RANGE RESEEDING DYNAMICS AND THE HETEROGENEITY OF PASTORALISTS FROM LAKE BARINGO, KENYA

by

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A Thesis Submitted to the Faculty of the

SCHOOL OF NATURAL RESOURCES AND THE ENVIRONMENT

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2020

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

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Final approval and acceptance of this thesis is contingent upon the candidate's submission of the final copies of the thesis to the Graduate College.

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ACKNOWLEDGEMENTS

I give my sincere appreciation to all the people who made the completion of my master's program a success. I would like to thank my co-advisors Jeffrey S. Fehmi and Anna Josephson for their guidance throughout my graduate program. Thanks also to Mitch McClaran for serving on my committee and providing support throughout this process.

Special thanks to the Rehabilitation of Arid Environments (RAE) Trust team and specifically to Elizabeth Meyerhoff for her guidance and resourcefulness in the development of my research long before I even started my graduate program. I acknowledge the efforts of Joseph Kulei, Bernard Lenariach, Raphael Kimosop and the rest of RAE team who helped me during the data collection process.

I would also want to thank the University of Arizona for providing a conducive environment to study. Special thanks to the Fulbright Program for believing in my dreams and sponsoring my education, and also to the Harry Wayne Springfield grant for generously funding and supporting my field work. To my friends and family here in the USA and back in Kenya, I am indebted for your love, patience and support over the last two years. And to all who accorded me support of any kind and are not mentioned, receive my unreserved gratitude.

My sincere gratitude to the Almighty God for his continued grace, love and good health during this research and my entire studies.

Diana Githu
May, 2020

DEDICATION

This project is dedicated to my parents Mr. and Mrs. Githu, my brother Joseph, my sisters Grace and Irene, and my niece Shantel with lots of love and appreciation for their patience and encouragement. Without your support, this would have been a tough and impossible journey. May God accord you good health, joy, peace and long life.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

“Pastoralism is not just a question of one animal [human being] following another [livestock]; people need to know that the pastoralist is a hero who has overcome adverse conditions of nature to make a viable livelihood.”

Asst. Minister Ali Wario,
Ministry of Special Programs
Office of the President; Republic of Kenya

Abstract

Land degradation, climate variability, socio-economic changes and population increase, are shrinking grazing lands making forage availability less predictable and affect the resilience of pastoralists communities. Interventions to improve pastoralists' resilience include the introduction of policies that offer pastoralists alternative sources of livelihood and encourage livelihood diversification that is climate-proof. Though viable, these interventions are not sustainable and often fail because they lack to embrace the needs, aspirations and preferences of these uniquely cultured communities. This research taps into the potential of range reseeding as an intervention that can rehabilitate degraded lands for profitable use ultimately improving their resilience to climate variability and other interrelated challenges by engaging in diverse income generating activities without having to change their culture which is entirely livestock based. This study uses two pastoral communities, the Tugen and the Njemps from Lake Baringo, Kenya to study the dynamics of range reseeding as pastoralists who own, manage and use reseeded fields. The study interviews 193 pastoralist households and determines characteristics of adoption of the range reseeding exercise, field use, herd characteristics and the challenges of the different localized geographical landscapes to these two communities. The results suggest that these communities are different in several ways. The Tugen community initially reseed more fields than the Njemps, but later, the Njemps reseed more fields and of larger sizes. The two tribes also differ in their field use with Tugen participating more in cutting thatching grass while the Njemps prefer to engage in fattening programs, two activities with varying levels of profitability. Each community also faces different sets of challenges based on their geographical landscapes. Invasive species and short-term flooding are the greatest challenge among the Njemps, while insecurity resulting from resource-based conflicts is common among the Tugens. The average survival rate for livestock following the 2019 drought was 75% with both communities having similar herd sizes per household. Through these findings, the study advocates for range reseeding to be replicated and up scaled into other dry land counties of Kenya and Sub-Saharan Africa as a possible intervention to improve resilience to climate variability and a strategy for poverty alleviation. At the same time, it cautions on the importance of accounting for heterogeneity of communities that benefit from interventions.

Key words: Land degradation**,** variable climate, sedentarization, sustainable range management.

INTRODUCTION

Land degradation reduces biodiversity and ecosystem function and productivity due to disturbances from which the land cannot recover from unaided (UNCCD, 2020). Disturbances can include human activities and habitation patterns such as unsustainable agriculture, over grazing by livestock and over exploitation of forests and woodlands resources (Lobell et al., 2008). These human activities result in soil erosion, deterioration of the physical, chemical, and biological properties of soil and long-term loss of natural vegetation (UNCCD, 2013) which in turn take away the capacity of the land to provide regulating, socio-cultural, and supporting services (Irwin et al., 2007). Given that rangelands (drylands) comprise the majority of terrestrial land worldwide (Lund, 2007) and its inhabitants depend on the land for sustenance, land degradation is a problem of global concern widely affecting the sustainable development of many regions in the globe, especially Sub-Saharan Africa (Nkonya et al., 2016). Land degradation is increasingly linked to food insecurity, vulnerability to climate change and poverty (UNCCD, 2020).

Land degradation, including conversion to cropland and climate change, coupled with demographic pressure affects the people who depend on rangeland resources. Degradation of rangelands is especially problematic because these lands are usually characterized by biophysical limitations including low biomass production due to constraints related to soil, temperature, and water availability making the living conditions naturally harsh (Lund, 2007). Over 600 million people depend on rangelands for their livelihoods, majority of whom are pastoralists. Pastoralism supports people on less productive land and includes the fundamental aspect of mobility where people and their animals move in search of pasture and water for their livestock. The pastoral culture has social systems ensuring that animals efficiently convert limited ecological resources into sustenance based on their knowledge of the surrounding ecosystems (Ayal et al., 2018). In addition to land degradation, pastoral societies also face many threats to their way of life caused by challenges related to climate change, political and economic marginalization, inappropriate development and increasing resource competition (Kirkbride, 2008).

The most extreme predicted effects of climate change occur in the deserts and grassland areas – the rangelands – the very same ecosystems on which pastoralism thrives (Villamor & Badmos,

2016). The pastoralists culture is based in the resilient adaptation to variable weather and land condition amidst diminishing range resources, though there are limits to their resilience (Meybeck et al., 2012). As droughts increase in intensity, duration and extent of the physical climatic anomaly of exposure (Arnell, 2016) and the non-pastoralist population grows, the result is loss of herding lands to private farms, ranches, game parks, and urban areas, making it difficult for pastoralists to adapt to changes in the external environment (Opiyo et al., 2014). Further, national development plans often also fail to acknowledge pastoral economies and continue to marginalize them on the basis of their geographical remoteness and ethnicity (Kirkbride, 2008; Husmann, 2016). Many governments still find the pastoral culture to be outdated, needing replacement with modern livelihood systems (Vetter, 2005). As a result, development projects among pastoral communities fail to embrace significant aspects of the pastoral culture which limits their potential to live sustainably. Introduction of sedentary policies among pastoralists is an example of failed policy interventions as it limits mobility which is the backbone of the pastoral culture (Reed & Stringer, 2016).

