Evaluating The Resource Supply Thresholds That Trigger Livestock Movement Leading To Grazing Conflicts In Northern Kenya

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ABSTRACT: Grazing conflicts in Northern Kenya is causing critical scenario that is drawing the attention of many stakeholders, communities and Governments alike. The objective of this study was to find out the thresholds of grazing resources throughout the year in the Community conservancies, and how these contribute to livestock movements in search of grazing resources. The study used an integrated Mixed-Method approach of experimental and social survey designs to assess how competition for limited resource triggers intra and inter-conservancy conflicts. In this study a total of eight experimental plots measuring 50mx50m were set up, two in each of the three community-owned conservancies, and two in a private conservancy to assess forage availability during dry and wet seasons. The privately owned conservancy acted as the control. Clip-dry-and-weigh method was used to assess forage capacities. Five samples of Clippings were obtained using 0.5mx0.5m wire quadrant randomly distributed in each plot in both seasons. Visual estimates were used to assess ground cover percentages while grass height and weight measurements were taken to assess biomass characteristics. We found that the months of June to October had the lowest forage availability. Through use of Remote Sensing we found that there are general decline in vegetation vigour during the period of January-March, and June to October when most grazing conflicts are experienced, and through Participatory GIS (PGIS) the respondents attested that this has been the cause of movements to unknown areas in search of browsable forage. It was found out that there is a close correlation between grazing conflicts and water and forage availability in the study area.

Key Words: Grazing conflicts, mixed-method approach, MODIS, Normalized Difference Vegetation Index (NDVI),

INTRODUCTION

In northern Kenya, traditional pastoralism and social-ecological systems are undergoing profound transformation. Diminishing resource base, changing social values and governance systems and new resource management institutions challenge the capacity of the community to effectively manage resources communally. Individual values and environmental perceptions play a substantial role regarding the resource use and management (Kaye.E. & E.King.2014). Pastoralism is a critical livelihood in Kenya and it accounts for over 80% of all economic livelihoods of the communities living in northern Kenya. Apart from water, forage is the second critical resource for livestock and wildlife. Climate related fluctuation in forage production is a major factor constraining the Kenyan pastoralists, especially form the more arid rangelands of northern Kenya (Jatzold, 1995). Highly variable amounts rainfall causes wide fluctuations in the amount and distribution of foliage available to livestock and wildlife. High but short-lived seasonal plant biomass production cannot be optimally utilized to compensate for low biomass production during the prolonged droughts when available pasture is insufficient to support resident livestock. During the prolonged drought, the body condition of the livestock deteriorates and its market value diminishes. Thousands of pastoralists lose their economic base, leaving many families poor and desperate (Jatzold, 1995). In River Ewaso Ng'iro catchment, over 90% of the land is covered by perennial shrubs and grasses, which constitute the principal forage for livestock and resident large game (Ericksen et al., 2011). Local variations in topography, soil and rainfall, produce corresponding seasonal and spatial variation in forage production and hence availability to livestock. At some point, the herders drive the livestock out of the area with rapidly diminishing water and pasture resources. Intercommunity conflicts and invasion of private ranches and conservancies by traditional pastoralists in search of pasture have been on the rise. The conflict has in many occasions led to losses of human lives and livestock in Laikipia County. The real or perceived drivers of the grazing conflict have not been well researched and hence their occurrences cannot be predicted with certainty. However, there are some reliable resource-threshold models that can be used to make prediction about triggers of livestock migration and the subsequent inter-community grazing conflicts. The triggers of livestock migration from one part of the rangeland to another can be environmental, ecological and social factors. These triggers of migration have not been fully investigated in Kenya's northern rangelands and are therefore not well understood. Changes in vegetation cover over time and space, and amount of plant biomass produced can provide reliable indicators resource thresholds. Remote Sensing techniques have been used in the East African rangelands to analyze spatial and temporal variation in vegetation cover. One of these is the Normalized Difference Vegetation Index (NDVI) which is used to indicate the relative amount of available pasture over a given period and can aid in correlating results from real-time field measurements, social survey and weather related data (Holme et al., 1987).

