Pastoralism: Research, Policy and Practice

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Pastoralist herd size maintenance during drought with the use of reseeded fields near Lake Baringo, Kenya

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Abstract

Land degradation, loss of access to land resources, climate variability, socio-economic changes, and population increase are among the factors that contribute to forage shortage among the pastoral communities. The loss of forage is critical, especially when droughts are frequent and prolonged. Interventions to improve pastoralists' resilience include policies that encourage livelihood diversification, that is, promoting enterprises that are less impacted by climate variability. This paper evaluates a reseeding project among pastoralists from Lake Baringo, Kenya, with the goal of rehabilitating degraded lands. Field owners participated in a survey and answered both quantitative and qualitative questions relating to their field and household characteristics. We use livestock herd size to assess households' conditions. We hypothesize that field characteristics including total land size reseeded, the total number of fields and the number of field locations, years of experience of working in reseeded fields, type of management, fencing, and the number of income-generating activities have an effect on herd size maintenance during drought. We find that the total number of fields and the number of income-generating activities have significant explanatory power in predicting a household's ability to maintain its herd size during drought. These findings suggest that reseeding by local pastoralists could be replicated and up-scaled into other dryland counties of Kenya and sub-Saharan Africa as a promising intervention to improve resilience to climate variability, alleviate poverty, and improve environmental conditions.

Keywords: Land degradation, Variable climate, Sustainable range management

Introduction

Rangelands are characterized by biophysical limitations, including low biomass production, extreme temperatures, and low water availability, which make the conditions naturally harsh (Lund, 2007). Despite these conditions, over 600 million people depend on rangelands for their livelihoods worldwide. Many of these people are pastoralists who move with their livestock in search of pasture and water. Pastoral social systems enable the conversion of the limited ecological resources into sustenance based on the pastoralists' knowledge of the surrounding ecosystems (Ayal et al. 2018). Given that rangelands 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 which widely affects the sustainable development of many regions in the globe, especially sub-Saharan Africa. Land degradation directly links to food insecurity, vulnerability to climate change, and poverty (UNCCD 2020).

Pastoral societies also face many threats to their way of life, such as challenges related to climate change, political and economic marginalization, a development that is not culturally accommodative, and increasing resource

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competition (Greiner et al. 2021; Kirkbride 2008). While the pastoral culture is based on resilient adaptation to variable weather and land conditions, there are limits to their resilience amidst diminishing range resources (Meybeck 2012). Droughts have been increasing in intensity, duration, and extent (Ayal 2018). When combined with the loss of herding lands to private farms, ranches, game parks, and urban areas, pastoralists can find it difficult to adapt to changes in the external environment (Opiyo et al. 2014). National development plans can often also fail to acknowledge pastoral economies and marginalize them on the basis of their geographical remoteness and ethnicity (Kirkbride 2008; Husmann 2016). Many governments still appear to consider the pastoral culture as outdated and needing replacement with modern livelihood systems (Vetter 2005). Modern livelihoods generally refer to the introduction of sedentary policies among pastoralists and limit their mobility, the mobility which forms the core of the pastoral culture and supports the livestock on which they depend for food (Reed & Stringer, 2016).

Traditional pastoralism has had to transform and include new strategies that help pastoralists adapt to the contemporary challenges facing their way of life. Among these strategies are changing mobility patterns where flocks of sheep and goats browse and graze in the vicinity of permanent homesteads while cattle-centred nomadism transforms into transhumance. Transhumance has cattle graze distant pastures in the dry season and near home during the rainy season (Anderson & Bollig 2016). These changes have led to intense use of reserved grazing areas resulting in degraded bare-soil patches with limited chance for natural recovery. The degradation can be seen as a result of modern movement constraints combined with traditional practices and strategies employed by pastoralists in relation to herd size and grazing management (Opiyo et al. 2015). The decrease in the quality and quantity of pasture also causes reduced herd survival rates among pastoral herds in Kenya and other parts of sub-Saharan Africa (SSA) (Baker and Hoffman 2006; Kirkbride 2008). In the interim, while land management and social structures adapt, reseeding degraded lands can return them to productive use.