Sustainable rangeland management considers environmental, economic, and social values and attempts to integrate them to achieve long term benefits. With sustainable management, rangelands can support livestock and the people that depend on them over the long-term (Mitchell, 2010). Rangeland management involves the care of natural grazing lands by planning and administering the use of rangelands to obtain livestock or game products consistent with the goals of conserving range resources. Rangeland management is rooted in strategies that attempt to decide proper grazing use, improve forage products, increase usability of the range, manage the livestock, and correlate grazing with other land uses (Stoddart, 1967). The most common activities supporting these attempts include bush control, water management, grazing management, and range reseeding. Many traditional management practices among pastoral communities are consistent with the principles of rangeland management used in non-pastoral settings. For example, in following patterns as pastoralists moved around with their herds, pastures were rested between grazing periods.

Integrating range reseeding and grazing management on degraded lands has the potential to address the needs of range managers, pastoralists, or ranchers. The explicit purpose of range reseeding is to improve ground cover to an extent not possible by grazing management alone

(Cerda, 2009). Reseeding is used on land denuded by overgrazing, degraded land, or the establishment of completely new pasture fields. On the other hand, grazing management ensures that the rangeland is in good condition by balancing the range composition of shrubs, forbs, and grasses and giving enough rest for regeneration after disturbances from grazing. When overgrazing occurs, it results in the loss of perennial grasses first, then of annual grasses and eventually in the complete denudation of the soil. If the process is stopped when some perennial grass roots are still available, then grazing management can be used to restore such lands by giving enough rest and allowing the grass to revegetate. Otherwise, if overgrazing continues until the roots are destroyed, the grasses cannot recover and the plants die off, necessitating reintroduction of the plants, which is achieved through reseeding. The best results of reseeding occur when native species are replanted in their former habitats (Pratt & Gwynne, 1977). Additionally, if range reseeding is to achieve its goals and to remain sustainable, it should be applied complimentarily with grazing management.

Traditional pastoralism observes the principles of range management including preserving range resources for future generations. To adapt to the contemporary challenges facing their way of life, pastoralists have developed new coping and adapting strategies. Among these strategies are changing mobility patterns where large flocks of small stock browse and graze in the vicinity of permanent homesteads while cattle-centered nomadism transforms into transhumance – that is, the animals are taken to distant pastures in the dry season and graze at home during the rainy season (Anderson & Bollig, 2016). This arrangement is challenged by the theory on the "tragedy of the commons" as coined by Hardin, (1968), or its revised version on common pool resources theory (Ostrom, 2002) where there is maximization of individual benefit at the expense of communal resources. Though circumstances may vary based on the heterogeneity and size of the communities, the pastoralists acquisition of too many livestock (Fratkin & Smith, 1995) and the privatization of the rangelands reduces range resources and exposes the land to degradation from overgrazing. In addition, as they continue to graze on reserved grazing areas during the frequent and prolonged dry seasons, they unknowingly end up overgrazing the reserves resulting in erosion patches that never recover even after rains because they are overgrazed beyond the grasses' capacity to re-establish. Most of the traditional practices and strategies employed by pastoralists in relation to herd size and grazing management are turning maladaptive making land degradation inevitable (Opiyo et al., 2015). It would be damaging for communities to abandon

the culture of pastoralism and its fundamental aspect of mobility in the event that it became climatically, environmentally, or economically unviable (Resources Detail, 2013). Policy reforms that guarantee pastoralists' right to mobility and investments that allocate dry season grazing rights on common use rangelands have the potential to secure pastoral lifestyle and significantly protect rangelands from degradation (Anderson & Bollig, 2016). However, the bureaucracies involved and weak enforcement mechanisms likely constrain such reforms from being sustainable (Fischer et al., 2020).

Range reseeding as an intervention presents new hope for pastoral communities. By reseeding degraded lands, grazing lands that had reduced capacity can be restored. Reseeded fields also provide different income generating activities that field owners can offer long-term engagement and profit if managed properly and sustainably. These activities include: dry season grazing, grass seed harvesting, cutting thatching grass, milking, engaging in fattening programs, bailing of hay, and leasing of land. In addition, range reseeding increases ground cover, offering conservation benefits to degraded land, while reseeded trees and grasses add to the carbon sinks sequestrating more above and below ground carbon. This in conjunction with the economic empowerment that comes with profitably using reseeded fields, field owners are able to improve their living standards and social status and that way achieving the three goals of sustainability which are environmental, economic and social improvements.

Recently, development policies and coping strategies among poor rural communities in Sub-Saharan Africa, pastoralists included, are focusing and supporting livelihood diversification and venturing in alternative income generating sources. Introduction of sedentarization polices among pastoralist communities is an example of a policy intervention that limits pastoralists mobility and supports livelihood sources that are less livestock based (Elhadi et al., 2012). The coping strategies and alternative livelihoods supported recently by development agencies include cultivated agriculture through green houses or irrigation, wage labor, entrepreneurship including petty trade and charcoal burning, all of which are considered to be climate-proof (De Haan, 2016). Though such policies and strategies are viable economically, pastoralists remain poor, vulnerable and dependent on food aid and safety net programs during periods of climate hazards (Weber & Horst, 2011). The unsustainability is due to the fact that the policies ignore the needs, aspirations and culture of the recipient communities (Emerton & Snyder, 2018). The potential of

range reseeding as an intervention introduced among pastoralists communities, is that it offers solutions against the same challenges of land degradation and climate variability and its associated effects, without requiring pastoralists to change their way of life. Making range reseeding more sustainable as an intervention, and worth consideration for upscaling in Sub-Saharan Africa.

This study was carried out in Kenya where many researchers are projecting that climate change will decrease food security, mainly through increased extremes and temporal or spatial shifts in climate variability (Eriksen & O'Brien, 2007; Herrero et al., 2010; Sherwood, 2013; Opiyo et al., 2015). Extreme weather events such as prolonged dry spells and intense rainfall are already affecting rural communities in arid and semi-arid parts of Kenya. In Baringo County, Kenya, the region of focus for this study, dry conditions and high temperatures were experienced in May of 2019 pushing the county into the alarm drought stage. Though the rains were expected in April, the vegetation condition was of severe deficit and a worsening trend was still being reported (EWS Bulletin, 2019). Similar conditions were witnessed by a third of Kenya's population who are pastoralists and dependent on the over 70% of the country's total land mass comprised of rangeland.

This project researches the dynamics of range reseeding among pastoral communities. It uses the Tugen and Njemps pastoral communities who are beneficiaries of range reseeding as an intervention that was introduced by the Rehabilitation of Arid Environment (RAE) Trust/Ltd over three decades ago. RAE introduced range reseeding among the pastoral Tugen and Njemps communities with the goal of demonstrating that severely degraded rangelands can be restored, and in so doing address food insecurity, poverty and other livelihood problems (Meyerhoff, 1991; de Groot, 1992). Household surveys were conducted among these pastoral communities who have been managing and utilizing reseeded fields that were planted through RAE's intervention. The primary occupation of the Tugen and the Njemps is extensive traditional animal husbandry where they keep indigenous livestock species selected based on survival and productivity. The Tugen are a sub-tribe of the larger Kalenjin people who are the fourth largest ethnic group in Kenya, with a population of approximately 200,000 people as of the 2019 Census. The Maa-speaking Njemps in Kenya live in the south and southeast side of Lake Baringo and their population is about 35,000 people. They are among the tribes considered as

minority groups in Kenya due to their small population numbers nationally. The Kalenjin and, by extension, the Tugen, are traditionally pastoral, while the Njemps culture underwent transformations from fishing to sophisticated systems of irrigation, that were mixed with pastoralism as influenced by the neighboring Samburu and Maasai (Salvadori, 1980).

