, the alternative against the status quo.

Discrete choice modelling is less prone to such limitations as CVM because respondents are given more choice sets, each containing the status quo, which is the baseline, and two to three proposed alternatives (Bennett and Blamey, 2001). They then select one alternative they prefer in each choice set. The levels of the attributes that characterize the different alternatives are varied according to an experimental design that permits estimates of the relative importance of the attributes describing the options to be obtained. Focusing on the differences in the levels of the attributes helps as well to prevent the incidence of yea-saying and associated biases (Alpizar et al. 2003). Monetary values for each attribute can easily be determined using the discrete choice experiment when the cost attribute is included in the design. This makes discrete choice modelling better suited for multiple options than the CVM. Therefore, when respondents make their choice of any alternative they prefer, they implicitly make trade-offs between the levels of the attributes of the grazing management regime from the different alternatives in a choice set (Carlsson et al. 2003).

CHAPTER THREE

VALUATION OF RANGELAND MANAGEMENT PRACTICES: DISCRETE CHOICE MODELLING IN THE PASTORAL SYSTEM OF TANA RIVER COUNTY, KENYA

Abstract

This chapter presents an economic analysis of pastoralists' preferences for various management practices and the economic value pastoralists place on them. The study applied the discrete choice experiment technique using a D-optimal design and a multi-attribute preference elicitation method to evaluate the economic value of rangeland management options used in pastoral areas of Kenya. The results showed that pastoral communities derive positive utility from connected systems that enable reciprocal access to resources in both wet and dry seasons. Pastoralism adapts to the spatial-temporal variability of pasture and water through herd mobility, hence the positive utility derived from practices that contribute to the availability of adequate water and pasture across the seasons. These findings provide empirical evidence on the social and economic net benefits of rangeland management practices that should be enhanced to promote sustainable management of rangeland resources.

Key words: Discrete choice experiment; economic values; grazing management; pastoralism; welfare values

3.1 Introduction

Rangelands, primarily comprised of savannas and shrublands, are found mainly in arid and semiarid zones, which cover about 41% of the global landmass (UNCCD, 2006). In Africa, rangelands make up 43% of the total land surface area, while in Kenya, rangelands constitute approximately 80% of the land mass and support over 70% of the livestock population. African rangelands are characterized by low, spatially, and temporally variable rainfall in addition to hot temperatures, leading to high levels of evapotranspiration. Given the scanty vegetation cover found in most rangelands in Africa, they also experience high runoff leading to floods (Mwangi and Dohrn, 2006), especially during heavy storms, which make them more susceptible to degradation (Reid et al., 2008).

Regardless of their climatic limitations, rangelands are socio-economically and ecologically important. They offer a variety of ecosystem goods and services with direct and indirect economic and social benefits to their inhabitants. Specifically, because these areas support the livelihoods of over 40% of the world's population (De Jode, 2009), there is growing recognition of their importance in meeting the basic needs of their inhabitants as well as global food security (Mortmore et al. 2009). In terms of ecological significance, rangelands provide habitats for wildlife, and as observed by Lund (2007), they also act as water catchments for various river systems. Besides, rangelands are also important areas for the storage of about 30% of world soil carbon (FAO, 2009). This implies that sustained higher levels of investment in the management of semi-arid areas can immeasurably support enhanced productivity and better incomes.

A fundamental transformation in management practices as well as better dissemination of knowledge, improved land-use technologies, and access to urban markets have the potential to sustainably enhance production and livelihoods in these areas. Investments in rangelands have largely focused on enhancing livestock production by increasing forage production. This is because livestock production in arid and semi-arid areas is an important source of household food and income and provides an important avenue for employment, especially when proper grazing and rangeland management practices that enhance productivity are put in place (Thornton, 2010).

To enhance livestock production and protect rangelands from degradation, various practices have been put in place to promote sustainable management of rangeland resources. Some of these practices have not been able to produce the desired levels of productivity and thus have failed to improve the welfare of the pastoral communities or prevent rangelands from deteriorating (Macleod and Brown, 2014; Torell et al., 2013).

An important contributing factor to the failures of range management practices is the paucity of comprehensive information on the socio-economic value of the impacts of these rangeland management practices (Costanza et al. 2016). The management of rangelands requires many decisions that would be facilitated by an understanding of the pastoralists' preferences on the practices to be included in rangeland management plans. Failure to include social and economic nonmarket values in decision-making processes may lead to undervaluing the net benefits of rangeland practices, which affects allocations of investments in conservation and ultimately leads to their degradation (Kelemen et al. 2014).

This study employed the discrete choice experiment (DCE) method (Louviere, 2001) to investigate pastoralists' preferences for various rangeland management options and their economic value. A DCE is a stated preference approach that can be used to value non-marketed goods and services (Garrod et al. 2014; Scarpa et al. 2003). Modeling pastoralists' choices allowed evaluation of how they would trade-off different levels of management attributes, as described in Lancaster's theory of consumer choice (Lancaster, 1966), which suggests that consumers derive their satisfaction from the attributes of a good and not just from the good per se.

3.2 Methodology

3.2.1 Study area

The study was conducted in Tana River County, Kenya, which is one of the six counties in the coastal region of Kenya. It borders Kitui County to the west, Garissa County to the northeast, Isiolo County to the north, Lamu County to the southeast, and Kilifi County to the south. It lies between latitudes 000’53" and 200’41’’ South and longitudes 38025’43" and 40015’ East and has a total area of 38,862.2 km2 and covers about 76 kilometers of the coastal strip. The county is composed of three administrative sub-counties, namely, Bura, Galole, and Tana Delta, and three constituencies, namely, Galole, Bura, and Garsen.

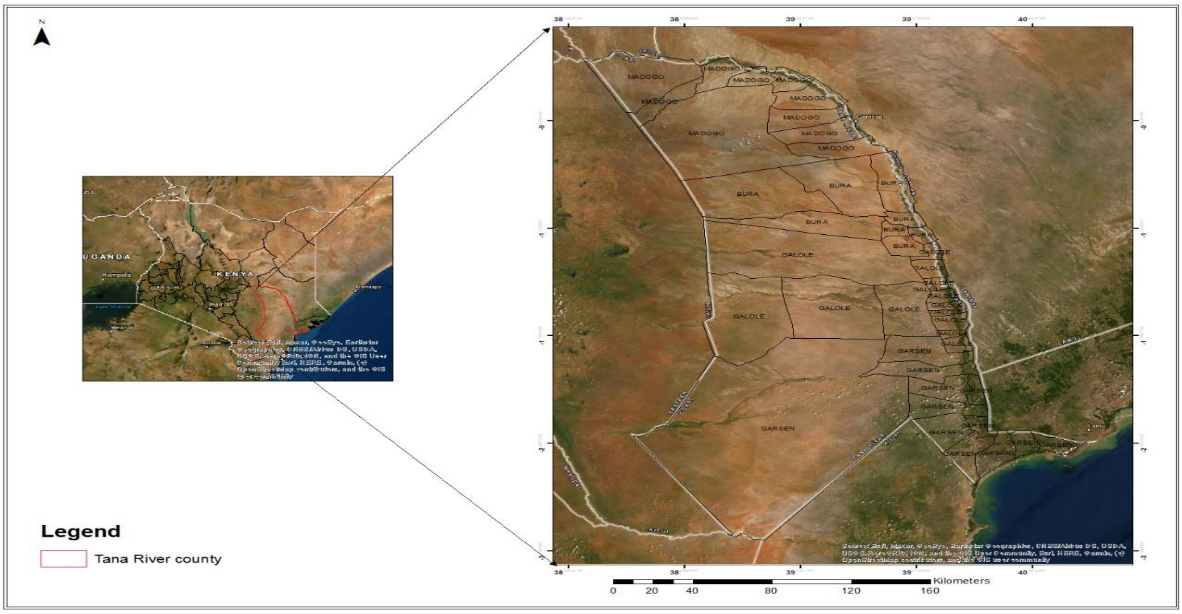


Figure 2: The study area

Tana River County has arid and semi-arid climatic conditions. The region experiences a hot and dry climate within agroecological zones ranging from III in the very highlands to VII in the plains or lowlands. Average annual temperatures are about 300 °C, with the highest being 410 °C around January–March and the lowest being 20.60 °C around June–July (Kipchirchir, 2014). Rainfall is low, bimodal, and erratic in nature. The total annual rainfall ranges between 220 mm and 500 mm, with long rains occurring in April and May and short rains in October and November, with November being the wettest month (Kipchirchir, 2014). The Inter Tropical Convergence Zone (ITCZ), which influences the wind and non-seasonal air pattern for the river Tana, determines the amount of rainfall along the river line.

The soils range from sandy, dark clay, and sandy loam to alluvial deposits. The soils are deep around riverine environments but highly susceptible to erosion by water and wind. Soils in the hinterlands are shallow and have undergone seasons of trampling by livestock; thus, they are easily eroded during rainy seasons. Vertisols or black cotton soils contain a high content of expanding lattice clays that exhibit swelling and shrinking features upon wetting and drying, leading to the formation of deep, wide cracks from the surface downward upon drying and sometimes undulating microtopography (Kipchirchir, 2014; Andersson, 2005).

The main vegetation cover in Tana River consists of very open shrubs (23%), open to closed herbaceous vegetation on temporarily flooded land (15.6%), very open trees (10.3%), sparse shrubs (8.3%), open shrubs (7.5%), and trees and shrubs (7.3%). Cropland is about 2.1%. The largest changes in land cover are the loss of closed forest (closed trees), water bodies, and open trees (Mwangi and Swallow, 2008). Tana River County is inhabited by the Orma, Wardey, and Pokomo ethnic communities, with a projected population of 276,567 (KNBS, 2014). The Ormas and Wardeys are nomadic pastoralists, while the Pokomo are agro-pastoralists who settle along riverbanks where they undertake small-scale subsistence farming (Kipchirchir, 2014). With the introduction of irrigation schemes, the landless farmers have been permanently settled in the schemes. The schemes have also attracted other external settlers, mainly farmers from other communities. Generally, permanent settlements are along the river Tana, irrigation schemes, and small urban centers (Allison & Badjeck, 2004).

3.2.2 Study Design

This study used a discrete choice experiment (DCE) design to determine the economic value of rangeland management practices. The use of a discrete choice experiment approach has been widely used to determine the economic values of the effects of various environmental interventions (Hanley et al. 2001; Hanley et al. 2006; Scarpa et al. 2003). Discrete choice experiments are based on stated preferences since they bring about information regarding individuals' preferences of environmental goods and services through the construction of a hypothetical, but realistic, market rather than on preferences of goods and services revealed from the actual behavior of individuals (Garrod et al. 2014; Ruto et al. 2009). The DCE technique is centered on random utility theory and the characteristics theory of value (Lancaster, 1966), which postulate that utility derived from consumption of goods is determined by the attributes of the goods and not the goods themselves. The decision to use a DCE approach for this study was driven by the desire to estimate values for different component parts of rangeland management practices. The component parts constitute the attributes of the DCE design. To construct the design, management practices were decomposed according to their attributes (or characteristics), and the combination of various levels of this set of attributes resulted in a scenario of change in environmental quality.

It is possible to determine the welfare estimates for a combination of attribute changes by making one of the attributes a price or cost term. This helps to estimate the marginal utility, which is used to determine the willingness-to-pay estimates for changes in attribute levels (Ruto et al. 2006). The discrete choice experiment designs can be categorized into two types: full factorial designs and fractional factorial designs. An experimental design in which all possible combinations of the levels of all attributes are provided to the respondents for a choice design is called a full factorial design (Kuhfeld et al. 2005). The full factorial design allows one to estimate all the main effects and interactions. Main effects refer to the independent influence of a change in the levels of one attribute on the choice decision given the average levels of other attributes (Otieno, 2011). Interaction effects show how a choice decision varies with a change in the levels of some attributes in a choice set, holding one attribute at a constant level. A full-factorial design allows for uncorrelated estimation of all the main effects as well as the interactions among the choices. However, using a full-factorial design is practically expensive and taxing to have all the respondents consider all possible combinations. This study used the fractional factorial design, particularly the orthogonal design.

Fractional factorial designs have fewer choices and less cognitive burden. Only a limited number of measurable attributes and their levels—not more than four or five levels—are included in the fractional factorial design (Kuhfeld et al. 2005). The orthogonal design is the widely used fractional factorial design that minimizes the correlation between the attribute levels in the choice situations. The orthogonality of an experimental design relates to the correlation structure between the attributes of the design, which ensures that the attributes are statistically independent (Scarpa and Rose, 2008). It is easier to use the orthogonal experimental designs to independently determine the contribution of each specific attribute to the variations of the dependent variable (that is, the choices observed). Rose and Bliemer (2009) suggest that it is important to have designs that are statistically efficient in terms of predicted standard errors of the parameter estimates rather than just looking at the correlation between the attribute levels. This results in an efficient design that essentially maximizes the information from each choice situation.

3.2.3 Rangeland management practices and their attributes

As required in the construction of the DCE design (Scarpa et al. 2003), the most important component attributes of the management options and scenarios used in the design of this study were identified by the local community members, which included community leaders, government officials of Tana River County, and representatives of water resource user associations, through focus group discussions. A total of six focus group discussions (FGD) were conducted to investigate pastoralists' attitudes towards rangeland management practices and to get information on the features of the rangeland scenarios that are important to them. The choice of attributes and levels was also based on a combination of evidence from the literature and information from focus group discussions with pastoralists at all the study sites. The rangeland management practices, and their attributes included:

- Regulation of grazing by designating wet and dry season grazing areas: The grazing ban in areas near the permanent water points at the peak of the wet season was meant to preserve them for dry season grazing. During the wet season, when forage is plentiful, grazing animals are to be moved far away from the permanent water points and only come back during the dry season. This would take either two months (the shortest duration of grazing animals away from the dry season grazing areas) or six months (the longest duration of grazing away from the permanent water points used as the dry season grazing areas).
- High-intensity, short-duration grazing alternated with long rest periods: Maximizing stocking density to ensure a forage threshold below which grazing is not possible to avoid overgrazing and land degradation. In this regard, pastoralists are to ensure that grazing livestock exert maximum impact on the pasture and soil in a particular area for the shortest time possible and allow ample time for the grazed pasture to regenerate before grazing again. Keeping animals in one place for the shortest duration of less than two days would be considered a high threshold; five days would be a medium

threshold; and keeping animals for more than a week would be considered a low threshold.

- Construction of additional water pans: The construction of additional water pans in the wet season grazing areas is necessary to ensure that animals do not return to the permanent water sources situated in the dry season grazing areas before the right time. In this regard, there are only two options: whether to construct more water pans in the wet season grazing areas or not.
- Increased biomass yield and more water availability are the outputs of improved rangeland management. Construction of additional water pans, preventing degradation and overgrazing, and preserving dry season grazing areas would have a positive effect on biomass yield and water availability in the grazing areas. Water pans capture and store more rainwater that often runs off. This would benefit the community and provide pasture and water across the seasons.

According to Scarpa et al. (2003), it is possible to determine the welfare estimates for a combination of attribute changes by including price or cost as one of the attributes. This enables the estimation of willingness-to-pay for changes in attribute levels (Ruto et al. 2009). Therefore, in addition to the selected attributes, a monetary attribute (price level) was included in this design to enable the calculation of welfare measures. Currently, in each community in the study site where there is a water pan, each household contributes 50 Kenyan shillings per month, which translates to 600 shillings (six US dollars) per annum.

The money was meant to pay the personnel guarding the water pan and ensure that it is well maintained. During the FGDs, the members agreed that given the addition of forage yield and more water in the water pans to accommodate all the households in the community, they would be more willing to pay an addition of either ten or twenty-five shillings per month. This therefore informed the price levels of 720 and 900 Kenyan shillings per annum, respectively, in this design. The common attributes for the grazing management practices identified in the focus group discussions held in study areas that were used in this design are shown in Table 3.1.

Table 3.1 Grazing management attributes used in DCE

	Management attribute	Description	Levels
1	Construction of additional water pans	Construction of additional water pans in the wet season grazing areas	No Yes
2	Forage threshold below which grazing is not allowed	The minimum amount of forage below which grazing is restricted to allow grazed pasture to regenerate after use.	High threshold Medium threshold Low threshold
3	Grazing ban near water points in wet season	Grazing ban near permanent water points during the peak of the wet season to reserve pasture for dry season grazing	Two months ban Six months ban
4	Increased forage production	Amount of forage produced	High forage production Medium forage production Low forage production
5	Increased water availability	Water availability in the water-pans and more infiltration into the soil	More water Less water
6	Annual grazing fee	Annual fee paid by households for membership in the use of grazing areas	KSh.600 KSh.720 KSh.900

To reduce the D-error and increase sampling efficiency, a two-stage design procedure was used to maximize D-optimality (Bliemer and Rose, 2010). The first stage involved a preliminary survey of 60 respondents in Galole, Bura, and Garsen sub-counties of Tana River County to obtain coefficients that were then used to generate an efficient design in the second stage. The efficient design generated in the second stage had a relatively good level of D-optimality (D-efficiency measure of 82%) and a good utility balance (B-estimate of 81%), which according to Otieno (2011) indicates that there was an insignificant likelihood of dominance by any alternative in the choice situations. The final design had 24 paired choice profiles that were randomly blocked into six sets of four-choice tasks.

Each respondent in the study area was randomly assigned to one of the six sets and asked to choose the most preferred option in each choice task. Each choice task had two alternatives (A and B) and the baseline or status quo (C), as shown in Table 3.2. A baseline/status quo scenario that showed the conditions as they were on the ground without any intervention was incorporated in the choice set as an alternative. This allowed those respondents who were satisfied with the status quo to select neither of the proposed alternatives without being forced to change, which, according to Hanley et al. (2001) and Ruto et al. (2009), helps the results obtained in the analysis to be more consistent with demand theory. Only the attributes presented in the choice set were considered in the choices made by the respondents during the survey. They were asked to consider each choice set independently of the others. An experimental design software called NGENE was used to generate the design (Choice Metrics, 2009). Adequate information was provided to enable respondents to understand the DCE exercise and be able to make independent and reliable choices in each situation based on their preferences. Each respondent was presented with a series of choice sets, randomly chosen from one of the six blocks of choice sets from the DCE design and asked to choose the most preferred option in each case.

Table 3.2 A choice set used in the DCE design.

Grazing management attributes	**Alternative A**	**Alternative B**	**Alternative C**
Construction of water pans	Yes	No	No addition
Biomass threshold to stop grazing	High	Medium	No threshold
Grazing ban in the wet season	Six months	Two months	No grazing ban
Forage yield	Lower yield	Medium yield	No extra forage produced
Water availability	Less water storage capacity	More water storage capacity	No influence
Annual membership fee (Ksh)	600	900	No membership fee
Which alternative do you prefer?			