Agro-pastoralists from Lake Baringo, Kenya, have been reseeding lands for more than three decades and these interventions have been promoted as addressing food insecurity, poverty, and other livelihood problems (de Groot 1992; Meyerhoff et al. 2020). This has been made possible through the presence of the Rehabilitation of Arid Environments (RAE) Trust/Ltd, a nongovernmental organization in the area that facilitates participatory range restoration on a cost-sharing basis. Our study seeks to determine the relationship between reseeding and herd size maintenance among communities that have been managing and using reseeded fields in conjunction with a drought. Drought stresses households' resilience on a variety of fronts and typically results in reduced herd size (Homewood and Lewis 1987, Kimiti et al. 2018). We hypothesize that field and household characteristics affect the maintenance of herd size during drought.

Study area

The study was conducted in Baringo County in the Rift Valley region of Kenya. Baringo covers an area of 11,015 km^2 (Koitaba et al. 2016) and encompasses Lake Baringo at about 129 km^2 (Kiage & Liu. 2009). The population of the area is about 667,000 people (Kenya National Bureau of Statistics 2019). The county can be divided into two major zones: the highlands and the lowlands (Jaetzold & Schmidt, 1983). This study focuses on the lowland regions near Lake Baringo basin, areas that are arid and semi-arid lands. Annual rainfall ranges between 400 and 600 mm with frequent droughts every 5 to 9 years (Ochieng et al. 2017). Temperatures range from a minimum of 10 °C to a maximum of 35 °C (Kiage & Liu. 2009; Odada et al. 2006).

Data were collected in four areas: Salabani, Meisori, Loruk, and Akorian sub-locations in Baringo North constituency, of Baringo County. These areas are the territories of the Il Chamus tribe known more commonly as the Njemps, and the Tugen tribe (see Fig. 1). Baringo County is one of the five most rural counties in Kenya, and over 50% of its population live below the poverty line (Diwakar 2018). Range degradation and drought in the region have led to low livestock production resulting in an increased number of households engaging in other income-generating activities among them crop cultivation, migration, beekeeping, irrigated vegetable farming by the shores of the lake, and petty trade (Johansson & Svensson 2002; Greiner et al. 2021). The region occupied by the Njemps is mostly flat and is covered by well-drained silt loam to clay loam alluvial soils. The region occupied by the Tugen has saline soils and the area is characterized by shallow, stony-sandy soils with rock outcrops, volcanic ash, and lava boulders (Elhadi et al. 2012). The vegetation in the areas surrounding the lake is dominated by trees and shrubs (*Acacia reficiens*, *Acacia tortilis*, *Boscia coriacea*, *Balanites aegyptiaca*, *Maerua angolensis*, *Cordia sinensis*, and *Salvadora persica*) with little undergrowth (Kiage & Liu 2009; Kaimba et al. 2011).

The lowland zone occupied by the Njemps tribe is dominated by invasive *Prosopis juliflora* bushes and *Opuntia ficus-indica* (prickly pear cactus) which has significantly changed the land cover of the region (Maundu et al. 2009). These species compete for soil nutrients