The main objective of the study is to evaluate household and field characteristics and use of reseeded fields to inform on the dynamics of range reseeding and the heterogeneity that exists between the pastoral communities of Lake Baringo, Kenya. To examine the dynamics of range reseeding, the gender of the field owner and the household sizes are used to explain the dynamics surrounding management of the reseeding fields. Larger household sizes are expected to influence field use as the larger ones offer more labor to engage in more activities (Edet & Etim, 2013). Women are expected to have more reseeded fields so as to get additional income from trading in the range reseeding outputs (Tefera & Kaneko, 2020). Other characteristics used to study the dynamics of range reseeding included the different fence types, the success of reseeding, the species used for reseeding, the total land size reseeded and the years of experience working with the grass field are among the field variables. To find out the heterogeneity that exists among range reseeding, the total land size reseeded, the number of fields reseeded per household, the herd size and the field use preferences among the two communities is compared. The null hypothesis is that these two communities will adopt the range reseeding intervention in a similar way. Low livestock production due to range degradation and drought should cause a growing number of households from both the Tugen and Njemps communities who fully depend on livestock to be incapable of sustaining their livelihoods (Johansson & Svensson, 2002). If these two communities are to sustain their livelihoods, it is expected that they will adopt to the range reseeding intervention as introduced by RAE in a similar way. That is, by reseeding equal land sizes and utilizing the fields for additional income.

In an additional analysis, the study hypothesizes that total land size reseeded, total herd size, number of activities engaged in and the years of experience working with a grass field will have a similar effect on herd survival rates in the case of a drought. Larger field sizes reseeded are expected to be more productive (Savastano & Scandizzo, 2017) as they offer more forage if the reseeding exercise is successful. The herd size and total land size are relatable variables as they determine the carrying capacity of the reseeded fields which impact productivity and survival

rate. The number of activities engaged in may also impact survival rates as different income generating activities can be utilized at different times of the year affecting the forage availability during the drought period. The number of years one has worked with a grass field may be a proxy for management and skill. This analysis is done with the goal of advocating for replicability and upscaling of range reseeding, as higher survival rates are directly linked to successful pastoral communities since their livelihoods are majorly livestock based.

Lastly, challenges that affect the Tugen and Njemps communities are also discussed. These challenges include, flooding, invasive species encroachment, insecurity and fencing/illegal grazing. Climate change effects and over siltation of the lake is causing the lake to burst its banks, resulting in the loss of grazing lands near the lake shores to floods (Odada et al., 2006). Invasive *prosopis*, *oppuntia* and *acacia reficiens* species (Maundu et al., 2009) are out competing indigenous species necessitating the need for range reseeding. Cattle rustling and tribal clashes especially near the tribal boundaries of the Pokot and the Tugen are common, as they dispute over grazing resources which results in unutilized grazing lands near the clashes hotspots (Kaimba et al., 2011). Lack of bylaws that protect field owners from illegal grazing fail to buffer the investments made when fields are successfully reseeding.

METHODS

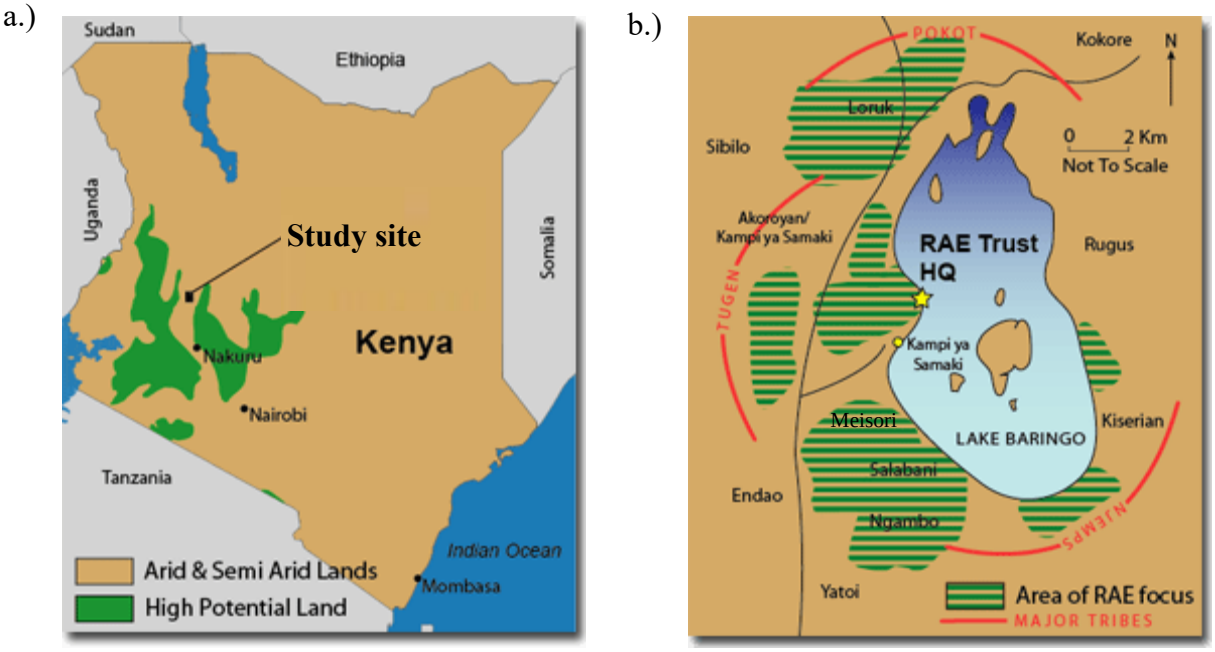
Study Area

The study was conducted in Baringo County in the Rift Valley region of Kenya. Baringo covers an area of 11,015 square kilometers, which encompasses Lake Baringo at about 165 square kilometers. The population of the area is about 667,000 people (KNBS, 2019). The county can be divided into two major zones: the highlands and the lowlands. This study focuses on the lowlands, which are areas in the Arid and Semi-Arid Lands (ASALs) climatic zones, covering a major part of the county (Jaetzold & Schmidt, 2010). The altitude of the region is between 700 m and 3,000 m, resulting in rainfall levels of 1000–1500 mm per annum in the highlands and 400-600 mm per annum in the lowlands, with temperature ranging from a minimum of 10°C to a maximum of 35°C (Kiage et al., 2007; Odada et al., 2006).

Baringo County has six sub-counties, with Baringo North containing all the four sub-locations that are the focus of the study. Salabani, Meisori, Loruk, and Akorian, are the sub-location where the household surveys were conducted. The area is predominantly inhabited by the Tugen and the Njemps, with the Pokot closely neighbor their territory (Figure 1). Baringo County is one of the five most rural counties in Kenya and over fifty percent of its population lives below the poverty line (Diwakar, 2018). Poverty is exacerbated by the extreme environmental conditions including severe droughts and floods, challenges of invasive species intrusion, limited access to: agricultural assets, education, health care, employment, information, extension technologies and other government services, in addition to other underlying causes of poverty experienced in the Kenyan ASAL areas (Mulinge et al., 2016).