3.2.4 Data collection

A multistage sampling procedure was used to determine the sample size. Three sub-counties, namely Bura, Galole, and Garsen, inhabited by agro-pastoralists and nomadic pastoralists, were purposefully selected in the first stage of sampling. The second stage involved systematic random sampling to select five locations from each sub-county, giving a total of 15 locations from which sampling was done. This procedure was repeated in the third stage by narrowing down to two smaller administrative units (sub-locations) within each location using the systematic random sampling technique, giving a total of 30 sub-locations. A formula by Orme

(1998) shown in Equation 1 was used to compute the appropriate sample size for the study, taking into consideration the projected number of households of the selected sub-locations.

$$N = 500\ x\ (\frac{L}{J\ X\ T}) \quad \ldots\ldots (1)$$

Where N is the sample size; L is the largest number of levels for any of the attributes, J is the number of choice alternatives; and T is the number of choice situations in the design. In this study where L= 3, J =3 and T = 5, the sample size was 100 respondents per Sub- County. Given the three sub-counties the total sample size was 300 respondents (100*3 sites). Data was collected through household surveys involving face-to-face interviews.

3.2.4 Data analysis

Each respondent was presented with a series of M = 4 choices. In each choice set, a respondent faced a choice between J = 2 alternatives of rangeland management plus a status quo. In each scenario (choice set), respondents were asked to choose between two management alternatives allowing for a status quo. The status quo represented the respondent's current feasible choice set. This is important in interpreting the results in standard welfare economic terms (Hanley et al., 2001). Therefore, the attributes of alternative *i* in choice situation *t* faced by individual *n* are collectively labelled as a vector $X_{int.}$ Revelt and Train (1998) give the specification of the utility derived by person *n* from alternative *j* as follows:

$$u_{nj} = \beta_n X_{nj} + \varepsilon_{nj} \quad \ldots\ldots (2)$$

Where X_{nj} are the observed variables that relate to the alternative and the decision maker, β_n, a vector of coefficients of these variables for person n representing that person's tastes and ε_{nj} is a random term that is *iid* extreme value (for simplicity, the subscript t for choice situation is suppressed). The coefficients vary over decision makers in the population with density $f(\beta_n/\theta)$.

This density is a function of parameters θ that represent the mean and covariance of the β's in the population.

The value of β_n and ε_{nj} are only known to the decision maker for all j alternatives and chooses alternative i if and only if $U_{ni} > U_{nj}\ \forall_j \neq i$. The probability that individual n chooses alternative i conditional on β_n, is given by the standard Multinomial Logit Model (MNL) as follows:

$$L_{ni}\ (\beta_n) = \frac{e^{\beta_n X_{ni}}}{\sum_j e^{\beta_n X_{nj}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Let $i\ (n)$ denote the alternative chosen by individual n in choice situation t. The probability of individual n's observed sequence of choices (conditional on β_n) is the product of the MNL with the assumption that the individual tastes, β_n, do not vary over choice situations in repeated choice tasks (although are assumed heterogeneous over individuals):

$$G_n\ (\beta_n) = \Pi\ L_{ni}\ (\beta_n) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Thus, the choice probability follows the expression**:**

$$P_n\ (\theta) = \int G_n\ (\beta_n)\ f\ (\beta_n / \theta)\ d\beta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

The expression in equation (5) above has two sets of parameters. The β_n is a vector of parameters that are specific to individual n (representing individual tastes, which vary between respondents) and θ are parameters that describe the distribution of the individual specific estimates.

The main objective of random parameter logit (RPL) is to specify the function f (β_n / θ) and estimate the parameter θ. The estimation of the parameter θ is done through simulation of the choice probability. This is attributed to the fact that the integral equation cannot be computed analytically due to its mathematical closed form (Train, 2003).

The log-likelihood function is specified as:

$$LL\ (\theta) = \sum_n \text{Ln } P_n\ (\theta) \qquad \text{...} \ (6)$$

The $P_n\ (\theta)$ is approximated by a summation over randomly chosen values of β_n. For a selected value of parameter θ, a value of β_n is drawn from its distribution and $G_n\ (\beta_n)$ representing the product of the standard MNL, is computed. Repeated calculations are done for several draws and the average of $G_n\ (\beta_n)$ is considered as the approximate choice probability.

The average is the simulated probability given by:

$$SP_{ni}\ (\theta) = \frac{1}{R}\sum_{r=1}^{R} Gn\ ({\beta^r}_n) \text{...} \ (7)$$

Where R is the number of draws and SP_{ni} (θ) is unbiased estimator of P_{ni} (θ) by construction. The P_{ni} (θ) is twice differentiable in the parameter θ and variable x, which facilitates numerical search for the maximum likelihood function and the calculation of elasticities. Then, the simulated probabilities are inserted into the log-likelihood function to give a simulated log-likelihood (*SLL*) function given as

$$SLL\ (\theta) = \sum_n \ln(Sp_n\ (\theta)) \qquad \text{...} \ (8)$$

The estimated parameters are those that maximize *SLL (h)*. Trade-offs between rangeland management attributes and money, i.e., the marginal willingness to pay (WTP), is computed as (Hanemann, 1984):

$$WTP = -1 \text{ X } (\frac{\beta_k}{\beta_p}) \quad \ldots\ldots (9)$$

Where β_k is the estimated coefficient for an attribute level in the choice set and βp is the marginal utility of income given by the coefficient of the farmer's membership fee (cost attribute). The marginal WTP (implicit price) for a discrete change in an attribute provides a measure of the relative importance that respondents attach to attributes. The results were derived from the analysis of the choices made by the respondents on the rangeland management profiles, which formed the dependent variable and the attributes described in Table 3.3 as the independent variables.

Analysis of all interviews from the focus group discussions, key informant interviews and the workshops was undertaken to provide a clear understanding of the rangelands. Transcriptions were analyzed using the principles of interpretative phenomenological analysis (Khawaja et al. 2008). Analyses were undertaken using NVIVO and involved two major stages. Employing an ideographic case study mode, transcripts were first read and coded using themes that emerged in each interview. The second stage of analysis involved taking a nomothetic approach to identify connections between the emergent themes identified in the first stage. Where connections were noted, themes were clustered into superordinate categories. Transcripts were then reread to ensure that such superordinate themes reflected the respondent's initial meaning. Group extracts from across the data were examined according to the new themes using the software. Shared themes were explained and illustrated using quotes from the texts. To measure the inter-rater reliability of the analysis, 10% of the data was randomly selected and examined by an independent rater to identify themes. These themes were then matched with those identified by the first rater. Cohen's kappa (Cohen, 1968) was used to calculate inter-rater agreement for the analysed themes. A kappa value of 0.91 ($p < .001$) indicated good agreement.

Table 3.3 Description of variables used in the choice analysis.

Variable	Description
WATERPAN	Construction of additional water pans in the wet season grazing areas (1= Yes, 0= Otherwise)
BIOTHRESH	The minimum amount of forage below which grazing is restricted to allow grazed pasture to regenerate before grazing (Low, medium, High threshold)
GRAZBAN	Grazing ban near permanent water points during the peak of the wet season to reserve pasture for dry season grazing (1 = Six months, 0 = two months)
BIOHIGH	High amount of forage yield (1 = Yes 0 = Otherwise)
BIOMED	Low amount of forage yield (1 = Yes 0 = Otherwise)
MOREWATE	More water available in the water-pans and more infiltration into the soil (1 = Yes 0 = Otherwise)
COST	Annual fee paid for using grazing areas (KSh.600, KSh.720, KSh.900)

3.3 Results

3.3.1 *Random parameter estimates for rangeland management attributes.*

Table 3.4 presents the maximum likelihood estimates for the RPL model for rangeland management practices. To estimate the WTP and avoid the possibility of getting extreme negative and positive trade-off values, the utility parameters for all attributes except the cost attribute, which was specified as fixed, were treated as random variables assuming a normal distribution (Revelt and Train, 1998).

The results of the RPL model had a log likelihood function of -160.04 and a pseudo-R^2 of 0.46. According to Louviere et al. (2000), values of R^2 between 0.2 and 0.4 are indicative of extremely good model fit equivalent to the range of 0.7 to 0.9 found in linear functions such as the stated choice ordinary least squares regression applications. A log likelihood ratio-test confirms that the RPL model provided a better model fit to the data compared to the conditional logit model. The results of the model in Table 3.4 indicate that all the mean coefficients of the attributes investigated are statistically significant ($\chi2$ =2316, 15df, $p < 0.00$).

The parameter estimate for annual membership fee was significant ($P < 0.01$) with a negative sign implying that community members were more likely to choose the profile or participate in the rangeland management practices that have more benefits to them at a lower cost. The negative sign allowed computation of trade-offs between each attribute and money. The coefficients in Table 3.4 show that the parameter estimate for more water levels is of greater magnitude than the rest of the parameter estimates for all the other attributes followed closely by the high biomass yield. The model therefore predicts a higher probability of pastoralists selecting a profile with rangeland management practices that will ensure more water storage capacity for the community as well as the biomass yield that will be able to sustain their livestock. All the random parameters estimates are strongly significant indicating that the means of this parameter estimates are statistically different from zero. Since this are random parameters, the results suggest the existence of heterogeneity in the parameter estimates that may be different from the sample population mean of the parameter estimates of these attributes. The standard deviations for the coefficients of all attributes are significant which means there are, heterogeneous preferences for these attributes.

Table 3.4 Random parameter estimates for sustainable management attributes.

Choice	Coefficient	Std. error	95% confidence interval	
WATERPAN	4.70***	1.01	1.20	8.26
LOWBIOTH	-3.14**	1.56	-8.15	-.073
MEDBIOTH	.4780*	3.58	-6.53	7.49
GRAZBAN	2.89**	1.37	5.62	6.13
BIOHIGH	10.57***	2.86	3.97	15.18
BIOMED	9.58*	3.07	4.3	16.37
MOREWATE	18.77***	5.79	7.04	29.75
COST	-.00627***	.00214	-.01047	-.00207
	Standard deviations of parameter distributions			
WATERPAN	13.98**	5.57	3.06	24.89
LOWBIOTH	5.83**	2.31	1.29	10.36
MEDBIOTH	3.89*	2.42	-.85681	8.65079
GRAZBAN	8.16***	2.78	2.70	13.63
BIOHIGH	0.01307***	3.01	-5.89	5.92
BIOMED	3.896*	2.425	-0.865	8.65
MOREWATE	7.02**	2.95	1.24	12.81
Log-likelihood	-160.47			
Pseudo-R^2	0.4651			
N respondents	300			
N choices	1200			

Statistical significance levels: ***1%, **5% and *10% respectively

The estimated means and standard deviations of the coefficients was used to determine the proportion of the population that places a positive value on a particular attribute and the proportion that places a negative value on it (Train, 2003) as shown in Table 3.5. Majority of the respondents placed a positive value on high biomass (100%) production and availability of more water (99.63%). However, 70.49% placed a negative value on low biomass threshold to stop grazing which was used as a proxy for high grazing pressure that is likely to result in overgrazing. A proportion of 63.16% of the respondents would prefer addition of water pans while 63.84% placed a positive value on the grazing ban around the water points in wet season to reserve them as dry season grazing areas.

Table 3.5 Preference shares of grazing management attributes

Attribute	Mean	Std. Dev.	Negative share (%)	Positive share (%)
WATERPAN	4.70	13.980	36.84	63.16
LOWBIOTH	-3.14	5.830	70.49	29.51
MEDBIOTH	0.48	3.89	45.11	54.89
GRAZBAN	2.89	8.160	36.16	63.84
BIOHIGH	10.57	0.013	0.00	100.00
BIOMED	9.58	3.896	0.70	99.30
MOREWATE	18.77	7.020	0.37	99.63

3.3.2 Economic values of the attributes

Table 3.6 presents estimates of willingness to pay (WTP) for the respective attributes derived from the model. The mean welfare estimates for the random parameters were obtained by simulations, drawn from 10,000 replications in R-software based on the RPL model results shown in Table 3.4.

The estimated pastoral communities' marginal WTP for water and biomass were the highest in the ranking of the attributes. The results indicate that each household was willing to pay Ksh. 2,088 and 1,528 annually for management of water and high biomass yield respectively. Further, results indicate that each pastoral household would be willing to accept (WTA) compensation of approximately Ksh.376 annually from a welfare loss if a low grazing threshold was tolerated in the grazing management. Respectively, the derived WTP for addition of water pans and dry season grazing reserves was Ksh.432 and 256 annually.

Table 3.6 Economic Values attached to the grazing management attributes.

Attributes	WTP (KSh)	Std error	95% confidence interval	
WATERPAN	432.56***	93.97	248.37	616.76
LOWBIOTH	-376.15***	110.71	-593.15	-159.15
MEDBIOTH	117.06*	357.72	-584.05	818.17
GRAZBAN	256.95**	134.53	220.68	276.68
BIOHIGH	1527.83***	263.01	1248.66	2494.98
BIOMED	1439.25***	247.65	953.87	1921.63
MOREWATER	2088.28***	369.35	1364.36	2812.21

Statistical significance levels: 1%; * 5%** and 10%* respectively**

3.4 Discussion

Tana River County is considered a water-scarce county in Kenya, with most of the area regularly experiencing extreme water shortages during periodic dry spells. Rapid population growth and inefficient use of resources increase the deficit between available water supplies and the needs of people. The entire county is drought-prone, and the vulnerability of the population to drought is high, with most of the people in the county living in very dry areas, especially the Orma and Wardey communities. This explains why the parameter estimates for the addition of water pans are positive with strong statistical significance. Pastoral communities derive a positive utility from the construction of water pans in the wet season grazing areas, which are areas far from the permanent water points. Rapid runoff during the rainy season frequently results in a high proportion of the water in the county not being utilized or even becoming destructive. Water scarcity is therefore the biggest constraint to the sustainable livelihoods of these communities, which depend largely on livestock as their main source of livelihood. Harvesting rainwater where and when it falls in the water pans presents opportunities to address both water scarcity and soil degradation at a local level. The addition of more water pans will therefore benefit the community in addressing the challenges of water shortages; hence, a higher proportion of the population places a positive preference on the construction of water pans.

The pastoral communities recognize the fact that regulation of grazing by designating wet and dry season grazing reserves is important as an adaptation strategy to the frequent dry spells. This is shown by the positive and significant parameter attribute for a grazing ban near permanent water points during the peak of the wet season to reserve pasture for dry season grazing and the opening of migratory corridors. This attribute was intended to reduce pressure around the water points in the wet season. During the wet season, there is usually plenty of pasture for the animals in the area. The animals can therefore graze at a distance from the water points and reserve areas near the water points for dry season use. Reserving these areas when the distant areas have enough pasture to sustain the animals is therefore vital in ensuring that, in dry spells, the animals come near the water points and find some pasture. Migratory corridors are to be designated to allow reciprocal access to the dry-season grazing reserves to avoid conflicts with the settled agro-pastoralists in the area. A positive utility can be derived from this attribute when there is a strong traditional governance system that can ensure sustainable management of the grazing areas with equitable benefits for all. This is because the community heads can be held accountable for their decisions and actions with regards to the governance of these areas.

Much of the land in the study area is governed as a commons with a set of rules and regulations created and enforced by the traditional council of leaders. This was evident in the preservation of watering points in areas where proper use and management were guided by traditional leaders with sanctions and penalties in the form of money or in kind (usually animals) for violations of community bylaws. Leveraging such institutions will greatly help in ensuring the communities have enough pasture near the water points in the dry season grazing reserves. As noted by Robinson and Berkes (2011), traditional governance systems that are well facilitated, strengthened, and properly linked with other governance structures ensure proper management of natural resources. When communal governance structures are strong, they are normally able to amicably deal with resource use, conflict, and the management of common resources such as water pans and grazing reserves (Robinson and Makupa, 2015). Therefore, supporting effective management institutions for water and pasture resources in Tana River County would enable pastoral communities to derive significant utility from the dry season grazing reserves accessed through migratory corridors.

The negative sign for the parameter estimates for a low biomass threshold shows that the pastoralists derive a negative utility from a very low threshold to stop grazing, with a very high proportion of the respondents placing a negative value on it. A low threshold means high grazing pressure. In this regard, pastoralists are to ensure that grazing livestock exert the least impact on the pasture and soil for the shortest time possible and allow ample time for the grazed pasture to regenerate as the grazing animals are moved from one place to another without affecting the regrowth of the defoliated forage. A very low threshold is likely to affect the regrowth of biomass, leading to overgrazing. The pastoral communities know that keeping animals in one area for a prolonged period of time affects the reestablishment of the defoliated pasture. High frequency of livestock grazing invariably leads to a decline in the plant's productivity, root biomass, and vigor (Kamau, 2004), particularly in species that are less tolerant to high grazing intensities (Metera et al., 2010). This results in low survival of palatable plants due to competition from less preferred plant species (Kioko et al., 2012), leading to colonization by highly competitive and tolerant plant species (Sternberg et al., 2000).

The ability of plants to replace tissues lost through grazing and withstand continued defoliation is a function of the rate at which stored carbohydrates are utilized during the dormant or slow-growing season and subsequently replenished during the rapid regrowth period (Adler, 2001). This above-ground plant growth dynamic is transmitted to the roots, as root growth declines when plant shoots are heavily defoliated because most of the carbohydrate reserves are mobilized and the leaf surface, which has photosynthetic capacity, is limited after being grazed upon (Holechek et al., 2001). Therefore, management practices must ensure a proper grazing threshold to avoid degradation. The pastoral community would hence not prefer a grazing practice that would likely lead to degradation of the grazing fields, hence the observed negative utility.

More biomass yield and higher water levels are the outputs of good grazing management practices. Having more water points, preventing degradation and overgrazing, and preserving dry season grazing areas will have a positive effect on biomass yield and water availability. This will benefit the community and provide pasture and water across the seasons. The parameter estimates of both water and forage are positive and strongly significant, which means that pastoral communities derive huge positive utility from both biomass and water. Drylands are predominantly used for livestock production, mainly through pastoralism. The movement of livestock herds is a central component of land management (Galvin, 2009). However, in the study sites, traditional mobility within the pastoralist system of the study sites has been compromised by declining access to water and forage resources. This undermines the ability of the communities to cope with the challenges of a complex and dynamic dry land system. The associated natural pastures are experiencing rapid degradation, thus reducing their contribution to livestock feed. Forage and water are therefore of significant value to pastoral communities, hence their positive utility.