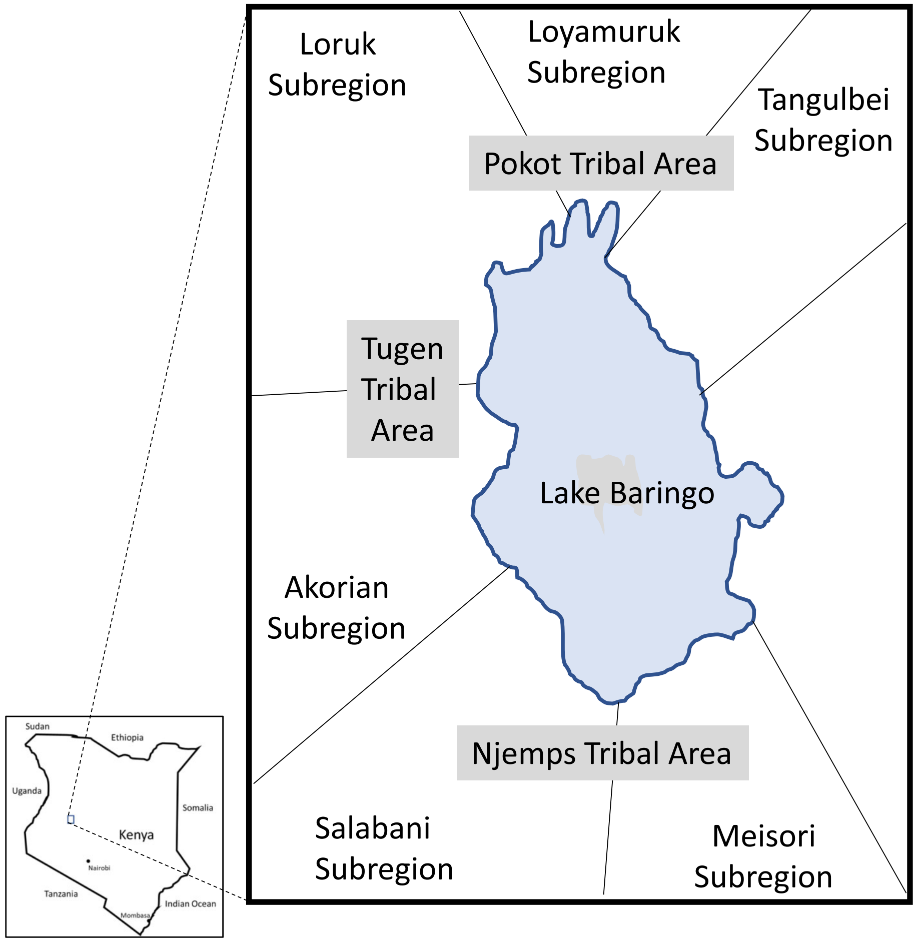

Fig. 1 Diagram of study site sub-locations

with the grasses, hence reducing the grazing capacity. Climate change and its effects along with siltation of the lake have resulted in the loss of grazing lands near the lake shores to floods (Odada et al. 2006). Kaimba et al. (2011) indicate that cattle rustling and tribal clashes are common between the Pokot and the Tugen, as they have disputes over grazing resources which result in underutilized grazing lands near the clash hotspots.

Methods

Reseeding

The respondents of this study are chosen from agro-pastoralists of Lake Baringo who use reseeded fields. These fields were reseeded with the support of the Rehabilitation of Arid Environments (RAE) Trust/Ltd, an initiative that began in 1982 (de Groot 1992) in the Njemps flats. The programme was later extended to other degraded lands in the region including the Tugen and Pokot territories. While communal fields have been reseeded in this region, this study focused only on the private enclosures for which management decisions and use are fully made by the field owner. Fields were planted using indigenous grass species including *Cenchrus ciliaris*, *Eragrostis superba*, *Enteropogon macrostachyus*, *Sehima nervosum*, and *Cymbopogon pospichilii*.

Sampling strategy

The target population was approximately 500 field owners who own more than 900 privately reseeded fields and were selected from the three pastoral communities that are dominant in Baringo County. The target sample was 150 respondents for household survey-based resources available. To determine which fields to visit, the private field owners were categorized by tribe and sub-locations (see Fig. 1). This resulted in 29 categories with the highest sub-location having 242 fields and the lowest having one field (see Table 1). 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 had 20 private field owners which is about 2% of all the field owners

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

Sub-location	Size (hectares)	Number of fields	Number of owners	Dominant tribe
Meisori	106	100	79	Njemps
Salabani	239.7	242	138	Njemps
Akorian	34.5	140	95	Tugen
Loruk	107.3	183	99	Tugen
Loyamuruk*	24.3	7	4	Pokot
Tangulbei*	29.9	20	16	Pokot
Total	**541.7**	**692**	**431**	

Note: * indicates locations not selected for further study

with private fields planted by RAE Trust/Ltd. As such, the Pokot tribe was omitted from the sample and all respondents were randomly selected from the Tugen and the Njemps and from four sub-locations.