A growing number of households from both the Tugen and Njemps communities cannot sustain livelihoods based on specialized pastoralism in which they fully depend on livestock systems. Low livestock production due to range degradation and drought has led to an increasing number of households engaging in other activities (Johansson & Svensson, 2002). In adapting to a harsh and variable physical environment, the Baringo pastoralists have developed principles and strategies for managing natural resources as they engage in additional economic activities for survival. Other income generating activities defining their socio-economic dimensions include crop cultivation, sending relatives off to urban areas for better wages, beekeeping and trade.

Figure 1: The study site



a.) The map of Kenya showing the exact study site.
b.) The tribal territories of Lake Baringo pastoral groups.

Source: (*The RAE Charitable Trust - Area Maps*, 2007)

The Baringo lowlands have complex soils with various textures and drainage conditions that vary across tribal lines. The Tugen are mostly in the highland areas, where the soils are saline and a large area is characterized by shallow, stony-sandy soils with rock outcrops, volcanic ash, and lava boulders. The Njemps region is mostly flat and covered by well drained silt loam to clay loam alluvial soils (Elhadi et al., 2012). The vegetation in the areas surrounding the lake is dominated by trees and shrubs (*Acacia reficiens, Acacia tortilis, Boscia corriacea, Balanites aegyptiaca, Maerua angolensis, Cordia sinensis* and *Salvadora persica)* with little undergrowth (Kiage & Liu, 2009; Kaimba et al., 2011). As the elevation increases, a wide variety of woody plant species combine with *acacias* to form the main vegetation layer with an understory vegetation of moderate to dense perennial forbs and grasses. The lowland zone occupied by the Njemps is dominated by invasive *Prosopis juliflora* bushes and *Opuntia ficus-indica* (prickly-pear cactus) which significantly change the land cover (Maundu et al., 2009). These species compete for soil nutrients with the grasses and suppress undergrowth establishment.

Figure 2: Soil types and vegetation differences

a.)

b.)

a.) Baringo hills including Akorian and Loruk
b.) Baringo lowlands including Salabani and Meisori

Range Reseeding in Lake Baringo by RAE Trust/Ltd

The respondents of this study were chosen from pastoralists from Lake Baringo who own reseeded range fields that were planted by the Rehabilitation of Arid Environments (RAE Trust/ Ltd). RAE is a donor funded non-governmental organization that has been working with pastoral communities from Baringo County with a mission of improving their livelihoods by enhancing the productivity and profitability of degraded drylands. RAE implemented its first reseeding project in communal rangelands on the Njemps flats in 1982 and later expanded its efforts to other upland sites (de Groot, 1992). Its efforts are targeted at land rehabilitation, income generation, and dissemination of knowledge. To achieve its objectives, indigenous grass and tree species are planted on the degraded land either as community enclosures or on private fields. To date, RAE has planted over 900 private fields and over 50 community enclosures, totaling to over 6,000 acres of rehabilitated land in the region. This study focuses only on the private enclosures and their owners. Private enclosures are fields for which management decisions, including field use, fully depend on the field owner. The field is planted following request from

the field owner through a RAE extension officer. The following process is used by private field owners seeking assistance in replanting their fields through RAE's intervention:

1. Prior to the planting season, RAE extension officers mobilize community members on the upcoming reseeding exercise. Announcements are publicly made during chief community meetings (*barazas*) and market days and through posters placed at shopping centers. Interested field owners then sign up for consideration.
2. The field owner pays subsidized prices for the service which ranges from 60 USD to 80 USD per acre based on distance between the field to be reseeded and RAE's headquarters. The prices are basically a loan that the private field owners pay by getting into contractual agreement with RAE to sell them the grass seed once harvested.
3. Once the private field owner gives their intention of wanting their fields planted, a field extension officer from RAE assesses the field and advices on the necessary pre-planting actions. Bush clearing and fence repairs are among the necessary actions before the planting.
4. When the field is ready, it is planted using a disc plow tractor or a ripper that tills the land into ridges and furrows along contours to slow down surface run off and allow for more rainwater to percolate into the ground. Field owners have the choice to choose from five different grass species that RAE services offer. These species include the grasses *Cenchrus ciliaris, Eragostis superba, Enteropogon macrostachyus, Sehima nervosum*, and *Cymbopogon Pospochilii*. They are all indigenous to the area. The dominant grass species surrounding the field owner's field is typically the preferred species for reseeding. These species are drought tolerant as they have evolved with the changing climate of the area. Some farmers also choose to have mixtures planted on their private fields. Dryland tree species are also sold to interested farmers to plant on their fields.
5. Actual reseeding involves the hand broadcast method. RAE extension officers ensure that this is done at the appropriate time as determined by the timing of the rains. If the seeds are insufficiently watered, they may germinate but later die which affects the success of the reseeding exercise. Timing is essential too as it mitigates predation from birds and rodents and losses to winds.

After the reseeding exercise, spot checks are conducted by RAE team to follow up on the success of the reseeding exercise. When the grass seed is ready, the farmers are also guided on the seed harvesting process. Once the grass seed is harvested and purchased, RAE team processes the grass seed, stores it through the post maturity phase, and packages it for sale to other parts of the country. The grass seed is packaged in sisal bags of ten kilograms each and stored in dry, well-aerated stores that are raised from the ground to avoid seed loss from termites, ants, and rodents. The grass seed finds ready market in Baringo and other dryland counties of Kenya. In recent years, sales have been made to neighboring African countries including Tanzania and Somalia. RAE is recognized by the Kenya Plant Health Inspectorate and government ministries as a source of quality grass seed for pasture improvement and for reseeding degraded rangelands.

Sampling Strategy

The target population was about 500 field owners who collectively own more than 900 private fields planted by RAE and were from the three pastoral communities that are dominant in Baringo, Kenya. The desired sample was 150 respondents for a household survey based on the time and financial resources available. To determine which fields to visit, I categorized all the private field owners by tribe and into the sub-locations they came from (Table 1). This resulted into 29 categories with the highest sub-location having 242 fields and the lowest having one field. The top two sub-locations with the greatest number of field owners per tribe was selected, leaving six sub-locations (two per tribe). The two sub-locations from the Pokot tribe with the highest number of reseeded fields only had 20 private field owners which is about two percent of all the field owners with private fields planted by RAE. As such, the Pokot tribe was omitted from the sample and all the 150 respondents randomly but equally selected between the two tribes: the Tugen and the Njemps-and from four sub-locations.

Table 1: Sub-locations, fields and the three tribes

Sub-location	Size (Acres)	Number of fields	Number of Owners	Dominate tribe
Meisori	261.9	100	79	Njemps
Salabani	592.2	242	138	Njemps
Akorian	85.3	140	95	Tugen
Loruk	265.1	183	99	Tugen
Loyamuruk	60	7	4	Pokot
Tangulbei	66.5	20	16	Pokot
Total	**1331**	**692**	**431**	

Data Collection

In Lake Baringo, Kenya, data was collected through the administration of a survey (see Appendix A), where 193 household visits were conducted in June 2019. At the time of the data collection, these communities were recovering from a prolonged drought and some of the targeted field owners were not available because they had permanently relocated, or they had migrated in search of pasture and water. Some of the fields that were intended for the survey were also no longer in use because they were submerged by the flooding of Lake Baringo, or their owners had abandoned them because of insecurity after tribal clashes over garzing resources. Newly reseeded fields had not been used for any income generation yet and were hence not used for the analysis. As a result, of the 193 households that were visited, only 98 were used for the analysis (Table 2) and are referred to as the respondents of the study. Appendix B examines in detail the 95 households in their sub-locations including reasons why they were not used in the analysis. All the fields used for analysis were those that were reseeded by RAE and their field owners engaged in the income generating activities from them. All the respondents who participated answered both close-ended and open-ended questions which related to household characteristics, field characteristics and use, and herd composition before and after the 2019 drought.