The estimated pastoral communities' marginal WTP for water and biomass were the highest in the ranking of the attributes, which show that pastoral communities obtain a high welfare benefit from adequate water and forage for their livestock. The economic value of any good or service is measured in terms of what consumers are willing to pay for the commodity, less what it costs to supply the commodity (Westernberg, 2016). The high marginal willingness to pay for water and biomass therefore shows the great economic value attached to them since for environmental goods and services such as rangeland ecosystems, the costs of supply are almost zero, so the consumers' willingness to pay for an environmental resource is usually considered the net value of the resource (Favretto et al., 2016; Kelemen et al., 2014). The basic premise is that ecosystem services arise, either intentionally or unintentionally, from conservation practices and can have either a positive or negative value (Mukama, 2010; Lambert, 2003). The scarcity of water, which seems to be a recurrent problem in Tana River County, was reported to force people to use similar water sources for both livestock and human consumption, regardless of their poor quality. As a result, livestock production, for example, in terms of milk yield, differs significantly between dry and wet seasons. Fluctuations in milk yield, exhibited in higher milk production in the wet season as compared to the dry season, were directly related to scarcity of forage and water resources coupled with energy expended in searching for forage resources. Thornton and Herrero (2010) reported that poor feed quality leads to poor rangeland productivity in terms of meat and milk production. This explains the high economic value attached to forage and water.

The willingness to accept (WTA) compensation from a welfare loss if a low grazing threshold is tolerated in grazing management can be attributed to the negative utility of overgrazing. A low threshold to stop grazing would allow animals to overutilize pasture in a given grazing site for a long period of time, which is detrimental to the survival and production of the plants (Steffens et al., 2008). Proper utilization increases forage quality by creating environmental conditions that deter the survival of invasive weed species while favoring the recruitment and survival of palatable forage and browse species (Kinyua et al., 2009).

Oba et al. (2001) observed that when an area is severely utilized to the extent that it does not allow regrowth after defoliation, undesirable forage species tend to upsurge at the expense of more palatable forage species, which results in an economic loss. Herbivores therefore essentially affect the composition and productivity of plants through changes in plant nativity, recruitment, and mortality (Adler et al., 2005), and this may affect the functioning of the community and its structure (Fortin et al., 2003). An ecosystem may resist changes produced by grazing up to a certain threshold, beyond which further changes are rapidly accentuated by stochastic abiotic factors such as rainfall. These accounts account for the negative utility derived from the low threshold, a proxy for high grazing pressure and thus willingness to accept compensation due to overgrazing. As indicated by Fraser (2003), given alternative investment opportunities, pastoralists would express a low preference for compensation programs that they might consider less cost-effective in the use of existing resources. Pastoralists would therefore prefer to invest more in enterprises that they perceive to offer high output at a lower cost.

3.5 Conclusion

The study sought to determine the economic value of grazing management practices in pastoral areas using discrete choice modeling. The results show that pastoralists would prefer to have a grazing management system in which: there are enough water pans to harvest and store water; there is a dry season grazing reserve; overgrazing is limited to avoid degrading the grazing fields; and there is enough forage yield and water for the animals. Pastoral communities derive greater utility from management practices that allow reciprocal access to pasture and water across the wet and dry seasons. Because livestock production is a viable source of livelihood for pastoralists in tropical rangelands, they are willing to pay more to have enough water and pasture for their animals. The grazing management practices should consequently include these features to enhance their acceptability.

Therefore, to improve resilience to droughts and enhance livelihood opportunities, investments in water provision and pasture development are essential as a strategy to promote better use of land, especially by pastoralists. This can be done through strengthened traditional governance systems that are facilitated and properly linked with other governance structures to ensure proper management of the natural resources that guarantee adequate water and pasture in non-equilibrium ecosystems. The various management practices put in place to protect rangelands from degradation and promote their sustainable management can therefore generate higher levels of productivity when there is comprehensive information on the economic and social value of the impacts of these management practices in rangelands.

CHAPTER FOUR

VALUATION OF ECOSYSTEM SERVICES FOR SUSTAINABLE RANGELAND MANAGEMENT IN TANA RIVER COUNTY, KENYA

Abstract

Ecosystem services provided by rangelands are on the decline, posing a significant challenge to the societal wellbeing and livelihoods of pastoral communities. Quantifying and valuing ecosystem services from the rangelands is therefore intended to improve decision-making through the generation of knowledge about ecosystem functions and their contribution to pastoralism and, hence, arrest their decline. This chapter identified ecosystem services resulting from sustainable rangeland management practices and assessed their role in the livelihoods of pastoral communities. This involved the community attaching monetary value to ecosystem services that do not have a market price but still play indirect roles in the market. To value the ecosystem services, the rangeland components, functions, and processes that produce valuable services and how these services translate into benefits for the pastoral communities were considered. For a complete valuation, both marketed and non-marketed goods and services were valued using cost-based approaches. The results show that rangeland ecosystem services hold significant economic value even though they remain undervalued because they are poorly understood and typically external to markets. The economic benefits of conservation of rangeland resources were found to be substantial, and depending on which services are counted, they both outweigh the costs involved by far. In pastoral areas, complete incorporation of the value of ecosystem services from rangelands through adequate valuation data and assessments would provide concrete arguments as to why stewardship of rangeland biodiversity is crucial to pastoral livelihoods, thereby reducing rangeland degradation.

Key words: Ecosystem services; Rangelands; Sustainable management; Economic valuation

4.1 Introduction

Rangeland ecosystems provide a wide range of ecosystem services that are beneficial to pastoral communities. Several studies (Constanza et al., 1997; Polasky et al., 2010; MEA, 2005) refer to ecosystem services as the outcome of effective interactions between humans and the environment that directly or indirectly protect and benefit human lives. Burkhard et al. (2012) describe ecosystem services as the contribution of ecosystems to human well-being and categorize them as provisioning, regulating, supporting, and cultural services. In the rangelands, most ecosystem services have been declining due to overexploitation of natural resources, invasive species, and climate change that synergistically act to alter rangeland ecosystems (Van et al. 2013). As populations increase in rangelands, the demand for natural resources also increases, as most of their livelihoods depend on the natural capital (Jamouli and Allali, 2020). As a result, rangeland ecosystems continue to face unprecedented pressure that could result in their degradation and conversion, thereby affecting their sustainability (Kagunyu, 2014).

Sustainable management of rangelands requires investments to protect the important environmental resources and the associated services they provide to the populations inhabiting them. Benefits for sustainable rangeland management must therefore exceed both the market and non-market costs, which include the loss of ecosystem services (Favretto et al. 2016; Keeler et al. 2016). However, many of the benefits from sustainable rangeland management, such as the ecosystem services protected or enhanced, are not readily recognized due to a lack of a market price and may be easily overlooked if only commercial revenues and financial costs were considered (Macleod and Brown, 2014). Similarly, the costs incurred because of rangeland degradation may not easily be captured due to the lack of monetary value associated with them.

Only a few previous studies have assessed ecosystem services in rangelands, and these have been unevenly distributed across rangeland habitats, ecosystem services, and geographical locations. Most of these have largely focused on the provision of a single ecosystem service, whereas rangelands often produce multiple services (Westerberg, 2016). Most of the studies have largely focused on the provisioning services (Suich et al., 2015), such as pasture, milk, and meat, and ecotourism (Macleod and Brown, 2014). This is inherently biased towards marketable goods that can provide cash income and their subsequent contribution towards economic dimensions of wellbeing.

In terms of ecological significance, rangeland vegetation protects fragile soil profiles, is a catchment for major rivers, and provides habitat for wild animals and plants. Despite the economic and ecological contributions of rangelands, there is considerable undervaluation of rangeland resources due to a lack of knowledge of the value of those resources that have indirect uses and non-marketed services (Westerberg, 2016; Torell et al., 2013). To understand the value of rangeland resources, both the ecological benefits of the rangelands and the economic benefits were valued in this study. Precise appraisal of rangeland goods and service values permits the integration of unquantified values into principal decision-making frameworks such as cost-benefit analysis and impact assessments, along with the costs and benefits that are easily quantified financially (Lambert, 2013).

Even though monetary valuations of ecosystem services can provide insight into the importance of ecosystem services for pastoral wellbeing and persuade for sustainable rangeland management, the case has been made against their use as a sole decision-making criterion when developing conservation or the development of interventions in rangelands. This therefore requires the integration of economic valuation with social justice, economic efficiency, and ecological sustainability in the policy and decision-making process (Farley, 2012). This, according to Constanza et al. (2017), is due to the plural values and multiple benefits of rangelands and the non-linear, complex, and dynamic nature of human-environment relations.

While connections are increasingly being made between multiple ecosystem services and multiple dimensions of wellbeing, fully understanding the relationship between ecosystems and wellbeing cannot solely entail listing the links between the two. The management of rangelands requires an understanding of the value of the ecosystem services derived from sustainable rangeland management.

Although there has been an increasing trend toward undertaking economic valuation of ecosystem goods and services, there are still data gaps, often resulting in incomplete cost and benefit assessments. Because of the short-term nature of development projects, the economic benefits of ecosystem services also tend to be measured in the short term (Torell et al., 2013; Xie et al., 2016; Kelemen et al., 2014). In the case of adaptation, there are similar difficulties in assessing the costs and benefits, specifically when looking at ecosystem-based adaptations and their related benefits (Favretto et al. 2016).

According to Chee (2004), the valuation of natural resources is considered a complex process because most of the services and benefits are not marketed, so placing a monetary value on them represents a challenge. This has led to little attention being paid to the values of ecosystems, mainly because their services are not fully traded in a structured market and thus receive no consideration in a decision-making process by various policymakers (Constanza et al. 2016). Valuation methods start with utility, the satisfaction derived from the goods and services provided by the ecosystem (Torell et al., 2013). This study therefore involved the identification of ecosystem goods and services resulting from sustainable rangeland management and the assessment of their role in the livelihoods of pastoral communities. The study mainly focused on the marginal changes in values under sustainable rangeland management rather than on the rangeland unit in a constant state.

4.2 Methodology

4.2.1 Data collection

The study adopted a participatory approach where data was collected using various qualitative research methods. The research methods included household interviews, focus group discussions, and key informant interviews. The population from which the sample was selected were pastoral communities living in Tana River County, numbering 300 households. Primary data was collected using a semi-structured questionnaire administered to the respondents through oral interviews at their homes.

Participatory scenario analysis workshops were used to strengthen participatory aspects by engaging the local community in interviews and discussions concerning the sustainable future of their rangeland management practices. Each workshop was comprised of participants who had knowledge of pastoral ecosystems. The participants consisted of a mix of interest groups such as NGO and intergovernmental organizations (IGO) representatives, county officials, resource user associations, and community members. During the workshops, participants identified actors in rangeland management in the county and ranked them according to their influence and role in grazing management, the role of county government in rangeland management, ecosystem services, the pressure and patterns of rangeland degradation, and decision-making. Focus Group Discussions (FGDs) involving 10–12 participants who had vast knowledge of the social and cultural practices of the area were done in each sub-county of Bura, Galole, and Garsen. Separate FGDs were conducted for male and female participants. The data collected was used to cross-examine the quantitative information collected from household surveys. The key informant interviews were also conducted with the extension officers, officials from the WRUA, Kenya Wildlife Service wardens, county directors of livestock, the director of environment and natural resources, and the county director of the national drought management authority.

Naturally, the pastoral communities use, value, and shape the environment they live in, so they were fully involved in scenario analysis as they are the ones who are affected and eventually will implement ideas, work with conflict resolution, or make decisions for sustainable management of their ecosystems. Community participation ensured better inclusion and integration of the existing values, experiences, and various types of knowledge in the study areas. Local expert knowledge and experiences improved the quality of the information obtained for decision-making, increasing its credibility and legitimacy. Considering the interconnectivity among the ecosystem service functions, which produce a range of intermediate and final values, caution was exercised in value aggregation to avoid double counting.

4.2.2 Valuation of ecosystem services

To value the ecosystem services, the rangeland components, functions, and processes that produce valuable services and how these services translate into benefits to the pastoral communities were considered. For a complete valuation of the services, both marketed and non-marketed goods and services were valued using cost-based approaches, as shown in Table 4.1. Cost-based approaches are based on estimating the costs that would be incurred if benefits from ecosystem services had to be recreated through artificial means. Since most of the benefits of the rangeland practices valued had no market prices, their values were inferred from how much it costs to replace or restore them after they have been damaged. The cost of replacing or restoring the ecosystem services was assumed to be a reasonable estimate of their value to the pastoral communities. Therefore, four main methods were used:

1. Avoided cost method used to estimate the costs that would have been incurred in the absence of the ecosystem services.
2. Replacement cost method used to estimate the costs incurred by replacing the ecosystem services.
3. Mitigation cost method used to estimate the cost of mitigating the effects of loss of the ecosystem service; and
4. Restoration cost method used to estimate the cost of getting the ecosystem service restored.

Table 4.1 Methods used to value the ecosystem services.

Category	**Ecosystem service**	**Valuation method used**
Provisioning services	1. Water	Avoided cost/replacement cost/Market pricing
	2. Fodder/pasture	Market pricing/production approach
	3. Fuel wood	Market pricing
	4. Acacia Pods	Market pricing
	5. Opoponax	Avoided cost/Market pricing
	6. Medicinal products	Avoided cost cost/Replacement cost
	7. Livestock	Market pricing
	8. Milk, meat, Hides and skin, Manure	Market pricing
	9. Trees/Timber	Market pricing/Avoided cost
Regulating services	10. Flood control	Replacement cost/ CVM
	11. Reduced Livestock loses	Avoided cost/ Market pricing
	12. Land productivity	Avoided cost/Production approach
Cultural services	13. Peaceful Human coexistence	Avoided cost/CVM
	14. Reduced Human Wildlife Conflicts	Avoided cost/CVM

4.2.3 Valuation of benefits

Through the household survey that was conducted alongside the stakeholder workshops, the community was asked to name the changes they had witnessed in the environment because of the management of rangelands under the resource user association. All respondents agreed that there had been a tremendous improvement in the availability of pasture and water, fuelwood, pods, Opoponax (natural fragrance), medicinal plants, tree and timber products, and livestock products such as milk, meat, hides, and skin. They also reported reduced losses of livestock through diseases, reduced floods, enhanced pasture production, and reduced human-human and human-wildlife conflicts. All the benefits mentioned were valued to determine the economic value of the benefits derived from sustainable rangeland management.

In valuing pasture, the replacement cost of buying hay would represent an added cost to the pastoralist if pasture no longer existed or was not adequate. In the absence of pasture, a substitute, hay, which has a similar function, would have been used by the community. The presence of pasture avoids the costs associated with supplying hay substitutes. The cost of providing a substitute for hay with a similar function was assumed to be equal to the monetary value of the pasture available because of proper management. To determine the amount of equivalent hay that livestock would consume in a day if pasture was not available, the tropical livestock units (TLU), which are livestock numbers converted to a common unit using conversion factors as shown in Table 4.2, were estimated (Chilonda and Otte, 2006).

Table 4.2 Estimated TLU for different livestock species

Livestock species	TLU equivalent
Cow	1.00 TLU
Sheep	0.10 TLU
Goat	0.08 TLU
Donkey	0.50 TLU
Camel	1.25 TLU

The concept of TLU provides a convenient method for quantifying a wide range of different livestock types and sizes in a standardized manner (Harvest Choice, 2011). The standard used for one TLU was one cow with a body weight of 250 kilograms. The estimation was based on assuming an average daily dry-matter (DM) intake of 2.5% of bodyweight (Mulindwa et al. 2009), meaning that each TLU would consume 6.25 kg of forage dry matter daily.

Higher-quality forages are fermented more rapidly in the rumen, leaving a void that the animal can fill with additional forage, consequently increasing forage intake (Mulindwa et al., 2009). Low-quality forages below 6% crude protein will be consumed at about 1.5% of body weight on a dry matter basis per day. Higher-quality grass hays above 8% crude protein may be consumed at about 2.0% of body weight. Excellent forages, such as good alfalfa, silage, or green pasture, may be consumed at a rate of 2.5% dry matter of body weight per day. The combination of increased nutrient content and increased forage intake makes high-quality forage very valuable to the animal and the producer. With these intake estimates, it was possible to calculate the estimated amounts of hay that needed to be available. The quality of grass hay was assumed to be good with 8% crude protein since it's made from green pasture (Mulindwa et al., 2009). A cow will voluntarily consume 2.0% of her body weight (5 kg of forage dry matter) per day based on 100% dry matter. Grass hay will often have 7 to 10% moisture. By assuming that the hay is 92% dry matter or 8% moisture, the cows would consume about 6.25

kg of forage dry matter per day. Hay wastage when feeding big round bales was also considered; this was difficult to estimate but generally has been found to be from 6% to 20% or more (Mulindwa et al. 2009). It was therefore assumed that 15% of the hay was wasted. This means that approximately 12.5 kg of grass hay must be provided for each cow each day. This is therefore equivalent to the standard size of a bale of hay, which is 13–18 kg, depending on the baler mechanism. One bale of hay during the dry season costs Ksh.400, including transport costs.

To have an indication of the livestock resource, an inventory of livestock by species and the annual growth rates per species were taken. The principal species considered were cattle, camels, goats, and donkeys. The number of livestock units for each species was estimated and multiplied by the total number of livestock species estimated from the average numbers kept by the respondents to give the total value of forage required per day per species.

Water was valued because of the avoided cost of buying water that the community would incur if it was not adequate. The volume of water used for domestic and livestock consumption was considered to determine the total quantity of water needed per household per day. If water was not naturally supplied, an alternative source of supply had to be found. The estimates by the Water Resources Management Authority (WRMA) (2013) indicate that goats, cattle, and camels require an average of 3.5, 23.3, and 33.5 litres of water, respectively, per day. However, this study used the estimates provided during the focus group discussions with pastoralists, which showed that goats, camels, and cattle require, respectively, 5, 35, and 25 litres of water per day. This is closer to the estimates for water demand used in the IIED study on the direct use value of ecosystem services that were developed by WRMA (2013). The assumption is that all animals, regardless of the variations due to species, breed, age, gender, lactation, pregnancy, water quality, climate, seasonal effects, animal activity, diet, or watering regimes, take the same amount of water.

The cost of buying water was assumed to be the monetary value of the available water. To calculate the total number of livestock that use water each day, this study used the average number of animals kept by each household from the survey and the stakeholder workshops. An assumption was made that only livestock kept by community members were using the water resources in the area. This is because the village heads would not allow other animals to graze in their area without their consent. Therefore, livestock that migrates into and consumes water from other areas was not included in the study because it was difficult to estimate their numbers. According to NDMA (2019), consumption of water in the Tana River and the nearby areas is about 15–20 litres per person per day. These figures are not far from what was found in the study, which showed that the average water consumption was 12 litres per person per day. Because this was within the range provided for in the NDMA (2016) report, 12 litres per person per day were used in the estimates. According to the NDMA, the average cost of water in drylands is Ksh.5 per 20-litre jerrican, which is above the normal average of Ksh.2 per 20-litre jerrican (NDMA, 2016). According to the community survey conducted during the study, the jerricans of 20 litres were each retailing at Ksh.5. Therefore, the price of Ksh.5 for 20 litres of water was used as reported in the survey.