Data collection

Data were collected through the administration of a survey that included both open-ended and closed-ended questions, where 193 household visits were conducted in June 2019. The respondents who participated in the study answered both quantitative and qualitative questions which related to the field owner's gender, the field manager (owner, paid help, or no one), years of experience with fields, the number of fields, the number of field locations, the cumulative land size, the kind of fencing (wire, living material, none), the number of species planted in the field, the owners' assessment of revegetation success, the number and nature of livelihood activities, and the number of each kind of livestock before and after the drought. Livestock herd sizes tend to be fixed as long as households maintain the number of animals that approximately maximize their available forage, herding capability, and risk, all of which vary dynamically. When conditions get worse, excess livestock can be sold or consumed. Herd sizes can also decrease due to natural mortality or theft and/or other loss (Cately et al. 2014). Herds can potentially increase in size each year by 50% (relatively few male animals are needed), but livestock offspring production for pastoralists can be low due to unfavourable maternal conditions for rebreeding, high mortality among immature animals, and delayed rebreeding to extend milk production. Herd size is a common way to assess the household wealth of pastoralists (Butt et al. 2009, Ducrotoy et al. 2017)

All the fields used for this analysis were reseeded with the support of RAE Trust/Ltd (Meyerhoff et al. 2020), and all fields had been used for grazing. Of the 193 households that were visited, only 91 were used in the analysis (see Table 2). The 102 responses not used for the analysis included those newly reseeded fields that had not yet been used for grazing, households where the targeted field owner was not available because they had permanently relocated or had migrated in search of pasture and water, households where owners had abandoned their fields because of insecurity due to tribal clashes over grazing resources, and those whose fields were not in use because they had been submerged by the flooding of Lake Baringo in the previous years. Additional records were also eliminated for not reporting herd data and for not engaging in any livelihood activity. As suggested by Fratkin and Roth (1990), some sample selection may exist: the pool of survey respondents may have discounted the poorest of the field owners because the drought may have forced them to move outside of our survey area. As such, our results should be viewed as a lower bound on these relationships.

Analysis

The Loruk sub-location herd survival data was visibly different from the other sub-locations (see Fig. 2). The known events in the Loruk sub-location appeared to need separate evaluation from the remaining sub-locations (Akorian, Meisori, Salabani) and analysis of these final three sub-locations formed the primary analysis. The response variable of herd size maintenance

Table 2 Sample population

Sub-location	Dominant tribe	Total households visited	Households used for analysis	Percentages
Akorian	Tugen	56	27	53.6
Loruk	Tugen	43	19	46.5
Meisori	Njemps	39	22	59.0
Salabani	Njemps	55	23	45.5
Total		**193**	**91**	