Table 2: Sample population

Sub-Location	Dominate tribe	Total Households visited	Households used for analysis	Percentages
Akorian	Tugen	56	30	30.6
Loruk	Tugen	43	20	20.4
Meisori	Njemps	39	23	23.5
Salabani	Njemps	55	25	25.5
Total		**193**	**98**	**100**

Analysis Methods

This study evaluates the dynamics of range reseeding by looking at household characteristics of field owners and field characteristics of reseeded fields among the Tugen and Njemps from Lake Baringo. The factors that were considered at the household level included gender of the field owner, age of the field owner, size of the household and the people who were involved with the management of the field. The management of reseeded fields mostly involves repairing the fence and ensuring that the field is protected from overgrazing and illegal grazing. Weeding is also done often to prevent encroachment by invasive species. Field characteristics that are considered in studying the household dynamics include, the total land size reseeded, fence types, success of the reseeding exercise, the species used for reseeding and the years of experience working with a grass field. For analysis, the mean and standard deviation of these variables based on the sample's responses are considered and reported in the results. To examine the similarities and differences of the Tugens and the Njemps with respect to range reseeding activities, the factors that were considered included how the communities adopted the reseeding exercise when they first reseeded their fields, how much land they reseeded, their field use, their herd sizes and observed geographical characteristics. In addition to an examination of the mean and standard deviation of the variables considered, t-tests were performed to verify the hypothesis postulated in comparing how similar or different the two tribal groups are. An OLS regression was also performed where survival rates are regressed with total land size reseeded, total herd size, number of activities engaged in and the years of experience working with a grass field. Since livestock are assets and a source of livelihood for pastoralists, higher survival rates are associated with improved resilience to climate variability, advocating for the importance of range reseeding.

RESULTS

1. Household Characteristics

Almost 90 percent of the respondents were male (n=88) with only 10 of the respondents and field owners being female (Table 3). The total household count was an average of 9.76 people ranging from a minimum of four people per household up to a total of 35 household members. Though majority of the field owners are men, the field management responsibilities of fencing the field and ensuring that no illegal grazing occurs lies with the entire household. The majority (59.2%) of the respondents managed their fields with the help of the rest of the household. More than a third (38%) of the respondents paid laborers to help with field management while three percent had no management plans for their fields.

Table 3: Household characteristics *(n=98)*

Category	Percent (%)	
Household Characteristics		
Gender		
Male	10.2	
Female	89.8	
Education		
No education	32.9	
Primary level	31.7	
Secondary level	21.3	
Tertiary level	10.6	
No Response	3.5	
Field management		
By owner and family	59.2	
By paid labour	37.8	
No management	3.0	
	Mean	**Std. Dev**
Age	48.5	14.6
Total household count	9.8	5.5

2. Field Characteristics

The total land sizes reseeded was on average 4.53 acres per household. Households had more than one field planted with the additional ones either being extensions made on initially existing fields or as new fields in other places up to five different locations. These fields varied in size

ranging from 0.3 acres to 30 acres, with total land sizes ranging from 0.3 to 48.1 acres (Table 4). These fields were protected by different fence types based on the preference of the field owners and their financial resources. Live fences were the most common fence type in the area, with 85.8 percent of the fields protected by live fences made from *cactus* and twigs and shrubs from *Acacia* and *Prosopis* species found near the fields. Eleven percent of the fields were protected by wire fences and three percent of the fields had no fences. Respondents had worked with their reseeded grass fields for close to ten years on average. All the fields were on average 37 minutes from the nearest reseeded community enclosure and 56% of the respondents said that they used the community enclosures to some extent in addition to using their private fields. Over 90% of the respondents felt that the reseeding exercise success was above average with just 7% reporting that the success of the reseeding exercise was poor. Though the value was from field owners self-reporting, it was high and implies that the reseeding exercise was highly successful. Over 98% of the respondents reseeded their fields using *Cenchrus ciliaris* (buffelgrass) while 14.44% reseeded their fields using a mixture of the other species.

Table 4: Field characteristics

Category	Percent (%)	
Fence types		
Wire fence	11.2	
Live fence	85.7	
No fence	3.1	
Success of Reseeding		
Good	26.0	
Average	66.7	
Poor	7.3	
Use of community enclosures		
Great Extent	38.5	
Moderate extent	5.3	
Minimal extent	9.2	
No extent	46.9	
Species used for reseeding		
One species	85.5	
Multiple species	14.4	
	Mean	**Std. Dev**
Total Land Size	4.5	7.0
Minutes to nearest CF	37.7	30.7
Years of experience with reseeded field	9.8	7.5

3. Heterogeneity of Pastoralists

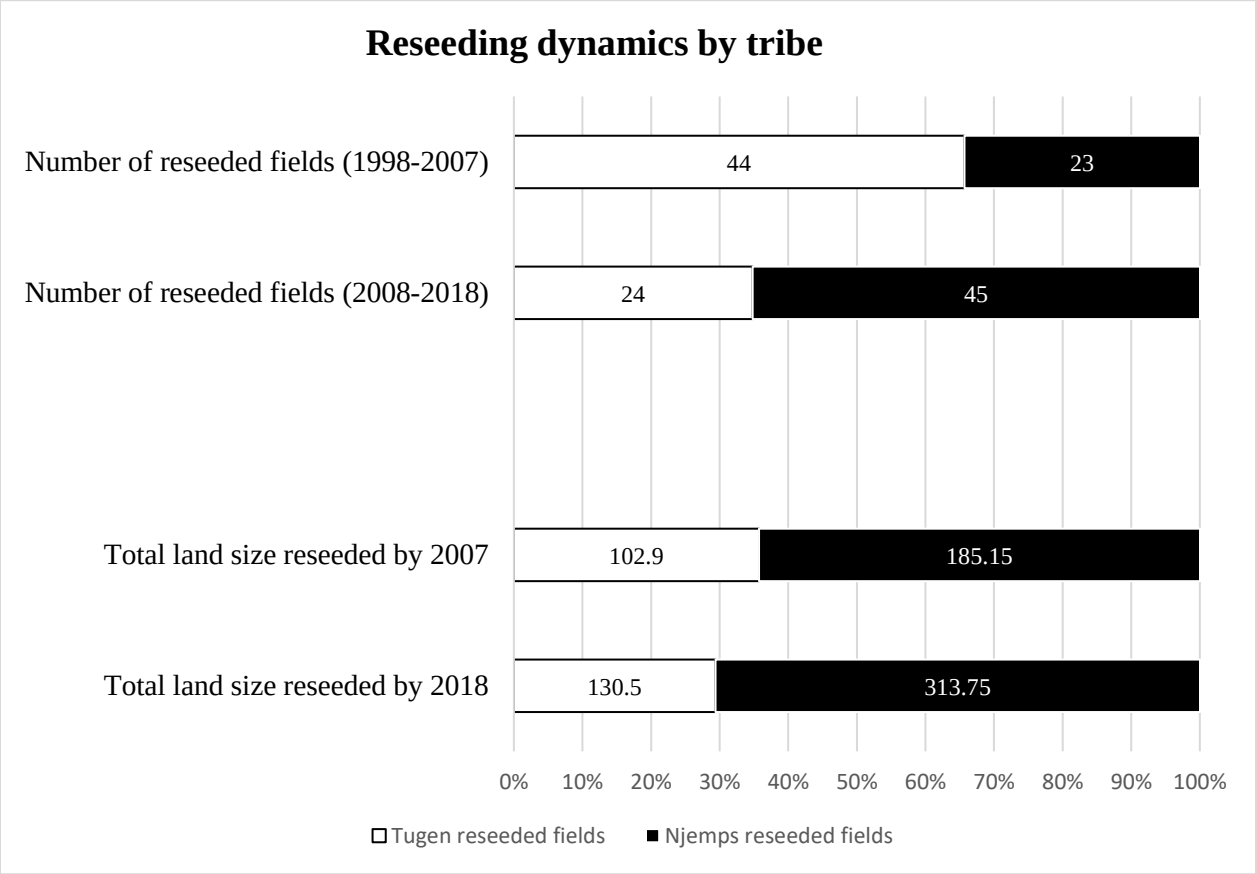
a.) Adoption of range reseeding by the tribes