The restoration cost technique was used to determine the value of regulatory services for flooding control. Effective rangeland rehabilitation has the potential to improve plant growth and, in turn, forage productivity in terms of herbaceous species diversity, species richness, relative abundance, percent composition, biomass production, and percent cover of perennial grasses. This improves the hydraulic conductivity of the soil, increasing water infiltration and reducing floods (Lutta et al. 2019). Therefore, the monetary value of the rehabilitated rangelands is assumed to equal the cost associated with restoration of the original state of households if flooding happened.

To determine the value of fuelwood, we used the locally estimated market prices provided during the focus group discussions and the averages from the surveys for our calculations. Most households depend on wood energy for cooking and heating. It was found that each household uses one load of fuel for two weeks (14 days). The load, which, according to the group discussions, usually consists of dead wood and not felled timber, is sold to the households at a rate of Ksh.300. From the survey, all the respondents reported that they use fuelwood as a source of energy, which was valued at a rate of load.

Another important product from the ecosystem valued in both scenarios was the use of Opoponax (Commiphora holtziana). Opoponax, also called "sweet myrrh," has been used in perfumery and for treating wounds and clearing respiratory congestion among pastoral communities. To estimate the value of opoponax, the proportion of households that collect opoponax in the study area was estimated, and the average number of kilograms of opoponax collected was multiplied by the average price in the local market, which was Ksh.80. Other studies have shown that one kilogram of opoponax is sold to the Chinese market at a rate of Ksh.300 to 450 (Sala, 2014), while in Ethiopia, the traders export opoponax to the Middle East for US$15.66 (Ksh.1,377) (Aboud et al. 2012). However, in our calculations, the actual local market price stated by the respondents collecting and marketing Opoponax was used.

The present value of the incremental change in livestock products such as milk, meat, hides and skins, and manure arising from the different rangeland management practices was also considered using Equation 10.

Equation 10:

$$\sum_{t=0}^{30} \frac{(\Delta\ in\ LSP * price\ of\ LSP}{(1+i)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(10)}$$

Where,

Δ = *is the incremental change*

LSP = the livestock product (Either milk, meat, hides and skin, manure)

i = prevailing interest

For example, discussions in the focus group discussions revealed that, milk availability per household stood at 1.5–2 litres per day compared to one litre per day under normal circumstances. The increase was attributed to availability of pasture and browse, and livestock were grazing within reasonable distance from homestead during the wet seasons and had dry season reserves. The average milk price ranged from Ksh.40–60 per litre.

Pastoral systems were inherently flexible, enabling families and households to make effective use of constantly shifting resources. Livestock numbers have declined due to recurrent droughts, a shrinking grazing resource base, resource use conflicts, and cattle rustling. Proper rangeland management through community organizations such as the Resource Users' Association in the study area has managed to mitigate livestock losses through proper planning and holistic management of resources. The avoided cost resulting from the loss of livestock, which can be attributed to sustainable rangeland management, was estimated in the focus group discussions. The average number of livestock a household would lose to drought, conflicts, pests, and diseases before and after proper rangeland use planning undertaken by the Resource Users' Association was estimated. This was multiplied by the prevailing market price of livestock species, as shown in Equation 11.

Equation 11

$$\sum_{t=0}^{30} \frac{(\Delta\ in\ LS\ losses * price\ of\ each\ LS\ species}{(1+i)^t} \text{..................................} (11)$$

Where,

Δ = *is the incremental change*

LS = the livestock species

i = prevailing interest

The cultural benefits arising from sustainable rangeland management practices were also valued. Reduced conflicts have been shown to be the major benefit of sustainable rangeland management. Resource use conflicts for people and their livestock are one of the primary drivers for communities establishing resource user associations. Peace and security are the foundations for all economic and social development, as well as the planning and management of natural resources on community land. Without peace and security, there is little opportunity for investment, and people are unable to plan how to manage their land. From the stakeholder workshops and FGDs, it was revealed that conflicts among pastoral communities and farmers are largely caused by competition over control of and access to natural resources, particularly water and pasture. Other causes of conflicts included historical rivalry, deep-seated cultural values, land issues, political incitements, and the proliferation of illicit arms. Both intra- and inter-community conflicts revolved around control over and access to natural resources, particularly water and pasture. Intra-community conflicts were largely caused by land disputes. Inter-community conflicts were the most common types of conflict caused by historical rivalry and competition for water and pasture. Climate change and the associated environmental risks, such as droughts and floods, induce forced migrations and competition over natural resources among pastoral communities, with potential negative consequences for political stability and conflict resolution.

It was reported that community elders from the conflicting communities made treaties on peacekeeping. The council of elders determined that the community of the assailant would be fined 10 cows if it was a man and 5 cows if it was a woman, which was paid to the council of elders of the victim. Upon payment of the fine, a goat would be slaughtered, and the blood would be used for cleansing. A goat meal would be shared among the warring communities' elders as a sign of peaceful coexistence. However, this strategy largely dealt with the situation at hand and thus served specific warring situations. The study established that even after the brokering of peace through the council of elders, sometimes conflicts flared up depending on the intensity of the socio-economic hardship the communities were undergoing. For instance, if livestock loss continued unabated due to climate vagaries, raiding would persist. With proper rangeland planning and policies in Tana River County, such as the Tana River County animal grazing control act of 2018, resource use conflicts have declined, and the number of cases of attack has largely reduced by 50 percent.

To estimate the value of peaceful coexistence, the average number of cases of people killed before and after proper rangeland use planning was determined. The difference was multiplied by the number of cows paid as fines. The value of cows was determined by the market price of livestock, as shown in Equation 12.

Equation 12

$$\sum_{t=0}^{30} \frac{P(IAx\ LSFP) * Price\ of\ LS}{(1+i)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Where,

P= the proportion of change in attacks

IA = initial estimated number of attacks reported,
LSFP = Livestock fines paid,
LS = livestock

Human-wildlife conflicts have also decreased significantly, especially in the area. Wildlife, livestock, and people shared the same resources and coexisted together. Human deaths resulting from human-wildlife conflicts have been drastically reduced through proper grazing management. This value was estimated as an avoided cost by multiplying the change in human-wildlife conflict cases by the compensation rate awarded by the Kenya Wildlife Service.

The costs incurred by the operations of the Kiraguni Water Resource Users Association were used to estimate the operational costs of rangeland management. The resource user association was used as a unit for managing the rangeland sustainably. The unit requires investment in institution building, infrastructure, and operational costs. Using key informant interviews with the chairman, secretary, and treasurer of the unit, document reviews, and surveys, the major costs of the unit were found to be incurred through:

- Awareness and capacity building of all stakeholders to understand and seek solutions to the degradation of natural resources, to generate collective action and respect for water resources, livestock grazing plans, by-laws, traditional knowledge, and ecosystem functions.
- Safeguarding of agreed rangelands management and rehabilitation plans and practices, including household grass banks, clearing invasive species, warrior/herder forums, elder-endorsed enforcement plans, and rangelands social clubs
- Re-seeding and fodder production
- Management of forest and wetland ecosystem management systems to stabilize, recover, and sustain the forest and wetland resources.

4.2.4 Estimation of future benefits and costs

The benefits accruing because of the proper management of rangelands and the costs incurred therein were expected for several future years to come. This is because investments in rangeland improvements and management practices usually have a life expectancy of more than one year. To estimate the future benefits based on the current year's estimates, Equation 13 was used.

Equation 13:

$Vt = V_0 \ x \ e^{rt}$………………………………. (13)

Where,

Vt = Value after time t.
Vo= is the current value
r = % rate of growth in the prevailing conditions,
t =Time, and
e= Euler's number

For livestock estimates, the estimated annual growth rates for the livestock sector in Kenya under the Africa Sustainable Livestock 2050 (ASL, 2050) report that developed agreed scenarios for livestock in 2050 (FAO, 2018) were used. The report also shows the annual consumption rate of animal products and the long-term projects under the prevailing and anticipated conditions. The report shows that livestock species will be declining in numbers by the year 2050. This was also confirmed in the stakeholder workshops and survey, where the respondents attributed the decline to the major challenges facing livestock production in agro-pastoral and pastoral areas that were skewed towards the adverse effects of climate change and variability.

The study found that pastoralist communities are currently faced with a complex array of challenges linked to vicious cycles such as frequent, devastating droughts and declining resilience capacities. Other challenges include inadequate extension services, financial constraints, and low adoption of innovations. As a result of this, the herd size per household in pastoral communities will be declining. Despite the decline in herd size, the growing urban population will likely consume more high-value food products, in particular animal-source foods such as meat and milk, as shown in Table 4.3.

Table 4.3: Livestock production change rates

Species	Annual growth rates (%)
Cattle	-1.6
Goats	-0.7
Camel	-1.6
Meat	2.55
Milk	2.56
Cow	2.1
Shoats	1.3

Source: FAO, 2018

Changes in the prices of various goods and services over time were determined using Kenya's projected inflation rate. The IMF report on Kenya's economy showed that in 2018, the average inflation rate in Kenya was about 4.69%, a significant decrease from 7.99% in the previous year. Forecasts show Kenya's inflation leveling off at around five percent in the near future (IMF, 2019). A 5 percent future inflation rate was therefore used in the calculations. A human population growth rate of 2.7% (KBS, 2019) was used to determine changes in the human population in the study area.

4.2.5 Discount rate

Discounting was used to compare costs and benefits occurring over different periods of time by converting costs and benefits into their present values. Discounting is based on the concept of time preference, which generally means that people prefer to receive goods and services now rather than later. The opportunity cost of the use of capital funds was used because money used in the sustainable management of rangelands has a cost. It was assumed that if the money was borrowed, the cost was the interest that had to be paid, and if it was financed from the cash reserves of the community members, then the cost was the interest foregone or that could have been earned on those funds if they had been lent out. Therefore, a sensitivity analysis of the results from the cost and benefit analysis was done using three discount rates of 3.5%, 8.5%, and 12% that have been used to appraise projects in Kenya.

In a study to determine the economic opportunity cost of capital funds in Kenya, Roksana (2015) found that the estimated discount rate for Kenya ranges from 10% to 14.5% in real terms. After various sensitivity analyses, the study concluded that a 12% real rate was the suitable discount rate for Kenya to be used in investment decision-making. This is also the social discount rate used by the African Development Bank (AFDB) for the economic appraisal of investment projects. A discount rate of 8.5%, which is the average banks' deposit rate and represents the Central Bank of Kenya benchmark interest rate (Onduru and Muchena, 2011), was also used. A lower interest rate of 3.5% was also used, which, according to Dallimer et al. (2018), represents a typical figure used by national and international donors and policymakers. It is the rate at which government appraisal costs and benefits are discounted using the social time preference rate.

A cost-benefit analysis was done to determine whether the benefits of sustainable rangeland management outweighed the costs of the action. To do this, a resource user association was used as a rangeland governance structure or unit through which the costs incurred by the management were established. The analysis focused on quantified advantages (benefits) and disadvantages (costs) associated with the management options. The governance structures ensure sustainable rangeland management practices such as controlled grazing while conserving soil and water and the establishment of forage trees along with grasses and legumes to enhance biodiversity. This study focused on the ecosystem benefits that arise from the proper management of the rangelands by considering the benefits of action in terms of ecosystem services.

Cost-benefit analyses are used for this purpose, as they compare the costs of adopting a sustainable practice against the benefits derived from it (Dallimer et al., 2018). When it comes to decision-making, timing is the most important element; therefore, a thirty-year timeline (between 2019 and 2049) for expected costs and revenue and how much they will pan out over the period was agreed upon by community members involved in the assessment. The future costs and benefits were converted into their present value by discounting the benefits by the prevailing discount rate. The net present values were computed by subtracting costs from benefits. A sensitivity test showing what would happen to the indicators if the parameters and assumptions were different from base-case values was also done.

Most investments in range improvements and management practices usually have a life expectancy of more than one year, and the benefits begin to accrue after a span of more than ten years for some investments. This usually leads to operation and maintenance costs incurred over a span of years. These improvements should, as their main objective, bring in a flow of returns or benefits over a projected period. The future flows of returns and expenditures do not have a common point in time. Therefore, to be able to bring future flows to a common time base, several factors were taken into consideration. The time value for money was considered by setting a 30-year timeframe (2019–2049) over which to perform the analysis and discounting the future benefits that accrue and costs incurred over the same period. These, according to Dallimer et al. (2018), allowed the calculation of the net present value (NPV) of the different benefits and costs involved in sustainable management of rangeland resources under the different scenarios under study, as shown in Equations 14 and 15.

Equation 14

NVP of accrued benefits = $\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}$................................ (14)

Equation 15

NVP of incurred costs = $\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}$.................................... (15)

Where,
B_t = incremental benefits at time t,
C_t = incremental costs at time t,
i = prevailing interest rate
n = number of years.

The benefit-cost ratio was used to compare benefits and costs from sustainable rangeland management as shown in Equation 16.

The BCR was computed as follows:

Equation 16

$$BCR = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} \Big/ \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} \text{ .... (16)}$$

4.3 Results

4.3.1 Ecosystem services inventory

The study assessed the type and state of ecosystems services stocks and flows based on the ecosystem service framework of the Millennium Ecosystems Assessment (2005). The ecosystem services that were participatorily determined during the focus group discussions, and key informant interviews are shown in Table 4.4.

Table 4.4: Ecosystem services identified in the study sites.

Provisioning services	Regulating services
• Water • Fodder/pasture • Fuelwood • Acacia *tortilis* pods • Opoponax • Medicinal plant products • Livestock • Milk, meat, hides and skin • Manure • Timber/construction materials	• Flood control • Reduced loss of livestock • Water purification, • Air quality maintenance, pollination, pest control, • Erosion control • Climate control with carbon storage and sequestration.
Supporting services	**Cultural services**
• Nutrient cycling	• Peaceful Human-Human interactions • Human-Wildlife coexistence

4.3.2 Net present values of the ecosystem services

Table 4.5 presents the net present value of the benefits for sustainable rangeland management. In the estimation of the costs and benefits, only the benefits accrued, and costs incurred because of sustainable rangeland management were estimated. The focus was on both marketed and non-marketed goods and services from the rangeland ecosystem. The net present value of the benefits was estimated, and the costs involved in the management deducted from the total benefits.

Table 4.5 Value of benefits per ha/year

	Ecosystem services	Present Values (USD) under different discount rates		
		3.5%	8%	12%
Provision services	Water	3.83	2.01	1.30
	Vegetation (Pasture)	156.40	84.14	55.78
	Pods for animal feed	1.86	1.11	0.57
	Fuelwood	9.41	4.84	3.07
	Medicinal value	2.46	1.48	0.32
	Opoponax	2.74	1.35	0.82
	Incremental value for milk	61.34	67.74	23.64
	Incremental value for meat	4.47	2.03	1.15
	Incremental value for hides and skin	3.99	3.02	1.89
	Incremental value for manure	2.69	1.67	1.08
	Trees saved	3.28	1.58	1.12
Regulating services	Flood control	3.75	1.84	1.13
	Reduced Livestock loses	21.47	10.61	6.51
Cultural services	Social cohesion	12.36	6.66	4.38
	Reduced Human wildlife conflicts	0.40	0.22	0.14
	Total	290.46	190.29	102.91

The benefits of action for sustainably managing and rehabilitating rangelands far outweighed the costs incurred in the management process. The main costs (Table 4.6) incurred were through the scouting of rangeland resources to inform planning of grazing, guarding of the differed grazing reserves, community meetings, administration allowances of the staff, as well as rangeland restoration activities such as gully rehabilitation and removal of the invasive species. Based on this analysis, the NPV per hectare was positive irrespective of the discount rate. The net present value per hectare was £183.7, £278.4, and £98.5 using 8%, 3.5% and 12% discount rates respectively (Table 4.7).

Table 4.6 Costs incurred per ha/year.

Costs per ha/year	Present values of costs (USD)		
Discounting rate (r)	3.5%	8%	12%
Scouting	2.47	1.35	0.90
Guarding cost	1.93	0.95	0.58
Community meetings	3.23	1.74	1.14
Restoration costs	2.79	1.50	0.99
Operational and maintenance costs	1.63	1.03	0.80
Total	12.04	6.57	4.40

Table 4.7 Net present values

Net present values	Discounting rates		
Discounting rate (r)	3.5%	8%	12%
Benefits	290.5	190.3	102.9
Costs	12.0	6.6	4.4
Net Present Values	278.4	183.7	98.5
Benefit cost ratio	24.1	29.0	23.4

4.4 Discussion

The approach used in this study for determining the value of ecosystem services for management practices that mitigate rangeland degradation considered the cost of re-establishing the high-value rangeland lost and the benefits drawn from the same. This basically involved looking at the value of rangeland degradation actions and the costs of inaction, which is the sum of annual losses due to rangeland degradation. The results have demonstrated that rangelands have numerous ecosystem services that are beneficial for the livelihoods of pastoral communities. As a result, the cost of action to rehabilitate rangelands was found to be lower than the cost of inaction over a 30-year period, therefore justifying the need for urgent action to avoid rangeland degradation and restore degraded areas. The pastoral communities depend on natural resources for their livelihoods, so the degradation of rangelands would mean a decline in ecosystem services, disproportionately affecting their livelihoods (Nkonya et al. 2008).

As shown by the results, complete incorporation of the value of ecosystem services from rangelands through adequate valuation data and assessments would provide concrete justification as to why stewardship of rangeland biodiversity is crucial to pastoral livelihoods, thereby reducing rangeland degradation. Ecosystem services often hold significant economic value (Egoh et al. 2008), but they remain undervalued within policy decisions because they are poorly understood and typically external to markets (Favretto et al. 2016). As a result, cost-benefit analyses are biased towards development over conservation, and planning efforts miss potential win-win areas and associated opportunities to finance conservation in innovative ways (Chan et al. 2006). This means that ecosystem services and biodiversity conservation are hardly incorporated into decision-making for rangeland management to an extent that is commensurate with the importance of their values. A literature review of the studies that have assessed the economic value of ecosystem services in Africa done by Jamouli and Allali (2020) shows that 28 studies conducted mostly in South Africa focused on services provided by wetland and forest ecosystems. Provisioning services was the most assessed category, and the market price was the most frequently cited method. Out of the 28 studies assessed, 19 (68%) focused only on a single ecosystem service, and the remaining nine (32%) examined multiple services, of which the combination of provisioning and regulating services was the most common. This means that not enough has been done to determine the value of ecosystem services in Africa that can be incorporated into land management decisions.

The results have shown the value of ecosystem services in reducing conflicts and enhancing social cohesion among pastoral communities. Land use and land cover changes in rangelands have led to conflicts between people, livestock, and wildlife over the scarce rangeland resources, with the intensity of the friction increasing over the years (Maitima et al. 2009; Campbell et al. 2003). Land use and land cover changes are also associated with the decline of ecosystem services due to the loss of plant biodiversity (Maitima et al. 2009). According to Glew et al. (2010), degradation of rangeland ecosystems results in environmental challenges that lead to the loss of land productivity, which in turn leads to deteriorating livelihoods in rural areas where most of the poor heavily depend on natural resources. The resulting scarcities are often exacerbated by poor ecosystem services prohibiting and dispossessing pastoral communities of access to land, water, and grazing resources for pastoralists whose main livelihood is livestock production (Mulinge et al., 2015).