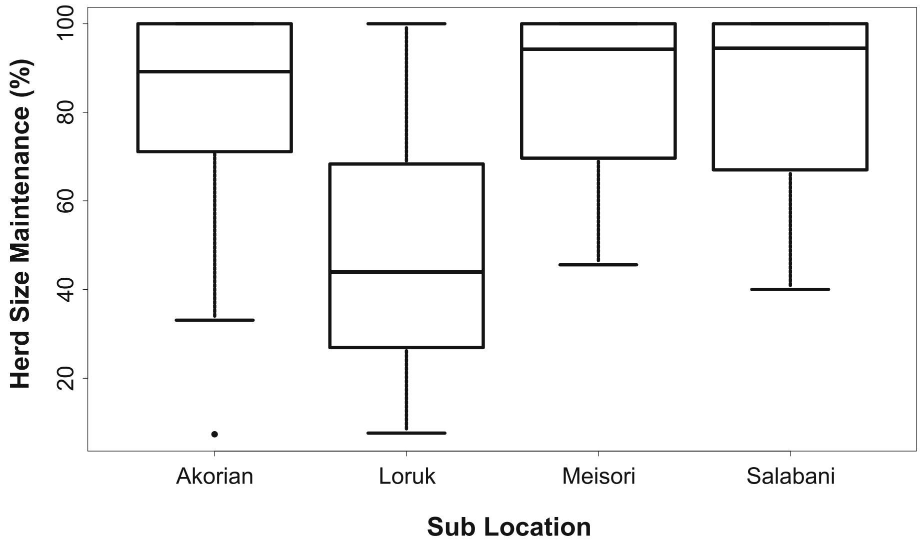

Fig. 2 Herd size maintenance percentages. *Note:* Figures obtained through comparing herd size from before and after the 2019 drought for the agro-pastoralists from the four sub-locations near Lake Baringo, Kenya

was regressed against the explanatory variables: sub-location (Akorian, Meisori, Salabani), owner's gender (male, female), the field manager (owner, paid help, or no one), years of experience with fields (years since the first field established), the number of fields, the number of field locations, the cumulative land size, the kind of fencing (wire, living material, none), the number of species planted, the owners' assessment of revegetation success, the number of livelihood activities, and the total herd size.

To ensure a large number of explanatory variable model did not mask one another, stepwise regression using the Akaike Information Criterion was completed using the step function in R (R Foundation for Statistical Computing, Vienna, Austria) which iteratively adds and drops model terms to combine both backward and forward selections. This resulted in the selection of the most informative model from among those possible. The residuals of both the initial model and the resulting parsimonious model were checked for normality and the response variable transformed but this did not change the selection of terms or levels of significance for any of the variables. The final parsimonious model had the herd size maintenance arcsine-square-route transformed to make the residuals meet the assumption of normality. All analyses were performed in R (version 3.6.1).

Results and discussion

Household characteristics and field traits

Analysis of the combined responses from the Tugen and the Njemps on the gender of field owner, field managers, land sizes, fence types, the success of reseeding exercise, species used for the reseeding, and the number of livelihood activities showed that 89.8% of the field owners were men (n = 88). 10.2% of the fields were owned by women. This is consistent with the pastoralist culture in which women have not traditionally had the right to inherit land (Talle 1988), but have the right to use the land and benefit from its resources (Allegretti 2018). As such, most of the fields are owned by men and the majority of the field management decisions are made by females. This difference between ownership and management is illustrated in the breakdown of who manages the fields, where the majority of the households (59.2%) have their fields managed by the owner with the help of the rest of the family members. The pastoral culture has been shown to be patriarchal and polygamous resulting in sufficient labour from family members, to share field management roles including, fencing, controlled grazing, and weeding. These activities are often spearheaded by women (Fratkin 1997; Allegretti 2018). In recent years, pastoral households have increasingly hired casual labourers to help with the field management responsibilities (Belay 2016). We find that more than a third (37.8%) of the respondents followed this trend. Hired labour can facilitate the migration of pastoralists and agro-pastoralists to other cities and towns in search of employment, education, and livelihood diversification as they adapt to a changing climate among other social challenges. The remaining respondents (3%) reported no field management.