RAE introduced range reseeding activities in Baringo in 1982 but it was not until the early 1990s that reseeding exercises were done on private enclosures. Range reseeding dates for this sample size range from 1996 to 2018. The 98 field owners own 189 fields of which 72 percent (n=136) have been reseeded just once. In the first decade when range reseeding was introduced, the number of Tugens who reseeded their fields were double the Njemps. But the Njemps, though fewer, reseeded more land area compared to their counterparts and the same trend is seen even in the following decade. However, the number of fields reseeded by the Njemps almost doubled those reseeded by the Tugen in the future years (Figure 3). Both communities had similar number of fields reseeded in the period 1998 to 2018.

b.) Total land size reseeded

The total land size reseeded differed by tribal membership with members of the Tugen tribe having statistically smaller land sizes with 6.53 acres for Njemps and 2.61 acres for Tugen (t-test $p = 0.0052$). The Tugen fields size ranged from 0.3 acres to 11.7 acres while those of the Njemps ranged from 0.5 acres to 48.1 acres (Figure 3).

Figure 3: Dynamics of range reseeding adoption



c.) Herd size

This study was conducted when pastoralists from Lake Baringo basin were recovering from the 2019 drought. Dry conditions and high temperatures experienced in the region had pushed Baringo County into the "alarm" drought stage, with the vegetation condition described as "severe vegetation deficit" (EWS Bulletin, 2019). Data on herd sizes before and after the drought was collected and used to estimate survival rates. The communities were also compared in terms of their herd size in animal unit equivalents (Table 5) (Kristjanson et al. 2002; Wilson 2003). Herd sizes did not differ by tribal membership with an average of 20.43 animal units for Njemps, and 20.86 for Tugen (t-test $p = 0.9091$).

Table 5: Herd size

Tribe	Cattle	Calves	Sheep	Goats	Kids/Lambs	Total
Njemps	11.97	1.75	5.49	6.65	0.60	20.43
Tugen	13.32	2.75	4.32	8.50	1.19	20.86
Total	**12.64**	**2.54**	**5.04**	**7.65**	**1.11**	**20.66**

Note: Figures are presented in TLU where 1 TLU is equivalent to 250 kg live weight, a cow=1 TLU, a calf=0.4 TLU, a sheep/goat=0.11 TLU, lambs=0.05 TLU, kids= 0.04 TLU (Kristjanson et al. 2002; Wilson 2003).

d.) Field use and seasonality

Tradable outputs could be obtained from engaging in income generating activities on the reseeded fields and selling them to markets. These activities were: dry season grazing, grass seed harvesting, cutting thatching grass, milking, engaging in fattening programs, bailing of hay, and leasing of land. The two tribal communities differed in their participation in the income generating activities (Table 6). The participation of the Tugen and the Njemps is at varying frequencies for all the different income generating activities. For instance, cutting thatching grass is more common among the Tugen than the Njemps: 40% of the Tugen participate in cutting thatch as compared to 12.5% of the Njemps. Similarly, engaging in fattening programs is more common among the Njemps than the Tugen: over 50% of the Njemps participate in fattening programs compared to 6% by the Tugen (Table 6).

Additionally, none of the households surveyed engaged in all seven of the activities (Table 7). On average, they engaged in two to three activities with a maximum of five combined activities. The most common activity was dry season grazing. 82% of reseeded field owners used fields for dry season grazing. Further, if a field owner engaged in just one activity, the activity was most likely dry season grazing. For the other activities, 78% engage in grass seed harvesting, 32% cattle fattening programs, 29% cutting thatching grass, 21% cutting and bailing grass, 18% leasing land and 9% milking livestock, (Table 7).

Table 6: Income generating activities among the tribes

Income generating activity	Njemps (n=48)		Tugen (n=50)	
	Frequency	Percent	Frequency	Percent
Dry season grazing	41	85	34	68
Grass seed harvesting	40	83	31	62
Fattening program	26	54	3	6
Thatching grass	6	12.5	20	40
Bailing of Hay	8	16.67	11	22
Leasing of land	9	18.75	7	14
Milking	6	12.5	2	4

Table 7: Income generating activities (n=95)

No of Activities	Dry Season Grazing	Grass Seed Harvesting	Fattening Program	Thatching Grass	Bailing of Hay	Leasing land	Milking
			Likelihood of engaging in an activity				
1	1	0	0	0	0	0	0
2	0.95	0.86	0.05	0.05	0.05	0	0.05
3	0.92	0.96	0.48	0.2	0.2	0.2	0.04
4	1	1	0.43	0.67	0.43	0.33	0.14
5	1	1	0.88	0.75	0.5	0.5	0.38
Total	**0.82**	**0.78**	**0.32**	**0.29**	**0.21**	**0.18**	**0.09**

These income generating activities could also be pursued at different times of the year, providing the households with an income for most parts of the year. The profitability of each activity varied with some being more profitable than others. These activities also follow each other and proper planning is required to ensure that the fields still remain successful. For example, grazing the field before grass seed harvesting would have meant that you could not obtain the benefit from grass seed harvesting (Table 8).

Table 8: The seasonality of income generating activities

Activity	**Benefit**	**Seasonality**
Grass seed harvesting	A one-acre reseeded field had the potential of producing 80 kg of grass seed per rainy season. Three to seven USD per kilogram.	Three months after the rainy seasons; the long rains from late March to early June and the short rains from October (Kipkorir, 2002, Kaimba et al., 2011).
Cutting grass for thatching grass and bailing of hay	Thatching grass bundle - two USD and a bale of hay three to four USD depending on the demand as at the time of sale.	Done after grass seed is harvested.
Leasing of land, dry season grazing, milking and fattening programs	Value varies widely. Dry season grazing benefit was valued by the cattle grazing days, milking was valued by the milk that could either be sold or used for household consumption. Fattening programs were the most profitable with benefits as high as 180 USD per cattle.	Continuously achieved if stocking rates are balanced with carrying capacity to prevent over grazing.
Note: With the changing rain patterns, grass seed harvesting, and related sales have been fluctuating in seasonality with harvesting happening as early as June and as late as February in the subsequent year, depending on whether the rains come early or is delayed. The delays affect the other activities as well.		