STUDY AREA, MATERIALS AND METHODS

Description of the study area

This study was conducted in three community and one privately owned conservancies in Laikipia and Isiolo counties in Northern Kenya. The conservancies were Ngarendare, Ilngwesi, Nasuulu and Lewa. The two counties have almost similar geophysical and climatic characteristics and are adjacent to each other, with Laikipia bordering Isiolo to the Northwest. The main soil types are Acrisols, Luvisols, Ferrasols, Alfisols, Ultisols, Oxisols, and Lithisols (Lerberg, 1988). These soils are all generally of low fertility and are highly erodible. The dominant vegetation in the two counties consists of scattered trees, shrubs and open grasslands (Lerberg, 1988). Laikipia and Isiolo counties are semi-arid and receive 450 - 800mm of rainfall per year. The rainfall pattern is bimodal with long rains occurring during the period between March and May while the short rains occur between October and December. There is a 4-6 month dry period with annual temperature ranging from 25^0C to 29^0C (Republic of Kenya, 2009). These climatic conditions result in very low crop yields at times, and are mostly dominated by nomadic pastoralism.

Study design

In order to understand the causes of livestock movement and subsequent conflicts among the communities and between the ranchers, the study area was divided into two categories: community managed areas (Ngarendare, Ilngwesi and Nasuulu) and privately managed ranch (Lewa Conservancy). The two study sites have similar climatic conditions, soil and natural vegetation. They have livestock and wildlife co-existing at different densities. They also have different forms of controlled livestock grazing regimes. Controlled livestock management is intended to regulate pasture off take and disturbance of vegetation by foraging animals. Grazing and browsing by animals reduces grass biomass, reduces ground cover and may affect plant composition and nutritional quality of the pasture. This study compared the effects of community based grazing control regimes and livestock management regime at the Lewa Conservancy. In the community conservancies, grazing is controlled through a mutually agreed and season-based grazing plan overseen by grazing committees. In Lewa Conservancy and other 15 private ranches in the study area, two management options exist. Paddocks and grazing rotation as well as use of fire and mechanical removal of unpalatable pasture species and hence improve pasture quality. The impacts of these grazing regimes are analyzed on a seasonal basis. In addition, Lewa Conservancy has established 28 permanent monitoring points to evaluate the condition of the rangeland. Information on range condition, land degradation status, grass biomass and species diversity was gathered annually by the ranch managers in the month of January to April and June to October. June. Range condition monitoring in the community lands was either irregular or non-existent.

Materials and methods

This study adopted a mixed methodology that combined both qualitative and quantitative approaches. This approach involved ecological methods of vegetation analysis and biomass assessment as well as complimentary social survey methods to gather data on traditional livestock husbandry (Creswell & Plano- Clark, 2007). The specific methods for data collection were forage surveys using transect walks and quadrats, administration of questionnaires and interview schedules, Focus Group Discussions (FGDs) and secondary research.

Forage assessment

Two sites were located in each of the conservancies grazing field and a plot of 50mx50m set on each site. The sites were selected based as much as possible on representation of the variation characteristics of entire grazing field like slope direction, forage species, vegetation growth forms and accessibility (NCRS,1997). Each plot contained 50 sub-plots (quadrants). To estimate available forage biomass, five quadrants were picked at random on each plot and clip, dry and weigh method used to estimate the biomas levels in both wet and dry seasons. 0.5mx0.5m square wire was placed on the subplot and all above ground grass cut using secateurs. The samples were put in Kirk papers and weighed, then oven-dried for 24 hours at 60^0c and weighed at 14 % moisture content. In order to predict the available forage biomass, simple linear regression equation was used: $Y = \alpha + \beta \times$ **(1)** (Le Hourerou & Hoste, 1977) was used Where**:** Y = dry matter production (kg/ha/year or season), X = annual or seasonal precipitation (mm) α = regression constant (-180 for herbs and – 400 for shrubs), β = regression constant (6.3 for herbs and 10 for shrubs)**.** Data on forage biomass was collected twice i.e. dry season data (February -March) and wet season data at the end of the growing season (May -June). Two transect walks were conducted between the plots to describe vegetation variability as well as tree and shrub density and diversity. Data on vegetation and soil characteristics was recorded on Range Condition Data Sheets.

Social surveys

The target population consisted of resource persons (livestock and range management officers), grazing committee members, key informants (ranch managers) and researchers working the in the entire study area. The respondents targeted were conservancy committee members picked from each, and the questionnaires administered by trained research assistants and the researchers. Four focus group discussions (FDGs) of between 8-12 people were conducted in each conservancy. These were used to clarify controversial issues in the course of the research. The surveys data were sorted, compiled and entered into excel spreadsheets for subsequent analysis using SPSS package. The findings are presented in graphs, satellite images and tables.