Benefits for rangeland rehabilitation through proper governance, such as the rangeland user associations, occur at both the household and community level and are typically not financial in nature. The results of this study have shown that the economic benefits of conservation of rangeland resources, as shown by the Kigaruni Water Resource Users Association in the study area, are substantial and, depending on the counted services, they both outweigh the costs involved by far. A comprehensive economic valuation study of a large-scale rangeland restoration scenario done by Myint and Westerberg (2014) showed similar results for the value of rangeland ecosystem services in communal rangelands in Jordan. In their study, the net present economic value to pastoralist communities of avoided forage purchases was estimated to be US$23 million, assuming that the communities themselves bear the management costs. Their results further showed that even without capitalizing on ecosystem services such as carbon sequestration or sediment stabilization, it is still in the interest of rangeland communities to manage their rangelands, provided they have adequate tenure systems and rights, because of the huge ecological benefits derived for the pastoral communities.

In these pastoral areas, financial mechanisms that capture the economic value of ecosystem benefits can help finance the rehabilitation of rangelands and the conservation of rangeland resources, freeing up resources for investment elsewhere. Although mapping and valuing ecosystem services can help inform planning efforts, they are not sufficient to motivate conservation. For most ecosystem services, financial mechanisms and institutions such as markets and subsidies do not exist to capture values and compensate landowners for bearing the costs of providing them (Pagiola et al., 2005). An increasing number of examples in Kenya demonstrate the potential of such mechanisms, including payments for services from conservation of wildlife (Osano et al., 2013), water management (Nyongesa et al., 2016), and land conservation (Curran et al., 2016). For all but these and a few other exceptions, however, payment schemes for services outside traditional markets are typically absent. Without such mechanisms, as observed by Naidoo and Ricketts (2006), many economic values associated with natural habitats will remain outside the calculus of agents who actually make land-use decisions.

The significant changes in ecosystem services that were observed in the study area were largely due to the sustainable rangeland management practices undertaken by the local Resource Users Association. The association put in place proper governance of rangeland resources despite their mandate largely being on the conservation of water resources. This means that in pastoral communities, local institutions are often an important interface between government and communities for effective rangeland management. Natural resources are the foundations for the development of pastoral communities, underpinning livelihoods, food security, trade, and employment. As found in this study, most communities rely on livestock and other natural-based resources to sustain their livelihoods. The results reveal that effective governance structures and capacity have assisted in the efforts to combat illegal and unsustainable rangeland resource exploitation. Depletion of natural resources is exacerbated by conflicts and, in turn, feeds into the cycle of insecurity and violence as clans and communities clash over access to the diminishing natural resource base of pasture, water, and forest resources. Conflict and environmental degradation, with their negative effects on each other, contribute to heightening rural poverty, and faced with the limited prospects for livelihood diversification, many people are opting out of the rural pastoral and agro-pastoral economies and into urban areas in search of employment or food aid. Poor land governance, mostly destruction of natural vegetation through activities such as overgrazing and illegal tree felling for fuel and timber, has caused increased runoff, flash flooding, reduced infiltration, soil erosion, and siltation in the water pans and other water reservoirs.

4.5 Conclusion

This study presents an economic valuation of the common ecosystem services resulting from sustainable rangeland management practices. The results have shown that investments in addressing land degradation have significant economic payoffs through improved rangeland productivity. The cost of acting to rehabilitate rangelands was found to be lower than the cost of inaction. Sustainable rangeland management and responsible land governance have great potential for achieving sustainable pastoral livelihoods and peaceful coexistence. Conservation benefits are the most important and usually complicated aspects of conservation development. These results demonstrate that not only monetary benefits should be regarded as benefits but rather the health of the environment, in which biodiversity is rich. The guiding principles are that people and participatory approaches should be at the center of the process and that governance and enabling policies and institutions should support the achievement of sustainable rangeland management.

CHAPTER FIVE
ADOPTION OF SOIL AND WATER CONSERVATION TECHNOLOGIES BY AGRO-PASTORALISTS IN TANA RIVER COUNTY OF KENYA

Abstract

Climate change exacerbates the naturally unpredictable rainfall and frequent droughts that affect arid and semi-arid lands. This has resulted in the deterioration of land resources, leading to forage and water shortages that negatively impact livestock productivity. To deal with climate hazards that affect agricultural production and food security in pastoral ecosystems, development agencies and governments are primarily supporting sustainable rangeland management strategies, such as soil and water technologies. The most common soil and water conservation technologies include Zai pits, water pans, and shallow wells. Some of these strategies have not been able to produce the desired levels of productivity and thus have failed to improve the welfare of the pastoral communities or prevent rangelands from deteriorating due to a low adoption rate at household level. This chapter focuses on the social, economic, and institutional determinants of the adoption of soil and water conservation technologies at the household level in pastoral areas of Tana River County, Kenya. The data was collected through household surveys, focus group discussions, and key informant interviews. The results show that access to extension services and training, monthly income level, main source of livelihood, land tenure system, membership in community groups, and availability of active farm labor significantly influenced the adoption, which needed a combination of technical efficiency with low cost and acceptability to pastoral communities. Pastoralists would thus need to be mobilized, trained on how to construct and use soil and water conservation technologies, and sensitized on the potential socioeconomic benefits of adopting them.

Key words: Rangelands, Soil and water conservation, Pastoralism

5.1 Introduction

Rangelands are important habitats for wild flora and fauna as well as for domestic livestock (Osano et al. 2013). Rangelands are predominantly used for pastoralism, which is a low external input subsistence system characterized by extensive livestock production (Wasonga 2009). Pastoralism is grounded in the strategic exploitation of resources that are not uniformly distributed in space and time (Wasonga et al. 2003). The spatial-temporal variability in water and pasture availability influences the mobility and settlement patterns of pastoral communities, leading to the development of pastoralism as the most suitable economic activity in arid and semi-arid areas (Galvin 2009). Pastoralists and agro-pastoralists are confronted with a variety of risks that constantly disrupt their livelihoods and devastate assets (Wasonga 2016). These risks, coupled with limited and increasingly ineffective risk management options, underlie vulnerability in pastoral systems. Some of the challenges facing pastoral communities include land tenure changes, a diminishing grazing resource base, and frequent droughts that undermine pasture and livestock productivity (Gao et al. 2009). Recurring droughts have a direct negative impact on natural pasture growth, often resulting in a lack of fodder and consequent economic loss for livestock that may reach disaster levels (Downing and Bakker 2000).

Traditional drought-coping mechanisms of both pastoralists and agro-pastoralists, such as splitting the herd into various groups spread over the community under the care of relatives, seem to have become less effective due to socioeconomic and political changes. In this context, drought contingency planning is gradually receiving more attention as an important strategy to lessen the impact of droughts (Wilhite 2000). Such planning can occur both at the government level and at the household or pastoral enterprise level. It invariably involves the formation of reserves, whether of pasture or water (Bruins 2000), in the wake of climate change and variability.

The agropastoral communities' capacity to cope with and adapt to the changing conditions of climate has further been compounded by the wider social and institutional contexts of pastoral systems. Human and livestock population growth has increased pressure on natural resources in pastoral areas (Kalungu et al. 2015). This, coupled with the loss of land and water resources to non-pastoral use and the interruption of migration routes, leaves livestock keepers with fewer accessible pasture and water resources and eventually impairs pastoralists' traditional drought coping strategies. In response to these challenges, development and government agencies have been promoting various coping and adaptation strategies, in addition to pastoralists and agro-pastoralists own initiatives to enhance production and food security in the face of extreme climatic trends in the arid and semi-arid rangelands of Kenya. A number of these adaptation strategies are specific to certain value chains, while others cut across different value chains, among them soil and water conservation initiatives aimed at improving rangeland productivity and availing water for livestock, domestic, and irrigation use.

Soil and water conservation is especially crucial for the arid and semi-arid areas that not only experience unpredictable rainfall and recurrent droughts but also heavy torrents and floods when it rains. Runoff harvesting enhances water security given that a significant part of tropical rain is normally lost as runoff, potentially causing erosion (Kalungu et al. 2015). It is important for harnessing otherwise transient flood water for use during extended dry seasons and droughts, as well as controlling soil erosion. As observed by Sidibe (2005) and Matata et al. (2010), harvesting water that would otherwise flood off is a case of preparedness and mitigation planning, as proper soil and water conservation technologies can make pastoral households better prepared to mitigate drought by managing the reduced input of rainwater more intensively and efficiently.

In Kenya's arid and semi-arid lands (ASALs), various soil and water conservation techniques, including the construction of water harvesting structures such as Zai pits, water pans, and shallow wells, have been used to capture the little rainfall received in these areas to support pasture and crop production (GoK 2014; Kalungu et al. 2015). These techniques are aimed at preventing soil erosion by reducing runoff, especially in sloppy terrain on rangelands, and improving the infiltration of water into the soil (Oweis 2016; Appels et al. 2016). Tana River County of Kenya is one of the ASAL counties where soil and water conservation technologies have been promoted as drought mitigation strategies, both for the purpose of soil and water management and the harnessing of run-off for livestock and domestic use, especially during drought periods. However, the impacts of these interventions are not yet fully felt due to the low adoption of the technologies by households. This chapter sought to determine socio-economic factors affecting their adoption aimed at harnessing runoff to improve pasture production in semi-intensive agropastoral systems in Tana River County, Kenya.

5.2 Methodology

5.2.1 Study Area

The study was carried out in Tana River County (Fig. 2), which covers 38,682 km2 and is in Kenya's coastal region. One of the important natural resources in the county is the River Tana, Kenya's largest river, which flows through the county as it drains into the Indian Ocean. The river Tana forms the Tana River Delta wetland, which covers about 1300 km2 and supports more than 100,000 inhabitants (Leauthaud et al. 2013). The county is largely semi-arid rangeland, receiving low and erratic convectional rainfall. The average annual rainfall is about 280–900 mm (GoK 2014). Rainfall distribution is bimodal, with the long rains occurring in

April to May and the short rains in October to December. The riverine and delta areas are highly vulnerable to flooding in years with high precipitation. The temperature of the area ranges from a minimum of 23 °C to a maximum of 38 °C (KIRA, 2014). Despite the dry conditions, agriculture is the main income-earning activity in the county, contributing roughly 82% of the households' income (GoK, 2013). However, only 6% of the total land is under crop farming, mostly in the riverine areas of Tana River County, as the mainland is drier and mostly dedicated to extensive livestock production.

5.2.2 Sampling design and Data collection

A multi-stage sampling procedure was used in the selection of a representative sample population. All three sub-counties that make up Tana River County, namely Bura, Galole, and Garsen, inhabited by the agro-pastoralists, were purposefully selected in the first stage of sampling. The second stage involved a systematic random sampling to select five locations from each sub-county. At the third stage, sampling was narrowed down to two smaller administrative units (sub-locations) within each location. A simple random sampling technique was used to select ten respondents from each sub-location for the study, giving a total of 300 respondents. A semi-structured questionnaire was used to collect data on the adoption of water harvesting structures among the 300 agro-pastoral households in the selected sub-locations. Prior to actual data collection, the questionnaire was pre-tested among 50 households through face-to-face interviews and reviewed by multi-disciplinary experts to ensure its adequacy and suitability to capture the required information. A total of 12 focus group discussions, each comprising between 10 and 12 people, were conducted, four in each sub-county. In addition, 24 key informants, comprising individuals from government line ministries, non-governmental organizations, and civil society organizations involved in the natural resource management and livelihoods of communities in the county, were interviewed.

5.2.4 Data analysis

The collected data was subjected to descriptive analysis to generate frequencies and cross-tabulations that displayed relationships in the data. The *t-test* and *chi-square* statistic were used to test for significance in differences in the socio-economic characteristics of the adopters and non-adopters of soil and water conservation technologies in the study area. The *chi-square* test was used for nominal data with categorical variables, while the *t-test* was used to test the differences in means of the continuous variables. A binary choice model was used to determine the factors that influenced adoption among the agro-pastoral households. The decision to adopt or not adopt a particular technology is a binary one that can be analyzed using binary choice models. Dichotomous outcomes such as adoption or non-adoption are related to a set of explanatory socio-economic variables that are hypothesized to influence the outcome (Neupane et al. 2002) and can be estimated using probit, logit, and linear probability. In this study, a logistic regression procedure using maximum likelihood estimation (Kmenta et al., 1986) was used to estimate the probability of a soil and water conservation technology being adopted. The Statistical Package for Social Sciences (SPSS version 26) software was used in the estimation of the model (Norusis 2008). A multivariate binary logit model was used because of the consistency of parameter estimation associated with the assumption that the error term in the equation has a logistic distribution (Ravallion 2001). The probability of adopting the technology at different level of the independent variable is estimated as:

$$P_i = E\,(Y = 1/\,X_i)$$

$$= \frac{1}{1 + e^{-(\beta_1 + \beta_2 X_i)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (17)$$

Where Y = 1 means the respondent adopted the soil and water conservation technology, while X_i is a vector of explanatory variables, and *e* is the base of natural logarithm.

Equation 17 can be re-written as

$$P_i = \frac{1}{1 + e^{-z_i}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (18)$$

Where $Z_i = \beta_1 + \beta_2 X_i$

Equation (18) represents a cumulative logistic distribution function. The P_i, given in equation (18) gives the probability that the respondents adopted the systems while ($1 - P_i$), is the probability that all the households adopted the systems.

$$1 - P_i = \frac{1}{1 + e^{zi}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots (19)$$

Equation (19) can be simplified as:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (20)$$

$\frac{P_i}{1 - P_i}$ = is the odds ratio that the households adopted the soil and water conservation technology. Hence the natural log of equation (20) can be expressed as shown in equation 5:

$$L_i = l_n\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_1 + \beta_2 X_i \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (21)$$

Where L represents the log of odds ratios which is in linear form in X as well as in the parameters, therefore, the logit equation can be specified as in equation 22.

$$L_i = \left(\frac{P_i}{1 - P_i}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon_i \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . (22)$$

Where:

X = *is* a vector of socio-economic factors influencing households' ability to adopt

β= is a vector of coefficient to be estimated

ε= is the error term assumed to be normally distributed with a mean of zero and variance δ^2

The presence of multicollinearity and heteroskedasticity in the independent variables were tested. For multicollinearity, a linear correlation coefficient which measures the direction of a linear relationship between two variables was used (Maddala 2001). To quantify the severity of multicollinearity, the Variance Inflation Factor (VIF) was used to measure how much the variance of the estimated regression coefficient is increased because of collinearity as shown in equation 23. According to Greene, (2002) if VIF (βi)>5, then multicollinearity is high.

$$VIF = \frac{1}{1-Ri^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (23)$$

5.2.5 Explanatory variables and their expected influence on Dependent variable

Several factors were hypothesized to influence the adoption of soil and water conservation technologies in the study area. The factors were generally categorized into socioeconomic and institutional factors. The socioeconomic factors included age, gender, education, household size, herd size, and income, while the hypothesized institutional factors were membership in community groups, access to extension services, and land tenure (Table 5.1).

Age: According to the theory of human capital, young heads of household have a greater chance of being taught new knowledge (Sidibe 2005) and, hence, are better prepared for the adoption of technological innovations (Akroush 2017). Since labor and credit markets are imperfect, older household heads lacking the labor necessary for construction and frequent maintenance of conservation structures may not easily adopt soil and water conservation technologies (Zegeye et al. 2001). Young people may also be more receptive to new ideas and are less risk-averse than older people (Barret et al. 2004). In this study, we expected the age of the household head to have both positive and negative effects on the adoption of soil and water conservation technologies.

Gender: Gender represents differences in adoption orientation between male and female heads of households. Gender determines access to resources and assets, particularly in pastoral contexts (Omollo, 2010). Male-headed households have more access to productive resources such as land and livestock compared to their female counterparts, who are constrained by low access to natural resources (Wasonga, 2009). Male-headed households were therefore expected to adopt soil and water conservation technologies more than their female counterparts.

Education: A household head's formal education has a positive effect on the adoption of soil and water conservation technologies because it enhances management skills and the ability to utilize information (Ahmed et al. 2013). Education would expose one to technical skills and knowledge and therefore create awareness and enhance adoption of soil and water conservation technologies (Hatibu et al. 2003). Education was therefore posited to increase the adoption rate of soil and water conservation technologies and was measured as the level of basic education attained by the household head.

Household size: The number of family members was hypothesized to either have a positive or negative influence on the adoption of soil and water conservation technologies. A larger household may have cheap and adequate labor for the construction and management of soil and water conservation technologies as opposed to a smaller household with no cheap labor (Alene et al. 2008). Consumption needs for a larger family may also be high, requiring more resources for the household to meet their family needs and reducing disposable income available for the development of soil and water conservation technologies (Ahmed et al. 2013).

Source of livelihood: The source of livelihood was expected to have a positive influence on the adoption of soil and water conservation technologies. This was measured as the main type of economic activity pursued by households. Households that rely mainly on livestock and crop production are more likely to adopt soil and water conservation technologies due to the environmental benefits of water conservation for livestock and crops (Manyeki et al. 2013), as compared to those who have alternative sources of livelihood.

Herd size: The size of a household herd was expected to have a positive influence on the adoption of soil and water conservation technologies. In pastoral communities, a large herd size is associated with more wealth (Omollo et al. 2018). Livestock is a productive asset that generates future income for households through milk production and calving and is easily sold for cash (Muthee 2006), which means such households can easily afford to develop soil and water conservation technologies. Herd size was measured by the number of tropical livestock units (TLU) in a household.

Household income: Household income was determined by the amount of revenue earned by the household on a monthly basis in Kenyan shillings. The level of household income was hypothesized to have a positive influence on the adoption of technologies. A household with a high income is expected to have enough capital to venture into more capital-intensive activities such as water harvesting structures (Zegeye et al. 2001).

Extension information: In this study, extension information referred to accessing production and market information and training. Extension services provide the requisite technical assistance and skills required for the construction and management of soil and water conservation technologies (Khalid et al. 2017). This increases farmers' knowledge and perception of the merits of soil and water conservation through better access to technical information and training provided by extension personnel (Akroush et al. 2017). Access to extension information was therefore hypothesized to have a positive influence on the adoption of soil and water conservation technologies among households.