4. Survival Rates and Range Reseeding

The study hypothesizes that total land size reseeded, total herd size, number of activities engaged in and the years of experience working with a grass field will have a similar effect on herd survival rates in the case of a drought. To investigate the effect of the drought on pastoralists, herd sizes were compared before and after the drought at the household level. Some households were able to completely recover from the drought, with a hundred percent survival rates, while other households lost all their herd. The National Drought Management Authority (NDMA) reported that the overall body condition of most livestock was below normal compared to similar periods during a normal year due to increase in trekking distances in search of pasture and water, coupled with reduction in pasture and browse quantity and quality. The average distances to water points for both households and livestock had also increased attributed to the drying of most surface water sources such as rivers, water pans, and dams as a result of the prolonged dry spell. A regression analysis is conducted to determine the relationship between total land size reseeded, herd size, number of activities or years of experience working with a grass field and animal survival rates associated with the 2019 drought. Land size was significantly associated with the survival rate ($p = 0.019$).

Table 9: Survival rate regression

Variables	**Co-efficient**	**Std. Error**	**t-statistic**	**Prob.**
Constant	0.735	0.078	9.39	0.000
Total land size	0.008	0.003	2.41	0.019
Total herd size	-0.002	0.001	-1.52	0.132
No of activities engaged in	0.036	0.019	1.94	0.057
Years of experience working with a field	-0.006	0.003	-1.61	0.111
R-squared	0.165			
Adjusted R-squared	0.121			
Prob > F	0.008			

DISCUSSION

In this study area like other rangelands of Sub-Saharan Africa, pastoralists households faced the negative impacts of extreme climate events along with poverty, water scarcity, resource based conflicts, disease, and food insecurity. With majority of the people of Baringo county below the poverty line, they were highly vulnerable to the consequences of climate variability and land degradation, and therefore ended up having to heavily rely on food aid and safety net programs for their survival from year to year (Diwakar & Shepherd, 2018). Range reseeding done on private fields or community enclosures is an example of an intervention taken to address climate variability and adapt to land degradation and its effects (Mureithi et al., 2016). Adaptation to climate variability is made possible through the income obtained from trading in reseeding related activities such as: dry season grazing, grass seed harvesting, cutting thatching grass, milking, engaging in fattening programs, bailing of hay, and leasing of land. All these activities can be engaged in during different times of the year.

Tefera and Kaneko (2020) find that Hamer pastoralists women from Omo valley, Ethiopia, were taking up land management and producing grass seed that they sold to sustain their livelihoods and adapt to climate change and its related challenges. Their findings on the Hamer pastoralists are consistent with those of this study where pastoral Tugen and Njemps communities also reseeded their fields, manage them and use them to get additional income. Though this study does not calculate the exact earnings made by each household, the respondents reported on the income generating activities they engaged in, on their reseeded fields. The Tugen and Njemps households are able to make additional income from trading in grass seed obtained from reseeded community enclosures and private fields and also from engaging in the other activities related to reseeded fields. The benefits and the management responsibilities are not just on women as is the case with the Hamer pastoralists, but the entire household helps with the management of the reseeded fields. Management responsibilities include activities of obtaining the benefits and field maintenance tasks such as fence repairs. Close to 60 percent of the respondents manage their fields with the help of other household members. As such, larger household size numbers are likely to provide more labor for grass seed harvesting and for venturing in other income generating activities compared to smaller household size.

Previous research has highlighted the role of livelihood diversification and its ability to manage extreme weather changes. Elhadi et al. (2012) finds that alternative income sources were more common among sedentary pastoralists than nomadic pastoralists. The alternative income sources pastoralists engage in were less climate dependent activities such as crop production, trade, wage employment or charcoal production to contribute to their income. The study by Elhadi et al. (2012) also finds that poverty and income inequality levels between the nomadic and sedentary pastoralists are highest during the dry season with the nomads having the lowest incomes. That study attributes this to reduced quality and quantity of pasture that was linked to land degradation, climate change and increased human population. All these factors increased pastoralists vulnerability during a calamity. The respondents of this study were faced with similar challenges that also reduced their grazing lands. Flooding, invasive species and insecurity were also additional challenges that reduce available grazing land in Lake Baringo, Kenya during the dry season. Range reseeded fields had the potential to provide additional grazing land that could be used during the dry season. This was shown by the 82% of respondents who used their fields for dry season grazing.

Pastoralists engaged in up to three income generating activities that were associated with range reseeding. The high success of the reseeding exercise (93% among the Tugen and the Njemps) meant that the pastoralists who invested in range reseeding as a source of livelihood, had higher chances of incomes from their investment and ultimately reduced their vulnerability to uncertainties. Though range reseeding and its associated benefits may not be entirely climate-proof, they were more convenient for the pastoralists as they did not require them to change their culture which was entirely livestock based and had been practiced for many generations. Better yet, the different activities could be engaged in during different seasons and as such, with proper planning, the pastoralists could have incomes for most parts of the year. Sedentary pastoralism would have required a significant shift of culture and a re-orientation of traditional practices for the pastoralists to accommodate the new alternative livelihood sources. Range reseeding and its associated benefits addressed pastoralists vulnerabilities without requiring them to shift from their culture.

Barr et al., (2017) finds that success of reseeding averaged 70% (± 3%) with mixtures yielding higher success rates . For this study, many of the respondents reseeded their fields using one

species but the success of the reseeding is much higher than Barr et al. (2017) reports. Possible explanations would be because the reseeding is done using indigenous grass and tree species that are drought tolerant and have adapted to the evolving conditions of this area. The majority of the respondents reseeded using *Cenchrus ciliaris* which is highly drought tolerant, has deep roots, and quickly regrows after disturbances to outcompete nearly all other vegetation. RAE also reseeded using grass seeds that has been processed and cleaned after harvesting and stored to undergo post maturity phase. All of these factors imply higher germination rates. RAE's long-term involvement in the reseeding exercise that spans over three decades has also enabled them to learn and relearn what works best in these region including the changing community dynamics. Mganga et al., (2015) findings supports that the choice of the species used for range reseeding in East Africa can be greatly influenced by their forage value for livestock and the soil characteristics, drainage, and climate characteristics, factors that may influence where they are to be reseeding. Mganga et al., (2015) also reports that native species including *Cenchrus ciliaris, Eragostis superba,* and *Enteropogon macrostachyus* have been successful for reseeding and fighting desertification in East Africa, the same species that the Tugen and the Njepms choose to reseed.

