Impact of Enclosures on Range Productivity in Chepareria West Pokot County Kenya

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Abstract
In the semi-arid areas of West Pokot particularly Chepareria, majority of the people live semi sedentary lives while others are nomadic pastoralists. In the last three decades, there have been concerted efforts to restore and improve rangeland in this area. Use of enclosures, which is one of the key interventions, by the Vi Agro-forestry a Non-Governmental Organisation, enhancing with many ecological processes such as disturbance, is a method of rehabilitating degraded rangeland, which in turn affects vegetation dynamics.
Adoption of these strategies by farmers has been gradual and some areas are still open and degraded. The aim of this study was to evaluate the effects of enclosures on range productivity in the semi-arid rangeland in West Pokot. Plant productivity, diversity and density were assessed in enclosures of different ages and in adjacent open land used for communal grazing. Questionnaires were also used to assess local community perception of the range restoration and improvement. Modified Whittaker plot was used for sampling in the selected enclosures and open areas. Herbaceous biomass and plant cover were greater in enclosures than in open areas.
The average herbaceous cover in the enclosed area was 76% while that in the open it was 55% which was significantly different, $P<0.001$. The average herbaceous biomass in the enclosure was 137.2kg/ha while in the open it was 37.8kg/ha respectively. Enclosed areas are more productive than open areas and should be adopted in other dry areas as a method of rehabilitating degraded grazing lands.

Introduction
Overgrazing and deforestation continues to affect the productivity and genetic diversity of forests, woodland and grassland resources in dry lands areas. Exacerbated by recurrent droughts, the ultimate outcome of deforestation and degradation of these resources will be desertification, loss of livelihood and increased poverty (Mengistu *et al*., 2015). Sustainable conservation and utilization of the dry land vegetation resources and rehabilitation of those that have already been degraded provides economic, social and ecological benefits (Mengistu *et al*., 2005; Kaye-zwiebel & King, 2014).
In this regard, different strategies are used world over to improve and rehabilitate/degraded rangelands. For example, establishing enclosures has emerged as a promising practice in different parts of Ethiopia (Angassa & Oba, 2010; Mengistu *et al.,* 2015). It is a fast method triggering invasion, germination/sprouting, recruitment, establishment and growth of seedlings, modified underground stems or roots of indigenous species of grasses, herbaceous weeds, shrubs and trees that already exist at the spot either being dormant or suppressed by other plants or unfavourable environmental conditions. These propagules invade the area faster and with better coverage than planted seedlings. It is a cheap method since natural processes lead to regeneration of the vegetation without any human interference and financial investment (Mengistu *et al*., 2015).
In Kenya in the last three decades, there have been notable changes in vegetation in parts of West Pokot specifically Chepareria Ward (Triple L, 2013; Karmeback *et al*., 2015; Wairore *et al*., 2015). These changes can be attributed to many factors especially related to land use and management (Wairore *et al*., 2015). In West Pokot there have been efforts to improve range productivity and rehabilitate degraded areas. The key management interventions in this area include use of enclosures and afforestation (Makokha *et al.,* 1999). These efforts were differently accepted by individuals and hence notable local differences in general range health in the area. This study is part of a multidisciplinary research initiative that seeks to evaluate the impacts of these interventions on land, livestock and livelihoods (Triple L www.triplel.se) in West Pokot.
The broad goal of the Triple L is to understand the drivers of the changes in this ecosystem and their interrelationships. For example, whether enclosures are leading to changes in land tenure from communal to private and the impact of these changes on social economics of the residents; whether improved livestock productivity can be attributed to enclosures and afforestation or changes in land tenure and what is the minimum land subdivision in this ecosystem; whether there is optimal size of enclosure and tree density for improved plant productivity and carrying capacity. This study seeks to understand the effects and mechanism behind the observed range improvement due to use of enclosures and afforestation
The objectives of this study are: To determine the impact of enclosures on plant cover, biomass, frequency and tree density within enclosures and in the adjacent open areas of Chepareria, West Pokot. To evaluate the

indigenous knowledge, on range monitoring and rehabilitation in Chepareria, West Pokot. To determine the effect of enclosure on soil seed bank and soil nutrients in Chepareria, West Pokot

Methods and Study Site

The research was carried out in Chepareria ward West Pokot County, where the climate is semi-arid. Purposeful sampling was carried out only in the areas where enclosures have been adopted and the adjacent open areas in Chepareria in West Pokot. The modified Whittaker plot (Stohlgren, 1997), was used for data collection. Twenty one sites within enclosures and comparable twenty one sites in the open areas were sampled. Vegetation cover was measured in the field by assessing the percentage of the ground that is covered by the existing annual or perennial vegetation (Park *et al*., 2015). Herbaceous material was harvested and weighed in the field and a sub sample taken and fresh weight taken. The subsample was dried in the laboratory for dry biomass (Cornelissen *et al*., 2003; Angassa & Oba, 2010; Mureithi *et al*., 2014; Mengistu *et al.,* 2015). Frequency of each species in the modified Whittaker plot was recorded in order to determine species composition and density. Trees and shrubs within the laid modified Whittaker plot (for the 20m by 50m), were counted, identified and recorded (Cornelissen *et al.,* 2003; Mekuria & Yami 2013; Zhan *et al*., 2013; Kasim *et al*., 2015).