Land tenure: Land tenure was measured as the type of respondents' land ownership and was hypothesized to have both positive and negative influences on the adoption of soil and water conservation technologies by households. On the one hand, a lack of tenure would make people reluctant to invest in soil and water conservation technologies on land that they do not formally own. Where land ownership and rights of use are complex, it may be difficult to persuade one to improve land that someone else may use later (Ahmed et al. 2013). This implies that households with private ownership are more likely to adopt the technologies than those with communal ownership. On the other hand, communal ownership of land would mean the community could pool their resources in terms of manpower to develop soil and water conservation technologies with ease, implying that adoption of soil and water structures is more likely under communal land tenure than in the case of private ownership.

Membership in social groups: Based on the study by McKague et al. (2009), community social groups improve cooperation among pastoralists, which enables them to pool their resources together and make proper decisions in the conservation of natural resources, hence increasing their adoption of a new technology (Omollo et al. 2018). Social groups provide social capital and help farmers pool resources for collective action, as well as increasing the capacity of members to access services such as credits, extension, and information, making them more likely to adopt soil and water technologies. Membership in social groups was therefore expected to have a positive influence on the adoption of soil and water conservation technologies.

Table 5.1 Explanatory Variables used in the empirical Binary Logistic Model

Variable	Description	Type of measure	Expected influence
Dependent variable			
Adoption	Whether a HH adopted or not	Dummy (1 if yes, 0 if No)	
Explanatory variables			
Age	Age of the HH head	Years (1, 2, 3)	-
Gender	Gender of the HH head	Dummy (1 if male, 0 if Female	+/-
Education	Education level of HH head	0 = None, 1= Primary, 2=Secondary, 3= College	
Monthly Income	Total income received my a HH in a month	1=<10,000, 2=10000-20000, 3=20,000-30,000, 4=>30000	+
Land tenure	Status of land ownership	1= Private, 2= Community, 3= Public	+
Membership in farm group	Registered member in a farmers group	Dummy (1 if yes, 0 if No)	+
Extension	Extension information and training	Dummy (1 if yes, 0 if No)	+
Active labour	Readily available labour force	Dummy (1 if yes, 0 if No)	+
Credit	Access to agricultural credit	Dummy (1if yes, 0 if No)	+

5.2.6 Perception on soil and water conservation technologies

The decision to adopt a new idea, behavior, or product is an active and dynamic process with interactions between the individual, situational factors, and contextual factors, as well as attributes of the innovation itself (Scott et al. 2008). The key to adoption is that the person must perceive the idea, behavior, or product as new or innovative. Rogers' Diffusion of Innovation Theory (1962) seeks to explain how new ideas are adopted, and this theory proposes that there are five attributes of a new idea or approach that effect adoption: relative advantage, compatibility, complexity, trial ability, and observability (Rogers 2003). An even-point Likert scale (Akroush et al. 2017) was used to assess the above-mentioned characteristics of adopters and gauge their attitudes by asking the extent to which they agree or disagree with their awareness of the need for water harvesting structures and their decision to adopt or reject their initial and continued use.

5.3 Results

5.3.1 Socio-economic characteristics of respondents

Tables 5.2 and 5.3 show the socioeconomic characteristics of the sampled households. The results show that those who adopted the soil and water conservation technologies (N = 204) were associated with a significantly (t (300) = 3.7, p = 0.00) larger herd size (Mean TLU 28.9 ± 16) compared to non-adopters (N = 96) who had a smaller herd size (Mean TLU = 21.9 ± 12.9). Non-adopters were slightly older (Mean = 44.7 years) than the adopters (Mean = 42.6 years).

Table 5.2 Socio demographic characteristics of the sampled respondents

Characteristic	Adopters		Non-adopters			
	Mean	Standard deviation	Mean	Standard deviation	*t*-ratio	sig
Age (years)	42.6	14.5	44.7	11.8	-1.36	0.17
Household size (number family members)	7.2	1.8	6.4	1.8	3.6**	0.03
Herd size (TLU)	28.9	16	21.9	12.9	3.7***	0.00

*****; Significant at 1% level; **: Significant at 5% level; *: Significant at 10% level.**

However, the mean age difference between the adopters and non-adopters was statistically insignificant ($t_{(300)} = -1.36$, $p = 0.17$). Those who adopted had a significantly ($t_{(300)} = 3.6$, $p = 0.03$) larger average size of the households than the non-adopters (Table 5.2). Majority (82.3%) of those who adopted the soil and water conservation technologies were male headed households, while more than half (55.9%) of non-adopters were female headed households. Gender was statistically significant ($\chi 2 = 19.8$, *df* = 1, $p < 0.000$) indicating that male headed households were more likely to adopt the soil and water conservation technologies compared to their female counterparts (Table 5.3). The adopters (86.5%) who were members of community groups were significantly higher ($\chi 2 = 106.9$, df = 1, $p = 0.000$) than the non-adopters (23%). There was no significant difference in the education levels of the adopters and the non-adopters ($\chi 2 = 1.09$, df = 3, $p = 0.78$) with 65.6% and 68.1% of adopters and non-adopters having had basic primary education respectively. The results also show that majority (76%) of the adopters had significantly more ($\chi 2 = 96.2$, df = 1, $p = 0.000$) access to extension services compared to non-adopters (17.6%). The main source of livelihood for majority (84.4%) of the adopters was mixed livestock and crop production compared to most of the non-adopters (60.3%) whose main source of livelihood was cattle keeping. The percentage of adopters (62.5%) who privately owned land was significantly higher ($\chi 2 = 155.94$, df = 1, $p = 0.000$) than that of non-adopters (19.1%) showing that land tenure is likely to influence the adoption of soil and water conservation technologies.

Table 5.3 Descriptive characteristics of respondents

Characteristics	Category	Adopters		Non-adopters		χ^2	Sig
		Frequency (N = 96)	Proportion (%)	Frequency (N = 204)	Proportion (%)		
Gender of HH head	Male	79	82.3	90	44.1	19.8***	0.00
	Female	17	17.7	114	55.9		
Education	None	33	34.4	65	31.9	1.088	0.78
	Primary	52	54.2	108	52.9		
	Secondary	10	10.4	26	12.7		
	College	1	1	5	2.5		
Main source of livelihood	Employment	0	0	7	3.4	146.9***	0.00
	Cattle keeping	12	12.5	123	60.3		
	Farming	3	3.1	25	12.3		
	Business	0	0	23	11.3		
	Livestock and crop production	81	84.4	26	12.7		
Monthly income (Ksh)	<10,000	46	22.5	82	85.4	105.8***	0.00
	10,000- 20,000	116	56.9	12	12.5		
	20,000-30,000	37	18.1	2	2.1		
	>30,000	5	2.5	0			
Land tenure	Private	60	62.5	39	19.1	155.94***	0.00
	Community	36	37.5	165	80.9		
Farmer groups	Member	83	86.5	47	23	106.9***	0.00
	Non-member	13	13.5	157	77		
Extension	Available	73	76	36	17.6	96.2***	0.00
	Not available	23	24	168	82.4		
Access to credit	Yes	78	81.2	12	5.9	48.6	0.00
	No	18	18.8	192	94.1		
Active labour	Available	84	87.5	40	19.6	124.1***	0.00
	Not available	12	12.5	164	80.4		

*****; Significant at 1% level; **: Significant at 5% level; *: Significant at 10% level**

Source: Household interviews (N = 300)

Significantly ($p = 0.000$), more adopters (81.2%) had access to credit and active labor (87.5%) compared to non-adopters. Monthly household income levels were significantly different ($\chi2 = 105.8$, df = 4, $p = 0.000$) between the adopters and the non-adopters, with majority (77.5%) of the adopters making at least more than Ksh.10,000 a month compared to non-adopters (14.6%). These results show that income, extension information, land tenure, availability of active labor, membership in farmer groups, access to credit, gender of household head, herd size and household size are likely determinants of the adoption of soil and water conservation technologies in agro-pastoral areas.

5.3.2 Perception of respondents on soil and water conservation technologies

The results in Table 5.4 show that majority of the adopters (81.2%) believed that soil and water conservation technologies have relative advantage in reducing agricultural risks by enhancing productivity and efficiency in conserving soil and water compared to non-adopters (25.5%). The adopters (77.1% who believed that the soil and water conservation technologies are compatible with their needs was not significantly higher ($\chi2 = 0.7$, df = 1, $p = 0.481$) than non-adopters (72.5%). This means that in terms of the compatibility of soil and water conservation technologies, all the adopters and non-adopters believe that the soil and water conservation technologies are consistent with their needs, and experiences hence they are essential. For soil and water conservation technologies such as water pans and Zai pits, it entails directing runoff from some external catchment area to where it is desired. In ASALs areas where soils often cannot absorb the heavy downpours, ground catchment rainwater harvesting acts as a tool to increase infiltration into the soil and decrease soil erosion. This thus helps to improve yield during a normal year, and more importantly, helps to prevent crop failure when rains are below the seasonal average.

Table 5.4 Perception of respondents about the soil and water conservation technologies

	Adopters		Non-adopters			
	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	χ^2	Sig
Relative advantage in reducing agricultural risks	81.2	18.8	25.5	74.5	82.66***	0.00
Compatible with existing needs and socially acceptable	77.1	22.9	72.5	27.5	0.70	0.481
Complex and difficult to understand and use	12.5	87.5	83.3	16.7	-0.68***	0.00
Triable and easy to follow and implement	55.2	44.8	53.9	46.1	0.044	0.901
Observable benefits	80.2	19.8	78.9	21.1	0.066	0.88

*****; Significant at 1% level; **: Significant at 5% level; *: Significant at 10% level**

Regarding the complexity and difficulty in development of soil and water conservation technologies in their farms, most of non-adopters (83.3%) significantly believed ($\chi2 = -0.68$, df = 1, p = 0.00) that it is quite difficult to construct the soil and water structures and therefore they needed more technical skills and knowledge compared to only 12.5% of the adopters. All the adopters and the non-adopters agreed that soil and water conservation technologies can be tried in demonstration plots before being implemented ($\chi2 = -0.044$, df = 1, p = 0.901). Demonstration farms are the most effective extension education tools for demonstrating technical skills including proper citing of the catchment areas, formulation of technical designs, and building of the structures (Moser and Barrett 2006). For pastoralists, demo plots provide an opportunity to demonstrate and teach appropriate soil and water conservation technologies, as well as venues to test new methods side by side with traditional methods. Although they require considerable time and effort, the payback comes when farmers more readily adapt practices, they perceive to be effective and appropriate under local conditions (Scott et al.

2008). Majority of the respondents (79.3%) agreed that soil and water conservation technologies have observable environmental benefits even though there was no significant difference ($\chi2$ = − 0.066, df = 1, p = 0.088) between the adopters (80.2%) and non-adopters (78.9%).

5.3.3 Factors that determine adoption of soil and water conservation technologies.

Table 5.5 shows that the mean VIF for exploratory variables included in the model was 1.33, which is lower than 5 hence no multicollinearity was detected.

Table 5.5 Multicollinearity test for the explanatory variables

Model variables	Tolerance	VIF
Gender of respondent	.810	1.23
Age of respondent	.782	1.27
Education level	.945	1.05
Main source of livelihood	.573	1.74
Average monthly HH income	.571	1.75
Member of farmers' group	.682	1.46
Extension services	.664	1.51
Land tenure	.804	1.24
Easy access to credit	.759	1.32
Availability of Active labor	.754	1.32
Mean VIF		**1.33**

All the independent variables used were therefore uncorrelated and independent making it appropriate for the model to estimate the relationship between each independent variable and the dependent variable independently. The results in Table 5.6 show that the model is statistically significant (p = 0.00), and the independent variable explains 87.9% (R^2 = 0.879) of the variation in households' decision to adopt the soil and water conservation technologies in the study area.

Table 5.6 Parameter estimates of Binary Logit model

Variable	β	S. E	Wald	Exp (β)	*P value*
Gender	-1.102	.748	2.171	.332	.141
Age	-.011	.025	.181	.989	.671
Education	-.037	.514	.005	.963	.942
Main source of livelihood	.659	.241	7.504	1.934**	.006
Monthly income	2.410	.630	14.645	.090***	.000
Land tenure	-2.220	1.099	4.081	.109*	.043
Extension information	2.159	.726	8.842	.115**	.003
Access to credit	-.556	1.222	.207	.574	.649
Active farm labour	3.623	.827	19.189	.027***	.000
Member of farmer group	3.711	.871	18.157	.024***	.000
Constant	21.149	4.222	25.094		

Statistical significance level: ***1%, **5%, *10%; Chi-square (df = 10) = 296.49 ($p < 0.000$); − 2log likelihood = 79.63; Cox and Snell R^2 = 0.628; Nagelkerke R^2 = 0.879

Out of the ten variables tested in the model, access to extension services and training, monthly income, main source of livelihood, land tenure, membership in community groups and availability of active labor were found to significantly influence the adoption of soil and water conservation technologies by households.

5.4 Discussion

The results imply that households with better economic standing, measured by the total value of their monthly income, are more likely to adopt labor-intensive soil and water conservation technologies. This is because such households are expected to have more disposable income and are therefore able to afford the hired labor required for the construction and management of water harvesting structures. As reported by Manyeki et al. (2013), labor cost for construction and maintenance of soil and water conservation technologies is one of the most important factors that determine adoption of such technologies at the farm level. The results show that many farmers in the study area were low-income earners. This means that they may not afford the manpower to move large amounts of earth that is necessary in some of the large soil and water conservation technologies, such as water pans (Rosegrant and Cai, 2002). Akudugu et al. (2012) reported that modern agricultural production technologies that were capital-intensive were less likely to be adopted. This explains the positive and significant influence of monthly income on the adoption of soil and water conservation technologies. The adoption propensity of most technologies increases with the percentage increase in disposable income because relatively rich households can afford labor and the inputs required for the technologies and are less risk-averse, perhaps reflecting economies of scale (Tigabu and Gebeyehu, 2018). Although most households in pastoral communities rely on family labor, exchange and hired labor are relatively common in labor-intensive technologies (Lugusa, 2015). This means that households with access to exchange or hired labor will be in a better position to adopt soil and water conservation technologies. According to Bardasi et al. (2011), the adoption of labor-intensive technologies might also put a greater burden on family labor, as their time might be reallocated from other households' income-generating activities. Therefore, households without access to family labor or constrained by imperfections in credit and labor markets might face difficulties in hiring (Vandercasteelen et al. 2018) or reallocating family labor away from wage employment to additional farm activities (Barrett et al. 2004). As construction of soil and water conservation technologies is very labor-intensive, adoption might be difficult for labor-constrained households that are unable to invest more person-hours of labor in soil and water conservation technologies.

This explains why the results show that the availability of labor has a positive and significant effect on the adoption of soil and water technologies. Adoption of soil and water conservation technologies requires technical skills, including proper citation of the catchment areas, formulation of technical designs, and building of the structures. Therefore, for effective implementation and subsequent adoption, farmers would require technical know-how and skills (Khalid et al. 2017). In addition, farmers may need to be mobilized, trained on the use of technologies, and sensitized on the potential socioeconomic benefits of adopting them (Adesina and Chianu, 2002), underscoring the role of extension services. The results show that access to extension services has a positive and significant effect on the adoption of soil and water conservation technologies. Extension officers can contextualize new ideas and innovations to suit local realities (Ahmed et al. 2013). It is tempting to assume that a system that works in one area will also work in another, superficially similar, zone. However, there may be technical dissimilarities, such as intensity of rainfall, and distinct socio-economic differences, hence the need for extension officers who understand the local area to contextualize technologies for easier adoption. Extension services in the study area are provided by the county government and development agencies, who, however, remain in the area only for the short duration of the project. This leaves the county government with the sole mandate of providing long-term extension services. In addition, farmers are reluctant to adopt new technologies due to socio-cultural factors such as reluctance to diversify into crop production by the pastoral community and a lack of evidence of the impact of these technologies on production and incomes through demonstration plots. Extension involves field visits and workshops on aspects related to soil and water conservation and other relevant value chains. These include crop planting and growing times, input utilization and value addition, the amount of product to sell on the market, as well as fodder establishment and conservation (Kidake et al. 2016). Improved participation, mobilization, and training of the local people would create an understanding of soil and water conservation technologies and make room for more adoption.

There was a significant influence of land tenure on the adoption of soil and water conservation technologies. The descriptive statistics show that the majority of pastoralists who adopted the soil and water conservation technologies privately owned land. This is partly explained by the fact that households may be reluctant to invest in soil and water technologies on land that they do not individually own, such as communal land. Where land ownership and rights of use are complex, it may be difficult to persuade someone to improve land that someone else may use later. To the contrary, Akroush et al. (2017) found that in Jordanian arid lands, adoption decreased when land was privately owned, and given the fact that the upfront cost of soil and water conservation technologies was too high, farmers were more interested in investing as a group or on communal lands to share the cost of adoption.

Membership in community groups significantly increased the adoption of soil and water conservation technologies. Community groups play a significant role in rural development, particularly in arid and semi-arid areas, by building on the knowledge that underlies socio-cultural practices when looking for new development opportunities. Arasio et al. (2020), while studying the group dynamics in pastoral areas, affirmed that groups are open to adopting external knowledge when it helps them improve their practices. Community groups also improve cooperation among the pastoralists, which enables them to pull their resources together and make collective decisions in the conservation of natural resources (Njuki et al., 2008; McKague et al., 2009). This could explain why membership in community social groups was found to be positive and significant in influencing adoption of soil and water conservation technologies. According to Van Rijn et al. (2012), social capital plays an important role in technology diffusion and adoption because local people are more likely to be motivated to participate with genuine commitment in initiatives that lead to sustainable changes in agriculture and resource management. The positive correlations therefore imply that adoption of soil and water conservation technologies increases with increasing levels of group involvement. This result corroborates the findings of Matata et al. (2010), who in their study on socio-economic factors influencing adoption of improved fallow practices among small-scale farmers in Tanzania found that membership in farmer groups positively influenced adoption of improved fallows.

5.5 Conclusion

This study reveals that both household socio-demographic, economic, and institutional characteristics should be considered in the dissemination of and widespread adoption of soil and water conservation technologies at the household level. The technical aspects of soil and water conservation technologies have been stressed in pastoral areas, though these results show that it takes more than just the engineering aspects. The results demonstrate that the adoption process has a social element and involves collegial interactions. Pastoralists require technical know-how and skills, capital, and organizational support for the successful adoption and use of soil and water conservation technologies. Social and cultural aspects prevailing in an area of concern are therefore paramount and will affect the success or failure of the promoted techniques. There is a need to design and develop alternative, effective policy instruments and mechanisms, strong institutional options for extension services, technical assistance, training, and capacity building that will facilitate the adoption of soil and water conservation technologies through participatory practices to ensure a better fit to the needs of agro-pastoralists. The creation of strong networking among different institutions related to the development of soil and water conservation technologies and the involvement of civil society, public and private financial institutions, and support services could be examples of mechanisms to enhance the adoption of soil and water conservation technologies in pastoral areas of Kenya.