The benefits of range reseeding, including the improved ecosystem services, could not be realized without also sustainably managing the rangelands. The socio-economic benefits associated with reseeded range fields acted as an incentive for proper management. In fact, all households in the study engaged in multiple income generating activities (an average of 3). The Njemps engaged more in fattening programs which was the most profitable income generating activity, though it required the fields to be well maintained and properly managed for its success. It could be assumed that the high profits expected from a successful fattening program were the motivation for proper management and explained why all fields owned by the Njemps were fenced. However, Emerton and Snyder, (2018) find that sustainable land management techniques most commonly practiced by farmers and those most preferred by farmers, were not those that yield the highest production gains or those that generated the greatest income, or involved the lowest costs. Their findings are in line with central tenants of utility theory in economics. Instead, they note that farmers choose techniques that were aligned with their needs, aspirations, preferences and culture (Emerton & Snyder, 2018). These finding were consistent with the behavior of the Tugen who choose to engage more in thatching grass as an income generating

activity, even though it was the least profitable activity. This may be because traditional houses among the Tugen community were grass thatched.

Other analysis of comparing the Tugen and the Njemps included the adoption of the range reseeding intervention which varied across the two decades after its introduction among the Tugen and the Njemps. At the beginning many Tugens reseeded their fields compared to the Njemps, but, a decade later, the Njemps reseeded larger and more fields than their counterparts. Their field use preferences were also different even though they keep similar livestock kinds and herd sizes. The different geographical characteristics of the locality for each community also presented different sets of challenges. The low-lying nature of the Njemps Flat adds unique challenges from flooding that reduced their grazing lands and affected alternative sources of livelihood, particularly crop irrigation at the lake shores. The invasive *Prosopis* species that is widespread in the open ranges of the Njemps flatland also limits the availability of pasture in the open rangelands. On the other hand, the Tugens, especially those from Loruk sub-location have to deal with challenges of lost pasture associated with unused grazing land as a result of insecurity where their territory abuts that of the Pokot tribe. Cattle rustling and tribal clashes over range resources were rampant in this region, forcing many pastoralists to migrate from their ancestral lands. The high insecurity in the region also limited development of social amenities such as schools and hospitals, which further disadvantaged this tribal group.

Illegal grazing was cited as a major challenge to the reseeded fields by nearly all the respondents of this study. Illegal grazing occurred when cattle that did not belong to the field owner grazed on a private field without the consent of the field owner. There existed no legal provisions that offered pastoralists a framework for compensation when their fields were illegally grazed. As shown by this research, 97% of the respondents invested in the different fence types available to secure their fields. This shows that they understood the importance of protecting their fields from uncontrolled grazing.

Herd survival rates recorded by the field owners of this study indicated the potential that range reseeding has on ensuring that pastoralists' livestock survive even after a drought. The survival rates were as high as 100% and 75% on average even though these communities had just been hit by a prolonged drought. Previous research indicated that severe droughts coupled with other

factors such as declining land productivity, shrinking grazing areas, and restricted movements can result in total herd loss among households in pastoral households (Fratkin, 2008; Groom and Western, 2013; Kirwa et al., 2012; Moo et al., 2013). Shrinkage in grazing land and recurrent droughts have been cited as attributes that decline herd size to total herd loss (Kimiti et al., 2018). All of the respondents of this study used reseeded fields for dry season grazing which showed that pasture was important for the pastoral communities of Baringo, Kenya. As shown in the regression, greater reseeded land size was associated with higher herd survival rates.

CONCLUSION

As illustrated by range reseeding among the pastoral Tugen and Njemps communities, diversified sources of livelihoods and the environmental benefits of grass fields could allow households to deal with challenges of climate variability, land degradation and poverty alleviation while maintaining much of a traditional way of life. The relatively high and long term success rates of the reseeding imply that this intervention was likely an appropriate one for the situation and that sustainable grazing management can be achieved. Indigenous grasses, at low cost and with little outside input, add conservation values to the land as well as provide a productive and resilient forage base for pastoralists. Future policies and institutions that support range reseeding on communal lands, private enclosures, or open ranges may expand these benefits. Potential avenues for further research include understand the changing culture of pastoralism given the current challenges and the opportunity reseeding open vast rangelands offer.

APPENDICES

Appendix A – Survey Instrument

The survey was administered through Qualtrics.

Demographic Basics

Name	Location	Gender	Age	Education Level	Family Size	Field Managed by	Relationship to owner

Labor Questions

1. For how many years have you worked with a grass field?
2. How much time per week do you spend working in the grass fields?
3. Does the field manager have other forms of employment or is it hands on?
4. Does the field owner have other sources of income?

Animal Questions

Category	Current herd size	Herd size loss	Total herd size (before the drought)
Cattle			
Calves			
Goats			
Kids			
Sheep			
Lambs			
Others			

1. How many households own the cattle?
2. How many were sold when and where did they come from?

Field Questions

Field Number	Reseeding Dates	Field Size	Walking time between homestead and Community Enclosure	Field Location Number	Fence type

1. How successful was reseeding?

Field Number	Good	Average	Poor	Comment
1				
2				
3				

2. How extensively do you use the community field?

Great extent ☐ Minimal Extent ☐

Moderate extent ☐ No extent ☐

3. What grass species are planted in your field?
4. Out of the list of the possible benefits listed below, which ones do you practice on your grass fields?
    a. Dry season grazing
    b. Grass seed harvesting
    c. Thatching grass
    d. Milking
    e. Hay bailing
    f. Fattening program
    g. Leasing
5. Rank the benefits based on the one that is most important to you (if you could only engage with one activity, which would it be?).
6. Rank the listed activities based on the one with the most income (money earned).
7. What were your expectations on reseeding your grass field?
8. Were the expectations meet? Explain your answer
9. How different would your life be without the grass field?
10. When is the last serious drought you can recall?
11. How often have you experienced droughts in the past ten years?
12. How long did that drought last?

Appendix B – Breakdown of Households not Used in the Analysis.

Tugen Tribe

1. **Loruk sub-location**

Households visited – 43

Households used for the analysis – 20

Households not used for the analysis – 23

Reasons

15 of the field owners had completely abandoned their fields because of insecurity and relocated to other places.

6 of the field owners no longer used their reseeded fields at all and were engaging in other activities.

2 had migrated in search of pasture and had not returned as of the time of the data collection.

2. **Akorian sub-location**

Households visited – 56

Households used for the analysis – 30.

Households not used for the analysis – 26

Reasons

8 of the field owners no longer used their reseeded fields at all and the fields had no fences or management strategy in place.

7 of the field owners had recently reseeded their fields and had not started using their fields yet.

6 field owners no longer planted grass seed on their fields and had other crops planted in the fields instead.

4 had migrated in search of pasture and had not returned.

1 had relocated from Akorian to the another county for a different job completely abandoning the reseeded field

Njemps Tribe

1. **Meisori sub-location**

Households visited – 39

Households used for the analysis – 23

Households not used for the analysis – 16

Reasons

5 were completely eroded and filled with gullies

5 of the field owners no longer used their reseeded fields at all and were engaging in other activities.

4 of the field owners had recently reseeded their fields and had not started using their fields yet.

2 were reseeded by other organizations besides RAE.

2. **Salabani sub-location**

Households visited – 55

Households used for the analysis – 25

Households not used for the analysis – 30

Reasons

9 of the fields were flooded and submerged in the lake.

8 were completely overtaken by invasive *prosopis sp*. and were no longer in use.

6 of the field owners had migrated and not returned yet.

4 of the field owners had recently reseeded their fields and had not started using their fields yet.

3 had their fields reseeded later by other organizations other than RAE.

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