The total land sizes reseeded were 1.82 ± 2.83 hectares (mean ± SD) per household. Households had more than one field (1.87 ± 1.31 fields) with the additional fields either being extensions of existing fields or new fields in up to five different locations. These fields varied in size ranging from 0.1 to 12.1 hectares, with cumulative land sizes reseeded ranging from 0.1 to 19.5 hectares. Land ownership in the rangelands of Kenya is mostly communally owned, though more recently, traditional systems have seen the critical institution of land tenure shift from communally owned to private lands. Individual land ownership in pastoral areas including Baringo is through occupation and usufruct, attributing to the rising population pressure and speculative official demarcation and adjudication of the land by the government. As such, to mark territory and for maximized reseeding benefits, fields are protected by fences of different types based on the preference of the field owners and their financial capabilities. The most common (85.7%) fence type in the area was live fences made from invasive *Opuntia* and *Prosopis* species and twigs and shrubs like *Acacia* and others found in the area*.* A smaller proportion of fields (11.2%) were protected by barbed wire fences. A few fields (3.1%) had no fences which matched the percentage of fields that had no management. Fencing is an important undertaking for field owners in order to protect their land from trespass grazing. Trespass grazing occurs when livestock that does not belong to the field owner grazes on the private field without the consent of the field owner. There are no current legal provisions that offer pastoralists and agro-pastoralists a framework for compensation when their grass fields are illegally grazed as compared to livestock illegally grazing a maize field. Lack of legal protection for field owners from illegal grazing fails to buffer the investments made by those who successfully reseed their fields. Considering that 97% of the respondents of this research invested in the different fence types to secure their fields demonstrates that they understand the importance of protecting their fields from uncontrolled grazing.

The respondents of this study have been stewards of reseeded lands for an average of 10 years. The majority of them (92%) felt that the reseeding exercise was successful with just 7.3% reporting poor reseeding success. Barr et al. (2017) found that the success of reseeding averages 70% (± 3%) with mixtures yielding higher success rates although their results were not from Africa. For this study, nearly all fields (98%) were reseeded using the native perennial bunchgrass *Cenchrus ciliaris* (African foxtail or buffelgrass), and 14.4% were reseeded using a mixture of native species including *Eragrostis superba* (Maasai love grass), *Enteropogon macrostachyus*, *Sehima nervosum*, and *Cymbopogon pospochilii*. The success rate of the observed reseeding activity was much higher than Barr et al.'s (2017) reports, and possible explanations would be because the reseeding was undertaken using indigenous species that are drought-tolerant and have adapted to the conditions of this area. Grasses native to Africa are known for their ready establishment, durability under grazing and disturbance, drought tolerance, and forage quality (Lobell et al. 2008; Overholt and Franck 2017). To foster success, the reseeding used grass seeds that had been locally hand-harvested by agro-pastoralists. The seed was then processed, cleaned, and stored to break dormancy and increase germination. Mganga et al. (2015) reported that native species including *Cenchrus ciliaris* and *Eragrostis superba* have been successful in reseeding and fighting desertification in East Africa and are the most preferred because of their forage value. Similarly, the Tugen and the Njemps prefer these species because of their native status, forage value, and grazing tolerance. The survey respondents engaged in (2.57 ± 1.53) income-generating activities associated with reseeded fields. These activities were dry season grazing, harvesting grass seeds, cutting thatching grass, milking cattle, engaging in fattening programmes, baling baling of hay, and leasing of land (Githu et al. 2020). The reseeding is a source of livelihood diversification. This diversification has the potential to reduce household vulnerability from uncertainties including climate-related disruptions causing forage shortages.

Herd characteristics

The purposes of pastoral herds include the regular provision of food in the form of meat, milk, and blood; cash income; a measure of exchange in terms of dowry; compensation of injured persons during raids; a symbol of wealth and prosperity; and security against droughts, disease outbreaks, and other rangeland calamities (Kaimba et al. 2011). The Tugen and the Njemps pastoral communities keep cattle, sheep, and goats (see Table 3).

For many pastoral communities, the act of counting animals is culturally offensive, and the survey respondents may not have been entirely forthcoming on their livestock numbers. This is consistent, however, with other studies, including Cately et al. (2014). The household herd sizes may include animals belonging to members of other households. Our survey does not probe into ownership issues but instead focuses on the herd that graze on the reseeded fields in question. We assume that any exaggeration of herd sizes will be consistent across households reporting on herd size figures before and after the drought to reflect the impact of reseeding.