CHAPTER SIX

PASTORALIST'S WILLINGNESS TO PAY FOR SUSTAINABLE RANGELAND MANAGEMENT PRACTICES IN TANA RIVER COUNTY, KENYA

Abstract

Rangeland ecosystems are dynamic and complex socio-ecological systems that support extensive livestock production. However, productivity in arid and semi-arid rangelands currently exhibits a downward spiral trend. Any attempt aimed at enhancing the resilience of rangeland ecosystems and pastoral production systems should therefore give priority to promoting sustainable rangeland management practices, especially those that ensure equitable and sustainable access to pasture and water throughout the year. This study determined socio-economic factors influencing the willingness to pay for sustainable grazing management practices in pastoral areas of Tana River County in Kenya. The data was collected through household interviews, focus group discussions, and key informant interviews. The study used the contingent valuation method to determine the willingness of pastoralist households to pay for sustainable rangeland management practices. The results show that willingness to pay increased with membership in community groups and income. The source of livelihood also had a significant influence on the households' willingness to pay for sustainable grazing management. Membership in resource user associations, traditional governance systems, and the distribution of income among households are therefore factors that require attention in efforts aimed at promoting sustainable rangeland management among pastoralist communities.

Key words: Pastoralism; Rangelands; Willingness To pay, Drylands

6.1 Introduction

Rangelands make up about 41.3% of the world's land surface and 43–45% of Africa's land surface (Mgalula et al. 2021). They are important habitats for wild flora and fauna as well as domestic livestock (Galvin, 2009). The dry lands are predominantly used for livestock production, mainly through pastoralism. Pastoralism is a low-external-input subsistence system based primarily on livestock production. The system is grounded in the strategic exploitation of resources that are not uniformly distributed in space and time (Wasonga et al. 2013). The spatio-temporal variability in water and pasture availability influences the mobility and settlement patterns of pastoral communities, leading to the development of pastoralism as the most suitable livelihood in arid and semi-arid areas (Omolo, 2010).

In Kenya, pastoralists are confronted with a variety of risks that constantly disrupt their livelihoods and devastate their assets. These risks, coupled with limited and increasingly ineffective risk management options, underlie vulnerability in pastoral systems. Some of the challenges facing pastoral communities include land tenure changes, a diminishing grazing resource base, and frequent droughts that undermine pasture and livestock productivity (Huho et al. 2011). The movement of livestock herds is a central component of land management (Galvin, 2009). However, it has been compromised due to declining access to rangeland resources occasioned, among others, by loss of grazing land to agriculture, poor watering point management, conflicts and insecurity arising due to the breakdown of traditional institutions, and social change necessitated by changing human aspirations and economic needs (De Jode, 2009). These challenges undermine rangeland productivity and therefore the ability of pastoral communities to cope with the challenges of complex and dynamic ecosystems (Reid et al. 2016).

For a long time, pastoralists have used various adaptive and flexible risk management strategies and resilience enhancement mechanisms to maintain their lifestyle (Barrow et al. 2007). Some of these strategies include pasture deferral which includes grazing ban near water points during the wet season by having wet and dry season grazing areas, maximizing stocking densities to ensure biomass threshold below which grazing is not allowed to avoid overgrazing, livestock species diversity which involves keeping mixed species of animals such as browsers and grazers to maximize the scarce resources, splitting of herds into satellite herds that graze and browse far away from the homesteads and home-based herds which involve lactating animals and young ones that graze within homesteads, and livestock redistribution among friends and relatives as an insurance (Oba, 2012; Wasonga et al. 2003). Unfortunately, due to changes in policies, increases in human population, and changing lifestyles, a number of these strategies are becoming increasingly constrained, thus affecting the pastoral production system (Reid et al. 2008).

Any attempt aimed at enhancing the resilience of pastoral livelihoods and environments should therefore give priority to promoting sustainable rangeland management, especially those that ensure equitable and sustainable access to pasture and water throughout the year. In Tana River County, Kenya, for example, communities have responded to recurrent droughts, associated perennial pasture scarcity, and increasing demand for forage and water by reviving and strengthening a communal system of governing their grazing patterns to help regulate sustainable use of grazing resources and ensure regeneration of the deteriorating land. The grazing system comprises opinion and religious leaders selected by the community who are guided by customary laws that preserve traditional laws and codes of conduct with amendments and additions based on the evolving environmental, social, and cultural context. Using the system, the communities have distinctly partitioned their grazing land into wet and dry season grazing units and drought grazing reserves. This zoning is designed to cater for pastoralists' needs in different seasons of the year and ensure that the resources are used sustainably. Additional water pans have also been constructed in the wet season grazing areas to ensure that animals do not return to the permanent water sources situated in the dry season grazing reserves before the right time. To maintain the water pans and ensure adherence to sustainable grazing patterns, each household is to pay some money agreed upon by the community. This study therefore sought to determine socio-economic factors affecting the willingness to pay for maintaining sustainable rangeland management practices in pastoral systems in Kenya. This is important in development of appropriate incentives that ensure improved rangeland productivity and provide information that would help in identifying the preferred level of environmental conservation services and designing appropriate policies for sustainable rangeland use and management.

6.2 Methodology

6.2.1 The study area

The study was done in Tana River County, located on the northeastern side of Kenya, as shown in Figure 2. The county is characterized by the spatial-temporal variability of water and rainfall. Seventy percent of the population rely on livestock production as their main source of livelihood (Kipchirchir, 2014). The dominant ethnic groups in the area are the Orma and Wardey, whose lives center on extensive livestock production—primarily cattle and small ruminants, camels, and donkeys—and the Pokomo, who do both livestock and crop farming along the river Tana (Andersson, 2005). The county is prone to droughts and extreme forage scarcity, making nomadic livestock production the most suitable economic activity in these areas (Lutta et al. 20019).

6.2.2 Data collection

The sample size was determined using a multistage sampling procedure. Three sub-counties, namely Bura, Galole, and Garsen, inhabited by agro-pastoralists and mobile pastoralists, were purposefully selected in the first stage of sampling. The second stage involved systematic random sampling to select five locations from each sub-county. At the third stage, sampling was narrowed down to two smaller administrative units (sub-locations) within each location. A simple random sampling technique was used to select ten respondents from each sub-location for the study, giving a total of 300 respondents. A semi-structured questionnaire was used to collect data on the determinants of market participation among smallholder livestock farmers.

6.2.3 Data analysis

A binary logit model (McConnel et al, 1989) was used to establish the factors affecting WTP since the responses were categorical and dichotomous in nature. Logistic model is one of the widely used models where the response variable is dichotomous, taking 0-1 values. WTP is a binary response of either yes or no and the outcome is a probability, which is expressed as Prob (Y = 1) when the answer is yes and as Prob (Y = 0) otherwise. The WTP variable is dependent on other variables of the respondent such as age, gender, level of education and income, source of livelihood, and resource use governance.

The probability of saying "YES" to a bid at different level of the independent variable is estimated as:

$$P_i \quad = E\ (Y = 1/\ X_i) = \frac{1}{1 + e^{-(\beta_1 \ + \beta_2 \ X_i)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(24)$$

Where Y = 1 means the respondent is willing to pay, while X_i is a vector of explanatory variables, and *e* is the base of natural logarithm.

Equation 24 can be re-written as

$$P_i = \frac{1}{1 + \ e^{-z_i}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(25)$$

Where $Z_i = \beta_1 + \beta_2 X_i$

Equation (25) represents a cumulative logistic distribution function. The *Pi*, given in equation (25) gives the probability that the respondents are willing to pay while *(1 – Pi)*, is the probability that all the households decide to pay as shown in equation 26.

$$1 - P_i = \frac{1}{1 + e^{zi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (26)$$

Equation (26) can be simplified as:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (27)$$

$\frac{P_i}{1 - P_i}$ = is the odds ratio that the household is willing to pay grazing management. Hence the natural log of equation (27) can be expressed as follows:

$$L_i = l_n\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_1 + \beta_2 X_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (28)$$

Where L in equation 28, represents the log of odds ratios which is in linear form in *X* as well as in the parameters, therefore, the logit equation can be specified as shown in equation 29.

$$L_i = \left(\frac{P_i}{1 - P_i}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (30)$$

Where:

X = is a vector of socio-economic factors influencing households' willingness to pay

β= is a vector of coefficient to be estimated

ε= is the error term assumed to be normally distributed with a mean of zero and variance δ^2

6.3 Results

The results show that livestock and livestock products were the main source of livelihoods for the communities accounting for 61.8% followed by mixed farming (35.5 %) and lastly formal employment (7%) as shown in Table 6.1. Majority (74%) of the households were headed by males with only 26% headed by females. The results also indicate that more than half of the household heads had basic education with 56.1 % and 14.6% attaining primary and secondary levels of education respectively. Of the three hundred household heads, 75% were willing to pay for the sustainable rangeland management practices.

During the dry season when water and pasture is scarce, 20% of the respondents buy supplementary feeds for their animals, 46.3% move to other areas in search of pasture and water while 29.3% sell their animals (Table 6.2). Some (2%) households split the herds to spread the risks so that the weak and lactating ones remain close to the homesteads and the rest are moved to distant places. Those that move to distant places face various challenges as shown in Table 6.3. Majority (63.3%) reported that violent conflicts, raiding and clashes over land use continually undermine their livelihoods. These, according to focus group discussions hinder the delivery of essential services such as education and human and animal health care adding to the plight of the poor pastoral communities. Transboundary epizootic disease transmission was also a major challenge that affected 15.9% of households that move in search of water and pasture. Some weak animals (12.6%) die on the way due to long distances while 7.6% are attacked by wild animals.

Table 6.1 Socio-economic characteristics of the respondents

Variable	Category	Frequency	Percentage of respondents (%)
Gender	Male	222	74
	Female	78	26
	Single	15	5
Marital status	Married	262	87
	Separated/widow	23	8
Education level	None	87	28.9
	Primary	169	56.1
	Secondary	44	14.6
Source of Livelihood	Formal employment	7	2.3
	Livestock keeping only	186	61.8
	Farming and livestock	107	35.5
Income	< 10000	144	48
	>20000	156	52
Member of User association	Yes	195	64.8
	No	105	34.9
Willing to Pay	Yes	225	75
	No	75	25

Table 6.2 Responses to pasture and water shortages

Responses to feed shortages	Frequency (N=300)	Percentage of respondents (%)
Sell the animal	88	29.3
Migrate to other areas	139	46.3
Buy hay	60	20
Use leased pasture	3	1.0
Hire labour to access distant areas	4	1.3
Split herd to spread risks	6	2

Table 6.3 Challenges faced by migrating pastoralists.

Challenges faced when moving	Frequency (N=300)	Percentage of respondents (%)
Conflicts	189	63.3.
Disease outbreaks from animals of different areas	47	15.6
Some animals die due to long distances	38	12.6
Attacks from wild animals	22	7.3
Unable to access markets	4	1.2

To determine factors influencing the WTP for improved rangeland management practices, the presence of multicollinearity and heteroskedasticity in the independent variables were tested. For multicollinearity, a linear correlation coefficient which measures the direction of a linear relationship between two variables was used. To quantify the severity of multicollinearity, the Variance Inflation Factor (VIF) was used to measure how much the variance of the estimated regression coefficient is increased because of collinearity as shown in Table 6.4. The result show that the mean VIF was 1.2 which is lower than 5 hence no multicollinearity. According to Greene, (2002) if VIF (βi)>5, then multicollinearity is high.

Table 6.4 Multicollinearity test on the independent variables

VARIABLE	VIF	1/VIF
Source of livelihood	1.41	0.707
Marital status	1.34	0.746
Group membership	1.24	0.806
Buy supplementary feed	1.15	0.867
Education level	1.14	0.877
Gender	1.13	0.888
Level of income	1.10	0.908
Age	1.08	0.924
Mean	**1.20**	

As shown with the result of the coefficient of determination R^2 in Table 6.5, 79% of the variation in the maximum WTP in the sample can be explained by independent variables. The level of significance of each variable was tested using the null hypothesis that these explanatory variables have no effect on the maximum WTP. The results in Table 6.5 show that the model is statistically significant (p = 0.00) with a log likelihood function of -38.18.

Table 6.5 Factors affecting Willingness to Pay for sustainable grazing management.

WTPAY	**Coef.**	**S. E**	**Wald**	***P value*|**
Buy-feed	1.360	.681	2.00	0.56
Source of livelihood	3.712	.654	5.68	0.000***
Group membership	1.388	.642	2.16	0.031*
Level of income	2.029	.433	4.69	0.000***
Level of education	1.602	.646	2.48	0.013**
Age	.005	.024	0.21	0.831
Gender	-683	.728	-0.94	0.349
Marital status	2.814	.732	3.85	0.000***
Constant	-9.839	2.01	-4.91	0.000
Number of observations (n)				300
Pseudo R^2				0.795
Log likelihood				38.17

Statistical significance levels: ***1%, **5% and *10% respectively

The marginal effects of the membership in resource user association reveal that households in resource user associations have 15.7 times greater chances of paying for the sustainable rangeland management practices than those who are not in any conservation group. Those who purchase feed are 13.4 times more willing to pay for sustainable rangeland management practices while those with higher income and education levels are 19.7 and 16.4 times more likely to pay for the sustainable rangeland management respectively as shown in Table 6.6.

Table 6.6 Marginal effects of the model.

Variable	Coef.	S. E	Z	P Value
Buy feed	.135	.069	1.93	0.053
Source of livelihood	.362	.107	3.37	0.001***
Group membership	.157	.089	1.77	0.077*
Level of income	.198	.058	3.41	0.001***
Level of education	.165	.075	2.19	0.028**
Age	.0005	.002	0.21	0.831
Gender	-.062	.063	-0.99	0.321
Marital status	.406	.132	3.08	0.002***

Statistical significance levels: ***1%, **5% and *10% respectively

6.4 Discussion

Rangeland degradation is receiving much-needed attention following the establishment of the Sustainable Development Goals (SDGs) by the United Nations in 2015, with their recognition of increasing threats to current and future land productivity and the provisioning of ecosystem services (UN, 2015). These threats include increasing demands for grazing land, food, energy, and water, loss of soil fertility, and conflicts over land accessibility and use. They are exacerbated by unsustainable rangeland use, poor management practices, climate change, and continuing high rates of land degradation. Rangeland degradation can be reversed by consequently applying sustainable grazing management practices, whose benefits outweigh the cost by almost seven times (Nkonya et al. 2011). The justification of investments in natural resource management depends on the nature and magnitude of the social and economic benefits the investment brings to society and individuals. Willingness to pay (WTP) has been used as a proxy indicator for the incentives accruing from social benefits. Various socio-economic factors affect the willingness to pay for sustainable grazing management practices in pastoral systems. The membership in resource user groups, source of livelihood, income, education levels, and marital status were highly significant in affecting the willingness to pay.

The results show that the source of livelihood has a positive and significant influence on the willingness to pay for sustainable grazing management practices. Those pastoralists whose only source of livelihood is livestock production are more willing to pay than those who have other alternatives as their primary source of livelihood, such as farming. This is because pastoralists, whose main economic activity is livestock production, derive more utilities from sustainable rangeland management practices that would provide more biomass and water for their animals across the seasons.

Resource user associations also play a significant role in the sustainable management of natural resources in pastoral communities whose land is communally owned. This could explain why membership in the resource user association was found to be positive and significant. The leadership of resource user groups is part of the traditional governance system and participates in decision-making at the local level. In pastoral communities, the leadership of the traditional governance systems is highly respected, and members are more convinced that they can ensure equitable access to the resources, and therefore they are more willing to pay for the conservation of the resources (McKague et al. 2009).

The leadership of the resource user groups plays an influential role in mediating conflicts, managing natural resources such as water, and administering other functions through customary law. These functions are mainly informed by cultural practices and customary rules. Traditional systems of governance characterize most forms of administration and governance in the study areas of Tana River County. The traditional systems of governance channel the desired stakeholder participation in a way that helps to address some of the chronic problems that constrain resource management, such as low levels of awareness, poor land and water use practices, low levels of compliance with regulations, and a lack of proper monitoring (Muricho et al. 2017).

According to Robinson and Berkes (2011), multilevel participation where all levels of institutions are networked may increase the adaptive capacity of communities and enhance their resilience to environmental changes. Therefore, the traditional governance systems, which comprise the leadership of the resource user associations, when strengthened, can ensure proper use of the range of resources, which enhances the confidence of the community in participating in resource management. According to McKague et al. (2009), social groups improve cooperation among pastoralists, which enables them to pull their resources together and make proper decisions in the conservation of natural resources, hence increasing their willingness to pay.

The levels of income earned by a household significantly influenced their willingness to pay for rangeland practices. Pastoralists who earned more income per month were more likely to pay for sustainable rangeland management practices than those who earned less. This could be due to budget constraints, where consumers may not be willing to pay when the payment is beyond their budget, with those with higher incomes affording to pay with ease. Demand for a good has to do with consumer choices, which are influenced by changes in benefits and costs, and this depends on income. This is, however, in contrast with the findings of Wattage and Mardle (2008), who found that household income was not significant in explaining the WTP because of wide variations of income in a pastoral community, while other studies like Prasher et al. (2006) and Thang and Bennett (2007) found that household income positively influences the willingness to pay for management of natural resources.

Similarly, the level of education had a significant influence on the willingness to pay for sustainable rangeland management practices. Educated people are assumed to have knowledge of the importance of natural resource conservation, and their understanding of the significance of sustainable resource management enhances their willingness to pay (Kisamba-Mugerwa, 2006). This is evident in the marginal effects of education in the model, where those who had higher levels of education were more willing to pay for sustainable rangeland management practices than those who were not educated because they were more enlightened on the importance of resource use maintenance and conservation. These results are similar to Kisamba-Mugerwa's (2006) findings, which revealed that educated household heads were more likely to invest in rangeland improvements due to their understanding of the effects of resource degradation and its negative impact on the productivity of the rangelands.

Marital status also had a positive and significant influence on willingness to pay. Those individuals who were married were more willing to pay for sustainable rangeland management. This was expected, especially in pastoral communities where, for any man to marry, he must have a certain number of animals (Gurmu et al. 2014). Therefore, the majority of married couples have animals that will require forage and water that sustainable rangeland management practices are more likely to provide, hence their positive utility. The married couples may also have extra needs than those who are not married, such as taking care of their children, providing food for the families, and paying school fees, which all must come from livestock production (Gurmu et al., 2014). The married couples whose main source of income comes from livestock and livestock-related products therefore must ensure that the animals have enough pasture and water (Amoo et al., 2017); hence, they are more likely to pay for sustainable grazing practices that will enhance livestock production. Similarly, since they are married with myriad responsibilities, they may not be willing to travel for very long distances in search of pasture and water; they would prefer to stay around homesteads and not move to very distant places in search of water and pasture. This explains why they are more willing to pay for sustainable grazing management practices.