Assessment of forage availability and variability using Remote Sensing technique

A proxy model for vegetation productivity known as Normalized Difference Vegetation Index' (NDVI) or greenness index was selected for assessing available pasture during the dry and wet seasons. Land sat images were obtained from land sat 4, 5, and 7 from the Regional Centre for Mapping of Resources for Development, Nairobi. NDVI is a relatively simple indicator of vegetation growth and coefficient (representing current productivity based on the amount of 'greenness' of the landscape remotely assessed from the sky by satellite). NDVI as a ratio of the reflected radiation over the incoming radiation in each spectral band individually. Hence, the index takes values ranging between zero and one. By design, NDVI therefore varies from -1.0 to +1.0. (Holme,et al., 1987)

RESULTS

The researcher sort to find out what resource levels in the conservancies triggered animal movement and subsequent grazing conflicts in the four conservancies. The grazing resources considered were pasture grass and water. Evaluation of the available forage, types water available and distances to watering points. and corroborated through the analysis of questionnaire responses and focused Group Discussions and their overall correlation to grazing conflicts ascertained.

- **Water availability**

The information from the data analysed was showed that most of community members cover long return distances to and from watering points. On average, it was found that most community conservancies do over 10 Km searching for water for their stock during the dry seasons, while there was a noted difference in Ngare Ndare and Lewa where the number of Kilometers to the watering point was shorter in the range of less than 5 Kilometers return.

The table below shows the water availability and accessibility to grazers per conservancy in the study area:

Table 1: *Water availability and access in different community grazing lands*

Distance From Water Point Per Conservancy	**0-5 km**		**5-10km**		**Over 10km**			
Statistics	F	%	F	%	F	%		
Ngarendare	27	100	0	0	0	0		
Ilngwesi	20	80	3	12	2	8		
Nasuulu	16	80	3	14	3	14		
Types of water sources	**springs**		**Wells**		**Dams**		**Others**	
Statistics	F	%	F	%	F	%	F	%
Ngarendare	16	58	0	0	7	25	5	19
Ilngwesi	5	20	10	40	5	20	5	20
Nasuulu	4	20	8	40	4	20	4	20

At Ilngwesi and Nasuulu there were fewer options of the types of watering points with Ngare Ndare having more options to chose which is springs and rivers. Numbers of water points were more for the Ngarendare and Lewa (control group) with a total of 15 water points. In the private conservancies, surface and rain water was harvested and stored in water pans and permanent earth dams. Water was also extracted from streams and boreholes. For example in Ngarendare forest, water was distributed to several watering points within short walking distances for the livestock and wildlife to access. The more closer and accessible the water points are in the conservancy the less the walking distance for livestock thus avoiding vegetation damage and land degradation, especially soil erosion, due to land trampling by large concentrations of animals.

Forage availability

Forage availability was evaluated by both available forage analysis, grass height measurements, observation of grass colour and growth vigour. Basal gaps were analysed through visual observations and estimations of percentages of ground cover and bare ground. Transect walks were done between the plots to ascertain the vegetation characteristics, soil and available browsable trees and shrubs. In the dry season data, generally all the community conservancies exhibited depressed forage and herbal cover, with bigger percentages of bare ground on Nasuulu, Ilngwesi and Ngarendare in that order. It was derived that Ilngwesi and Nasuulu have the lowest available forage biomass compared to other conservancies. Ngarendare forest has the highest amount of shrub density hence provides more shrub forage than the other conservancies. The figure below shows the overall biomas situation per conservancy in both seasons.