Table 3 Household herd size in tropical livestock units (TLU)

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: 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, and kids = 0.04 TLU (Kristjanson et al. 2002; Wilson 2003)

When comparing the sub-locations, herd sizes do not significantly differ (p = 0.46), with an average of 16.5 ± 14.6 TLU (Average ± SD) with 15.7 ± 13.1 TLU for the Akorian, 18.5 ± 16.5 TLU for the Loruk, 13.9 ± 9.9 TLU for the Meisori, and 18.1 ± 18.1 TLU for the Salabani sub-location. Households average 9.6 ± 4.9 members (average ± SD) with 8.3 ± 2.3 members for the Akorian, 12.6 ± 5.1 members for the Loruk, 6.9 ± 2.7 members for the Meisori, and 10.8 ± 6.6 members for the Salabani sub-location. This is an average of 1.7 TLU per household member. Herd sizes, in terms of TLU per household member, are double those found by Hauck and Rubenstein (2017; 1.1 TLU per household member) among Maasai pastoral communities from northern Kenya. These herd sizes are also similar to those from Nigerian pastoralists (Ducrotoy et al. 2017). While herd sizes fluctuate for many reasons (Kimiti et al. 2018), our finding of 1.7 TLU per household member raises some concern for this pastoral community. Fratkin and Roth (1990) classified pastoral households as poor if there were less than 4.5 TLU per household member because below 4.5 TLU per household, the livestock herd could not provide sufficient calories to support the household on its own. This implies that these agro-pastoralists were getting more than half of their calories from sources other than their livestock.

Herd size maintenance

Herd size maintenance differs in the Loruk sub-location (p = 0.002; see Fig. 2). The Loruk sub-location averages only 49% survival following the 2019 drought, while the Akorian, Meisori, and Salabani average 80%, 85%, and 82%, respectively. The reduced herd survival rates in Loruk may be attributed to security concerns that led them to abandon their land. This insecurity may be linked to newer forms of cattle theft between tribes in the area but differs from the long history of inter-tribal cattle rustling. Cattle rustling practices were motivated by traditional cultural ceremonies and events such as bride price paying, the celebration of the warriors, and competition among age-sets. Cattle rustling was a sport that had to be sanctioned and blessed by the elders, and the warriors involved used conventional weapons such as spears, sticks, bows, and arrows when acquiring livestock from another community. However, cattle theft has evolved into large-scale theft operations involving taking away thousands of cattle in broad daylight, exchanging gunfire, rape, abduction, and killing and wounding of men, women, and children (Kimani et al. 2020). Inadequate policies, shrinking of natural resources, acquisition of weapons, and a collapse of the traditional governance system are to blame for this change. Commercialization of cattle raids and political incitement have also led to large-scale violent raiding between neighbouring communities (Greiner 2013). Loruk sub-location borders the Pokot territory and is the most affected by cattle theft. Though they have invested in reseeding their fields, they do not seem to reap the benefits of having higher herd size maintenance as compared to the agro-pastoralists from Akorian, Meisori, and Salabani.

Analysis of the data from Akorian, Meisori, and Salabani sub-locations showed that the total number of fields (p < 0.001) and the number of activities (p = 0.044) had substantial explanatory power which was confirmed in a parsimonious model. The parsimonious model only explained about 20% of the variability in the data likely due to the relatively high herd survival rates (see Tables 4 and 5). Each additional reseeded field added 1.5% to herd size maintenance. More research is needed to better delineate the reason for this, though we believe that having more fields would allow for improved control of grazing and the ability to save forage. As such, the ability to graze some fields while resting others (rotational grazing) has been the essential observation that allows for improved land condition under livestock grazing worldwide (Flynn et al. 2017). The inability to defer grazing on sub-sections may explain why the total land size did not show up as a significant predictor of herd size maintenance. Larger undivided parcels offer only the option to graze or not to graze.