6.5 Conclusion

The findings of the study show that membership in community groups, income, and source of livelihood have a higher influence on willingness to pay for sustainable rangeland management. Membership in resource user associations, traditional governance systems, and the distribution of income among households are therefore factors that policy and strategic actions should give priority to in a bid to improve the welfare of pastoral communities. In an ecosystem where the grazing resource base is shrinking due to unsustainable grazing practices, pastoralists are willing to pay for sustainable rangeland management practices that would guarantee adequate pastures and water.

CHAPTER SEVEN

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 General Discussion

The degradation of rangeland ecosystems in Tana River County has rapidly increased, posing daunting challenges to achieving sustainable development and poverty reduction among the pastoral communities. This has resulted in environmental challenges that lead to the loss of land productivity (Kipchirchir, 2014), which in turn leads to deteriorating livelihoods (KIRA, 2014), where most of the rural poor heavily depend on natural resources. The resulting scarcities are often exacerbated by prohibiting and dispossessing communities of access to land, water, and grazing resources for communities whose main livelihood is livestock production and small-scale farming (Okal et al. 2020). In Tana River County, rangeland degradation manifests itself in the loss of vegetation cover and an increase in the proportion of bare soil surface. Due to these factors, rangeland degradation is particularly severe as the soils are highly erodible and the natural vegetation is scanty due to a combination of harsh climate and overgrazing. The rangeland ecosystems in the county are also facing extreme impacts from climate change, in addition to frequent drought and flood events that have had significant social and economic impacts on the communities in Tana River County. Severe droughts are increasingly being felt, with negative consequences for, among others, food production and water scarcity. The droughts have seriously affected the most vulnerable sectors in the county, including agriculture, forestry, health, water, industry, business and trade, tourism, and services (Okal et al., 2020).

Poor land governance, mostly destruction of natural vegetation through activities such as overgrazing, encroachment, and illegal tree felling for fuel and timber, and unsustainable crop farming practices have caused increased runoff, flash flooding, reduced infiltration, soil erosion, and siltation in the water pans and other water reservoirs.

The causes of land degradation identified in the study, such as unsustainable abstraction and exploitation of biodiversity, invasive species, and soil erosion, are mediated and altered by the institutional environment. The demand for fuel wood is one of the major drivers of deforestation in these areas. As a result, forests and woodlands are rapidly being degraded, while biodiversity is increasingly getting depleted, negatively affecting the basic ecosystem services, particularly in areas with no formal protection. According to Westerberg (2016), unsustainable rangeland use practices leave the land near bare throughout the year, reducing the hydraulic conductivity of the soil (Leauthaud et al. 2013). This results in surface runoff and floods that inundate homes and villages and disrupt transportation networks, ultimately affecting food security and market distribution systems.

Land improvement and mitigation of land degradation can come about through behavioral change among land users and their subsequent re-allocation of resources to land-improving practices. The land users' decisions regarding their resource allocation will depend on contextual factors such as incentives, knowledge, capabilities, or access to resources. These are partly a function of their socio-economic characteristics and partly the outcome of the institutional environment that enables and constrains their actions. Responsible land governance has great potential to be one of the cornerstones of achieving sustainable rangeland use and productivity. Land degradation has become a major challenge in arid and semi-arid areas because fertile soils are a non-renewable resource over human time spans, as their formation and renewal could take hundreds, if not thousands, of years. For this reason, the human management of communal rangeland resources will have wide-ranging consequences for human security for generations to come.

7.2 Conclusion

This study presents a qualitative and quantitative assessment of the economic value of rangeland management practices in the pastoral areas of Tana River County. The aim of the study was to value the economic contribution of the impacts of rangeland management practices by specifically looking at the economic analysis of pastoralists' preferences for rangeland management practices, the economic values pastoralists attach (welfare impacts) to the effective rangeland management practices and determinants of their adoption, as well as the socio-economic factors influencing the willingness to pay for rangeland management. Based on the results, most of the land in the pastoral community is communally owned. Weak statutory and customary institutions that govern communal land result in unsustainable land use. The causes of land degradation identified by the respondents, such as unsustainable abstraction and exploitation of biodiversity, invasive species, and soil erosion, are mediated and altered by the institutional environment. While community rangeland management approaches involve the implementation of technical practices, it is clear from the results that implementation of the practices depends on social and institutional capacity and that this will often require investment: for example, capacity development for community rangeland management organizations and strengthening the accountability of these organizations to their communities. Attention must also be directed to ensuring that the right incentives and a favorable policy environment are in place, including elements such as equitable land tenure systems and frameworks that enable the appropriate mobility of livestock herds.

The results of the study have also shown that the impacts of biophysical and socio-economic factors on pastoral communities are context-specific and must therefore consider how different elements interact at the landscape level, within or among ecosystems, and as part of different institutional arrangements and political realities. The broader institutional environment plays a major role in determining the sustainability of sustainable rangeland management practices, especially those aimed at conserving communally owned resources.

Including non-market valuation is critical to inform decisions on resolving rangeland degradation through economic tools, as many of these values take place outside of the current market values and thus rangeland valuations. Objective metrics, like economic values, provide a way for different stakeholders to compare the tradeoffs of alternative future options or scenarios and thus deliberate on rangeland issues from an equally informed position. Considering rangeland issues from the perspective of the economic values that nature provides involves measuring and valuing all the benefits of rangelands and rangeland-based ecosystems and the services they provide, including the losses incurred when the range is degraded. Combining this information with a thorough understanding of the economic drivers of rangeland degradation, the willingness to pay for restoration of the range, and the stakeholders' needs for the adoption of sustainable rangeland management approaches can support better decision-making for sustainable rangeland management. In pastoral areas, complete incorporation of the value of ecosystem services from rangelands through adequate valuation data and assessments would provide concrete arguments as to why stewardship of rangeland biodiversity is crucial to pastoral livelihoods, thereby reducing rangeland degradation.

7.3 Recommendation

The following recommendations arise from the results of the study:

- Pastoralists were found to attach a lot of value to herd mobility as a key strategy for tracking variable pasture and water in time and space. Interventions aimed at achieving sustainable rangeland management should therefore consider enabling mobility as a management strategy.

- The net present value of taking action against rangeland degradation remains positive and considerably high despite changes in discount rates, providing the obvious logic of investing in sustainable rangeland management and supporting its implementation through policy. Incorporating economic valuations in decision-making and providing economic justification for expenditures on rangelands ‘natural capital can therefore help to connect often diametrically positioned sectors of the environment. Mapping the net benefits of rangeland management practices and their preferences may consequently lead to the identification of on-the-ground actions that are economically efficient and sustainable for a given context.
- The holistic valuation of rangeland resources shows how different actors depend on nature. Because of this, the complexity of rangeland's capital management at all scales will require the integration of many types of knowledge, from traditional and local to scientific and universal, and the cooperation of stakeholders at all levels. Ensuring cross-sector collaboration may require engagement with a higher level of government to enable decisions that are made in the interest of the county as a whole rather than narrow sectoral interests. This is only possible when the stakeholders understand the value of the rangelands and exploit the opportunities available for achieving sustainable rangeland management.
- The results demonstrate that the adoption of soil and water conservation technologies has a social element and involves collegial interactions. Pastoralists would therefore require technical know-how and skills, capital, and organizational support for the successful adoption and use of sustainable technologies. It is important to design and develop alternative, effective policy instruments and mechanisms, strong institutional options for extension services, technical assistance, training, and capacity building that

will facilitate the adoption of rangeland management technologies through participatory practices to ensure a better fit to the needs of communities.

- In this study, not all values were included in the economic valuation and assessment of rangeland ecosystem services due to the limitations of time, capacity, and capital. For example, the value of rangelands in carbon sequestration was not included, although this is an important ecological service with current climate change and variability. The valuation of carbon sequestration requires time series data and not a static data set, which would not have been possible during the short period of the survey. These estimates need to be included in the economic valuation of rangelands and remain a key area in need of further research.

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APPENDICES

Appendix 1. Household survey questionnaire

Dear Sir/Madam

The University of Nairobi together with partners is working with the community of Tana River on the project called 'Economic valuation of rangeland management to enhancing the value of ecosystem services in pastoral systems. The desired outcome of the project is to identify rangeland management options that will strengthen the long-term livelihoods of the communities by ensuring adequate forage and water for all the communities living in pastoral areas. A review of current rangelands management practices in use and their impacts on water, forage and biodiversity related ecosystem services was done here during the workshop that involved the communities of Tana River. During this workshop we were able to identify the best practice that can enhance delivery of these ecosystem services together with your representatives. The improved grazing management practice that we propose is expected to ensure that there is adequate forage and water for use by all the users of the grazing areas. The improved grazing practice is also expected to reduce the amount of sedimentation which oftentimes affects the water storage capacity of rivers and dams. This assignment is therefore meant to assess the economic potential that the improved grazing practices will have in improving the livelihoods of the community and restoring degraded lands as results of their implementation in the study areas.

The **purpose of this survey** is to obtain information on various aspects of sustainable rangeland management practices in this area. Your participation in answering questions on these issues is highly appreciated. Your responses will be analysed together with those from other households. The results of this survey will be used to inform policy makers on better grazing management aspects that have a significant economic value to the society through enhanced grazing management that result in more water and forage for animal use. **Confidentiality** will be maintained on all information that you provide. I would like to request your permission to begin the survey now.

RESPONDENT'S CHARACTERISTICS

1 Gender	2.Age	3.Marital status	4.Relationship to household	5.Education	6.Main source of livelihood
Male 1 Female 2		Single 1 Married 2 Divorced 3 Separated 4 Widow 5	Household head 1 Spouse 2 Son/daughter 3 Other relative 4	None 1 Primary 2 Secondary 3 College 4	Employment 1 Cattle keeping 2 Farming 3 Business 4 Others (Specify)_____

7. What is your approximate average monthly household income from all sources?

Income category	Tick one
Ksh.10,000 or less	
Ksh.10,000- 20,000	
Ksh.20, 000-30, 000	
Ksh.30, 000- 40,000	
Ksh.50, 000 and above	

8. Ownership of grazing land
    1. Private
    2. Community
    3. Family
    4. Government

9. If private, what is the size of your land in acres________

10. Do you own livestock? 1 Yes 2. No

11. If yes, what is the size of your herd? Cattle_____ Sheep_____ Goats____ Others___

12. Do you have enough feed for the above livestock throughout the year? 1. Yes 2. No
    If yes, skip to Q17

13. If No, do you usually buy supplementary feeds for the animals? 1. Yes 2. No

14. If yes, what type of feed did you buy in the last dry season? ___________________

15. What was the price per kg of the feed you bought? __________

16. How much (Kilograms) of feed did you buy? ______

17. Are you a member of any user association group? 1. Yes 2. No
    If No, skip to Q20

18. If yes, do you pay any membership fee? 1. Yes 2. No

19. How much do you pay per year?

20. What do you do when there is a severe drought? 1. Sell animals 2. Move to new area

21. If you sell the animals, how many did you sell and what was the average price per animals? Number sold __________Price per animal________

22. What is the nearest livestock market…………………….

23. What is the average distance to the nearest market………………….(In Km)

24. If you, move where do you go to? ____

25. Would you stay in one play if there was enough forage and water throughout the year?

26. If yes, would you pay some fee for the maintenance of forage and water in the grazing area?

CHOICE EXPERIMENT

27. Tick one box for each statement.

Statement	1.Strongly agree	2. Agree	3. Disagree	4. Strongly Disagree
Forage and water scarcity is a serious challenge				
I am satisfied with current availability of forage and water				

28. If you consider having an improved grazing management system, how important would these features be in your opinion?

Attribute	**1.Not important**	**2.Moderately important**	**3.Very important**
More water pans in the grazing areas			
Grazing ban in wet season near water points			

Forage yield			
Increased water storage capacity of rivers and pans through reduced sedimentation			
Biomass threshold to stop grazing			

The improved grazing management practice will have the following attributes:

Grazing Attributes	**Description**	**Levels**
Addition of water pans	Addition of water points not large enough to affect water flows in the grazing areas	No Yes
Biomass threshold to stop grazing	The minimum amount of forage below which grazing is restricted	100 kg/ha 200 kg/ha 50 kg/ ha
Grazing ban	Grazing ban during the peak of the wet season	One month Two weeks
Forage	Amount of forage produced	Higher forage yield Medium forage yield Lower forage yield
Influence on water storage capacity in the rivers and pans	Storage space for water in the pans and rivers resulting from the reduced/increased sediment deposited in the pans and rivers.	More water storage capacity Less water storage capacity
Annual fee per animal head	Annual fee paid for membership in all grazing areas	Ksh.200 Ksh.350 Ksh.500

Now I will show you different types of grazing management practices that can be made by combining these features which will have different impacts.

Please compare the various types of grazing management practice shown each time and indicate **ONE** which you prefer.

Scenario 1

	Alternative A	Alternative B	Alternative C
Addition of water-pan	No	No	No
Biomass threshold to stop grazing	50 kg/ha	200 kg/ha	No threshold
Grazing ban near water points in the wet season	Two weeks	Two weeks	No grazing ban
Forage produced	Medium yield	Medium yield	No extra forage produced
Influence on water storage capacity in rivers and pans	More water storage capacity	More water storage capacity	No influence
Annual membership fee	Ksh.350	Ksh.500	No membership fee
Which alternative do you prefer?			

Scenario 2

	Alternative A	Alternative B	Alternative C
Addition of water pans	Yes	Yes	No addition of water pans
Biomass threshold to stop grazing	200 kg/ha	100 kg/ha	No threshold
Grazing ban near water points in the wet season	One month	Two weeks	No grazing ban
Forage produced	Medium yield	Lower yield	No extra forage produced
Influence on water storage capacity in rivers and pans	Less water storage capacity	Less water storage capacity	No influence
Annual membership fee (Ksh)	200	200	No membership fee
Which alternative do you prefer?			

Scenario 3

	Alternative A	Alternative B	Alternative C
Addition of water pans	Yes	No	No addition
Biomass threshold to stop grazing	100 kg/ha	100 kg/ha	No threshold
Grazing ban near water points in the wet season	One months	2 weeks	No grazing ban
Forage produced	Lower yield	Medium yield	No extra forage produced
Influence on water storage capacity in rivers and pans	Less water storage capacity	More water storage capacity	No influence
Annual membership fee (Ksh)	200	500	No membership fee

Which alternative do you prefer?			

Scenario 4

	Alternative A	Alternative B	Alternative C
Addition of water pans	No	Yes	No addition
Biomass threshold to stop grazing	50 kg/ha	200 kg/ha	No threshold
Grazing ban near water points in the wet season	One month	Two weeks	No grazing ban
Forage produced	Higher yield	Higher yield	No extra forage produced
Influence on water storage capacity in rivers and pans	More water storage capacity	Less water storage capacity	No influence
Annual membership fee (Ksh)	500	200	No membership fee
Which alternative do you prefer?			

Scenario 5

	Alternative A	Alternative B	Alternative C
Addition of water pans	No	Yes	No addition
Biomass threshold to stop grazing	100 kg/ha	50 kg/ha	No threshold
Grazing ban near water points in the wet season	Two weeks	One month	No grazing ban
Forage produced	Higher yield	Higher yield	No extra forage produced
Influence on water storage capacity in rivers and pans	Less water storage capacity	More water storage capacity	No influence
Annual membership fee (Ksh)	350	350	No membership fee
Which alternative do you prefer?			

Scenario 6

	Alternative A	Alternative B	Alternative C
Addition of water pans	Yes	No	No addition
Biomass threshold to stop grazing	200 kg/ha	50 kg/ha	No threshold
Grazing ban near water points in the wet season	2 weeks	One month	No grazing ban
Forage produced	Lower yield	Lower yield	No extra forage produced

Influence on water storage capacity in rivers and pans	More water storage capacity	Less water storage capacity	No influence
Annual membership fee (Ksh)	500	350	No membership fee
Which alternative do you prefer?			

Appendix 2: Question guide for focus group discussions

Objective

The main aim of the Focus Group Discussion is to obtain some general information on grazing management practices. Everyone's opinions are very important and you are all encouraged to participate fully in this discussion. The discussion will take about two hours to complete. I now request your permission to begin the discussion.

Sub-County__________ Village name __________Date________________

Questions for Discussion

1. What is the average size of the herd that are kept by the households?
2. Do you have enough feed for the above livestock throughout the year?
3. If No, do you usually buy supplementary feeds for the animals? If yes, what type of feed do you buy? What is average price of the feed bought?
4. Do you have any user association groups around?
5. What is the importance of having the user association groups such as WRUAs?
6. What are some of the challenges faced in the Resource user groups?
7. Do you pay any membership fee? If yes, is it monthly or annually? And how much do you pay?
8. Why do you pay for the membership fee?
9. What do you do when there is a severe drought? 1. Sell animals 2. Move to new area
10. If you sell the animals, what is the average price per animals?
11. If you, move where do you go to? And what are the challenges you face when migrating with the animals? How do you deal with them?
12. Would you stay in one play if there was enough forage and water throughout the year?
13. If yes, would you pay some fee for the maintenance of forage and water in the grazing area?
14. Do you have water pans around? How do you manage them and what are the challenges you face in managing them?
15. Do you have designated wet and dry season grazing areas? If yes, what are some of the challenges you face in the management of the grazing areas?
16. How do you ensure reduced overgrazing?
17. What can be done to ensure proper grazing management practices are upheld?

CHOICE EXPERIMENT

18. Do you agree or disagree with the following? What are your views on the same?

Statement	1.Strongly agree	2. Agree	3. Disagree	4. Strongly Disagree
Forage and water scarcity is a serious challenge				
I am satisfied with current availability of forage and water				

19. If you consider having an improved grazing management system, how important would these features be in your opinion?
    a) Construction of water pans in the wet season grazing areas
    b) Grazing ban near permanent water points in the wet season (Having dry and wet season grazing areas)
    c) Maximizing livestock densities in an area for short period of time (Forage threshold to avoid overgrazing)
    d) Having increased forage yields
    e) Having more water levels in the pans and rivers

20. What are your views with following levels of grazing management practices? Do you agree with them?

Management attributes	Description	Levels
Construction of water pans	Addition of water in the wet season grazing areas	No Yes
Forage threshold below which grazing is not allowed	The minimum amount of forage below which grazing is restricted	High threshold Medium threshold Low threshold
Grazing ban in wet season near water points	Grazing ban during the peak of the wet season to reserve pasture for dry season	Two months Six months
Increased forage yield	Amount of forage produced	High forage yield Medium forage yield Low forage yield
Water level in the rivers and pans	Water levels in the pans and rivers resulting from the reduced/increased sediment deposited in the pans and rivers and more infiltration	More water storage Less water storage
Annual fee per household	Annual fee paid for membership in the use of grazing areas	KSh.600 KSh.720 KSh.900

THANK YOU FOR YOUR PARTICIPATION!