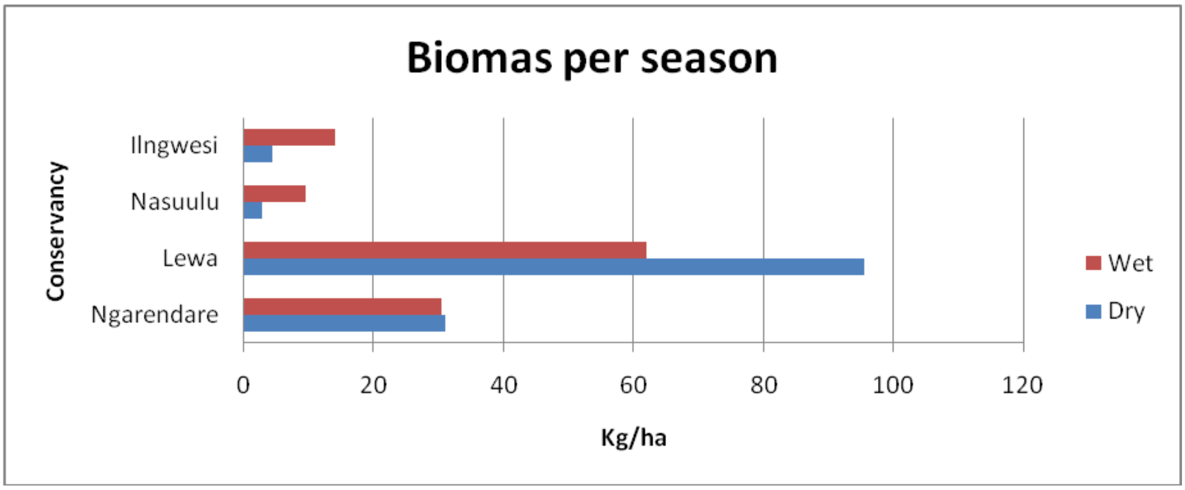

Fig 4.1: *Biomas per conservancy in wet and dry seasons*

It was noted that after the rains in April, all the community conservancies and the control showed improved forage availability, soil and basal cover characteristics. The control showed lowest bareground percentges in both the dry and wet season data collection periods. There was overall improvement in the observable vegetation greenness and vigour immediately after the wet season, with more brousable foliage species coming up after the short rains on both the communities and the control. In the community managed conservancies, this improvement was however shortlived due to immediate defoliation by the incoming livestock. This observaton was coroborated by Sammy Tema, a community liason officer at Ilngwesi, who told the reasearcher that immediately after thee rains, the livestock that had moved out during the dry season came back and broused on the emerging new herbage.

- **SpeciesVariability**

It was also found out that the forage productivity of the conservancy varies in the dry season with other factors. However, the grass species available on Ngarendare and Lewa, are doinated by Penisetum mezianum, and P. stramenium, the type that is not very palatable to livestock since it is tough and fibrous it can only be useful to livestock during the short period after the growing season, prompting the livestock to move to other areas with better palatable pasture Livestock also depend on other brouserbles like short trees and shrubs as witnessed at Nasuulu and Ilngwesi, effectively supporting the conclusion that dwarf shrubs are important forage in the arid areas (Schwartz et al. 1989). They concentrate on small drainage lines and water runoff tunnels and collection points and have longer growing periods than grass. At Nasuulu and Ilngwesi the ground cover was over 80% bare exhibiting widely spaced thorny herbs and perennial grass with huge basal gaps, scattered shrubs and short trees. Browsers depended on species like Grewia bicola, Rhus natalensis, Boscia angustifolia, devils thorn and Balanites eagiptica.

- **Correlation between the availablity of forage and grazing conflicts**

The study sought to find out and analyse the availability of grazing forage and the grazing conflicts to find out how they correlate with each other. The forage availability can be further explained by remotely assessing the periodic ground and vegetation characteristics using NDVI. The figure below exhibits the relationship between the grazing conflicts and the availability of pasture:

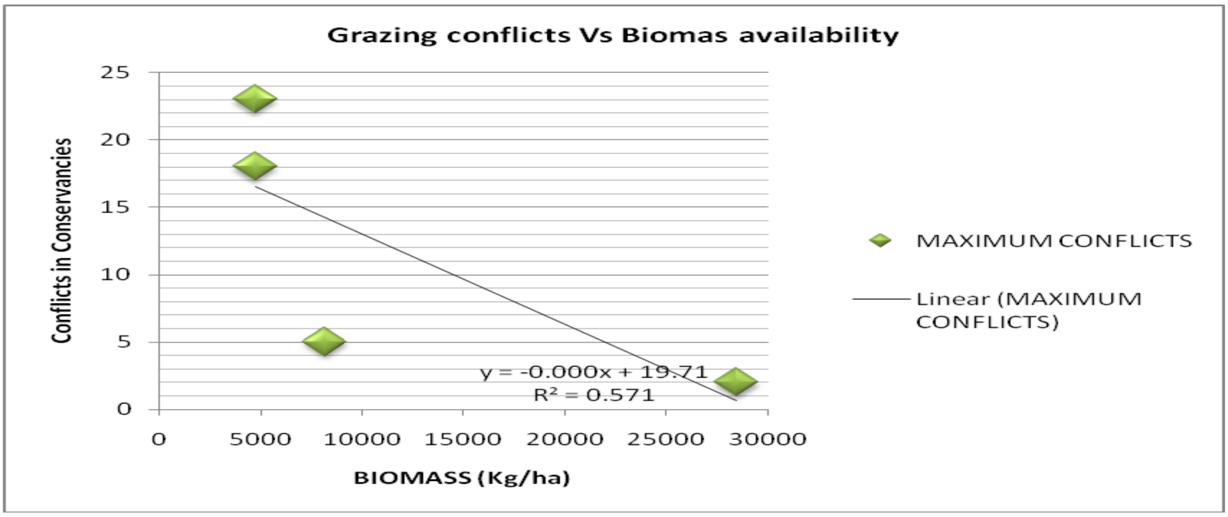

Fig 3: *Correlation between grazing conflicts and the forage availability*

It was found tha the forage availbility and grazing conflicts had a correlation gradient of R^2 =0.57, which tells that forage availability determines 57% of grazing conflicts in the study area. It can further be seen that as the biomas (forage) increases, conflicts decreases. Therefore we can safely derive that as the community forage base declines as a result of seasonality or droughts, more grazing conflicts are going to be experienced in the study area.

- **Remote sensing of forage availability**

The figure below shows the satellite images reflecting the NDVI of December 2017 during the wet season and the February 2018 which shows the vegetation situation in the dry season on the study area:

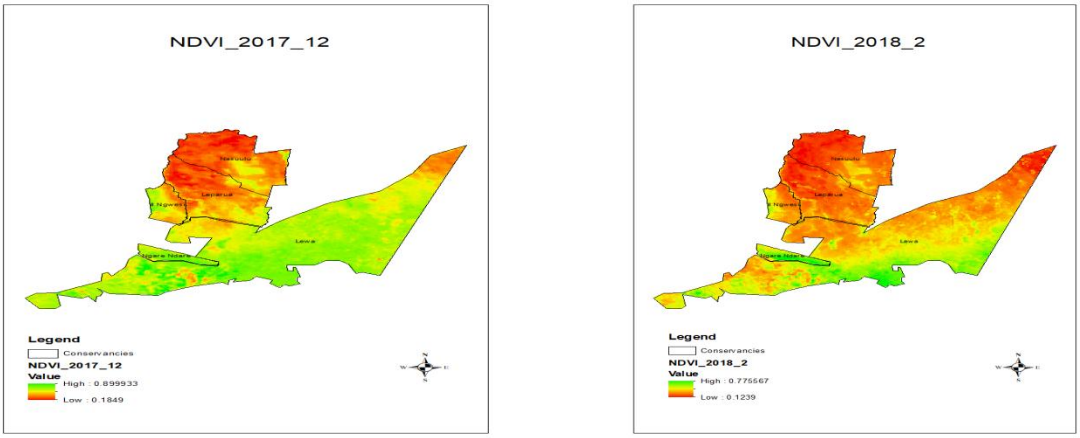

Fig 4. *The stelite images of December and February*

The graphical representation of the NDVI trend in the period between October 2017 and Feb 2018 in the study area is therefore as shown below:

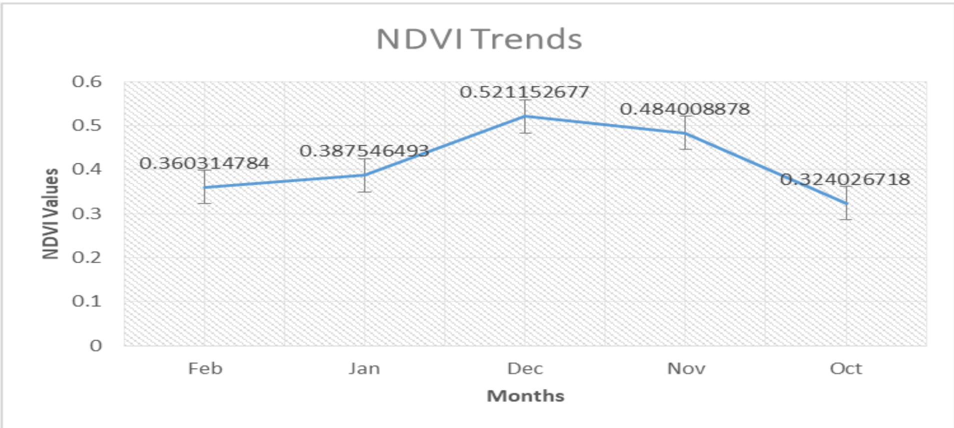

Fig 5. *NDVI Values in the dry and wet seasons*

DISCUSSIONS

This mixed method combined both the community views on the grazing potential of their land with the real time assessment of the availability of forage both in the wet and dry seasons. Rainfall variability and landuse in the study area are currently undergoing more profound changes than in the 1990s owing to rainfall variability and both human and livestock population increases. The rapid response to the scanty short rains of April-May seen in Nasuulu and Ilngwesi, shows that the forage recovery can achieve full ground cover if the it is given substantial recovery period. However, the rest period was insignificant as livestock returned immediately during the short rains. This scenario gave no chance for grass to re-grow to browsable levels. The resilience of the community conservancies is most dependent on precipitation. Grazing Planning, which is already in place according to the social survey, are showing no effective control of grazing, or are neglected or ignored in times of drought. If not, after the rains it should have been seen working where blocks are well designated for resting and regeneration or for grazing s elaborated by the grazing committees and the grazing coordinator. Despite the general greener appearance of the vegetation after the short rains, the river and gullies were dry, indicating that the short rains were never sufficient to feed the upstream communities and leave sufficient stream flow for the downstream communities. This infers that the downstream communities have to move up in search of the limited resource, as indicated by abandoned cattle 'bomas' at Ilngwesi. The huge percentages of bare ground witnessed at Nasuulu and Ilngwesi also suggests that there is little infiltration and huge evaporation hence affecting forage recovery potential. Due to continuous defoliation and browsing exhibited in the community conservancies, giving the grass and other herbal vegetation no adequate time to recover compared to the control. The huge basal gaps witnessed on the community conservancies in the dry season data period reduced significantly in the wet season grazing regime. This implies that applying the grazing plans effectively could significantly improve soil stability, reduce degradation, lead to high productivity of the rangelands leading to less movements of the livestock hence leading to less grazing conflicts in the study area

CONCULUSIONS
Basing on the responses it is clear that the months of June to October are the hardest periods of grazing in the study area. There are general decline in vegetation vigour, and through Participatory GIS (PGIS) the respondents attested that this has been the cause of movements to unknown areas in search of browsable forage. There are minimal forage for both small and large stock at Nasuulu, Ilngwesi due to large livestock numbers as well as little forage cover, triggering movements in search of pasture to far areas of upper altitudes like Ngarendare, Lewa and the mountain areas. Therefore this situation leads to conflicts and more environmental externalities. On the water situation, the community can benefit from sand dams and the county governments of Laikipia and Isiolo are the potential supporters to ease access to water and reduce grazing conflicts. Lewa has already installed a number of dams, an initiative that can be replicated to community conservancies. More boreholes need to be surveyed and installed at Nasuulu and Ilngwesi.

RECOMMENDATIONS
This study did not include the analysis of forage supplied by shrubs and trees. It is recommended that other suppliers of livestock forage rather than grass be analysed in the study area. It is imperative that destocking is considered as mitigation factor to restore degradation and reduce stock movements. Further research to establish the real figures of stock losses due to grazing conflicts in the study area is recommended. This will enable future studies on relationship between grazing conflicts and real economic losses to be ascertained. It is also important recommendation to ascertain the real distances of movements of livestock to correlate this with grazing conflicts along the movement routes, and enable prediction and decision making in different regions affected by grazing conflicts

ACKNOWLEDGEMENTS
This study would not have been successful without the support of Nasuulu, Ilngwesi, Ngarendare and Lewa WC staff for allowing me to access, conduct and search research information in their areas. We acknowledge Mr. Edward Ouko of the Regional Centre for Resource Mapping for Development, Kenya for his contribution in remote sensing, and John Ngujiri for his assistance with statistical analysis.

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