Table 4 Herd survival regression full model

Variables	Pr(>|t|)
(Intercept)	0.00132**
Sub-location Meisori	0.470
Sub-location Salabani	0.484
Gender male	0.694
Managed by owner	0.658
Managed by a paid worker	0.303
Years of experience	0.688
Number of fields	0.046*
Number of field locations	0.263
Total land size	0.886
Fence type none	0.831
Fence type wire	0.767
Species used	0.384
Reseeding success good	0.267
Reseeding success poor	0.131
Total herd size	0.738
Number of livelihood activities	0.060*
Adjusted R-squared	0.081
Prob > F	1.384

Significance designed by 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ''1

Table 5 Herd survival regression parsimonious model

Variables	Pr(>|t|)
(Intercept)	8.01e−14***
Number of fields	0.0006***
Field locations	0.167
Number of livelihood activities	0.044*
R-squared	0.212
Adjusted R-squared	0.177
Prob > F	0.001

Significance designed by 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 '.' 1

One may expect that having more locations would be associated with a negative effect on herd size maintenance. Livestock movement has been shown to expose the herds to risk (Butt et al. 2009) but this must be balanced by the need to move to available forage (Baker and Hoffman 2006) and the need for water. We see that the movement between locations was not associated with a change in herd survival. It may be the case that the distances were not long enough to be associated with higher risk. The number of activities had significant explanatory power (p = 0.044) for herd survival with each additional activity adding 0.3% herd survival. Earnings from other income-generating activities may have supported the purchase of forage for their herds once they had exhausted dry season grazing on their reseeded fields. Our results are consistent with those of Ducrotoy et al. (2017), for Nigerian pastoralists and agro-pastoralists. They describe diversification of livelihoods as an important way for households to mitigate risk and allow resilience in the face of changing environmental and social conditions. However, Ducrotoy et al. (2017) also note that for their Nigerian pastoralists, diversification also correlates with smaller TLU per household member which the authors associate with poverty or a move away from a pastoral lifestyle as a primary livelihood. The addition of activities may represent household economic pressure in maintaining desired herd size which in turn may take away resources from mobile herding activities and indicate a transition toward a more sedentary lifestyle.

Regional environmental conditions, such as drought and aridity, combined with social and legally 55 driven changes in herding behaviour, have been thought to result in resource degradation and especially the loss of grasses and grasslands (Kassahun et al. 2008). While some of the environment would benefit from reduced grazing, the extant plant community across much of Africa seems a product of grazing and may convert to a woody dominated plant community in the absence of grazing (Oba et al. 2000). As with most ecological systems, balance among grazing and rest plays a role. Nonetheless, given that pastoralists and agro-pastoralists have been commonly seen with a negative view by the environmental conservation world and routinely used as the villain of the tragedy of the commons (Turner and Schlecht 2019), it is notable that the agro-pastoralists in our sample were able to restore and then conserve their restored grazing lands across decades when they have control over them.

Conclusions and recommendations

Reseeding among the pastoral Tugen and Njemps communities is correlated with diversified sources of livelihoods and generally stable herd sizes. The reseeding appears to offer environmental benefits along with allowing households flexibility in responding to the challenges of climate variability, land degradation, and poverty. The high success rates and the long-term sustainment of the reseeding imply that this intervention is appropriate for the situation and that sustainable grazing management can be achieved in these areas. When sustainably managed, reseeded fields can support a more sedentary lifestyle for the pastoralists and the agro-pastoralists. Future policies and institutions that support larger-scale reseeding on communal lands, private enclosures, or open ranges may expand these benefits although simultaneous additional work is needed on the social and legal frameworks for pastoralists and agro-pastoralists to fully benefit from reseeding. Future research should try to understand the changing culture of pastoralism given the current challenges and the holistic impact of reseeding large-scale communal lands.

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Authors' contributions
All authors conceived the study methods. Diana Githu collected the survey data. Diana Githu and Jeffrey S. Fehmi analysed the data. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study received ethical approval through the University of Arizona Institutional Review Board (IRB), protocol number 1905646702 on 06/06/2019.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests. But also note that Diana W. Githu worked as an employee of the Rehabilitation of Arid Environments (RAE) Trust/Ltd from January 2016 to June 2018.

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