Seed bank sampling and soil nutrient analysis was carried out, where 10 soil cores of 4cm diameter to a depth of 10cm within each of the ten $1m^2$ sub plots of the modified Whittaker plot, were taken put in a bucket and mixed thoroughly and a sub sample taken for analysis. The samples were washed over a sieve after mixing them together. The samples with the seeds were put in trays and placed in a greenhouse for germination.. Seedlings were identified, counted and removed immediately (Horneck *et al*., 2011; Bekker *et al*., 2016).

Knowledgeable herders (key informants like elders, chiefs) were selected based on age and experience and interviews on broad issues related to indigenous range resource management techniques were conducted (Wairore *et al*., 2015). A semi structured questionnaire was used to establish prevailing traditional techniques to assess and monitor range condition and probable mitigation measures taken if the status of the range resource was undesirable (Oba, 2009; Abate *et al*., 2010; Shiferaw *et al*., 2013).

Data management and analysis

Data collected through the questionnaires were analysed through descriptive statistics. T-test was used to compare and analyse vegetation and soil seed bank in enclosures and those in the open areas. Correlation was also used to compare cover with other quantitative measures like biomass and cover. Data were presented in graphs, pie charts and tables.

Results

Enclosures had significantly influenced the average number of trees in Chepareria rangeland (t_{40}= 0.048, $P<$ 0.01). The number of trees increased with the age of the enclosure Open areas had significantly lower biomass than enclosed areas (t_{40}=4.413P<0.001).

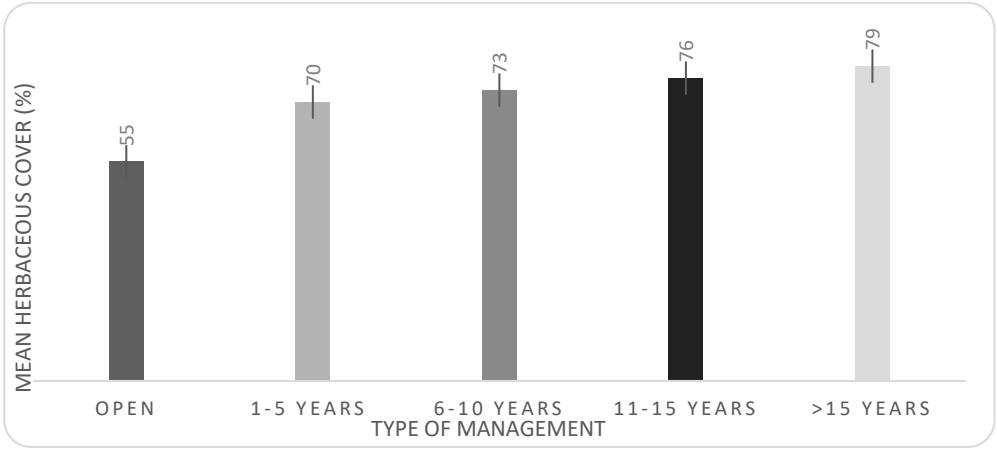

Figure 1.Herbaceous cover in % at different ages of enclosures

The average biomass in enclosed areas was higher compared to open areas. In the open (0 enclosure) average biomass was 37.7 grams, while in the enclosures it was 86.4 grams in the 1-5 years old, 185.9 grams in 6-10 years old, 111grams in 10-15 years old and 159.2 grams in the >15 years old respectively in different classes.

From the results of the study, it was evident that in Chepareria, majority of the farmers in the region rely on enclosures for grazing their livestock where they divide their land into paddocks and afterwards transfer the livestock to different paddocks after one area is exhausted of pastures.

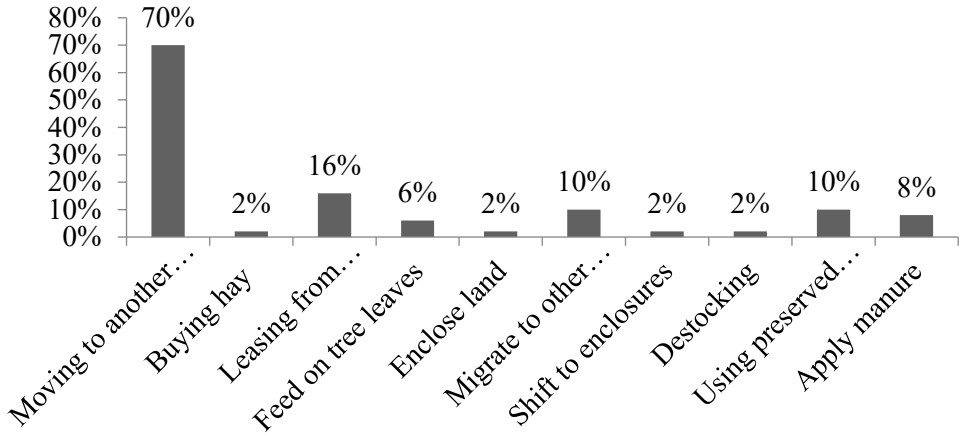

Figure 2. Grazing preference/ when land is too poor for grazing

The condition of the rangeland has changed in the last twenty years. In Chepareria, West Pokot, it is evident that the pastoralists have embraced the use of enclosures because of the benefits they derive from them.

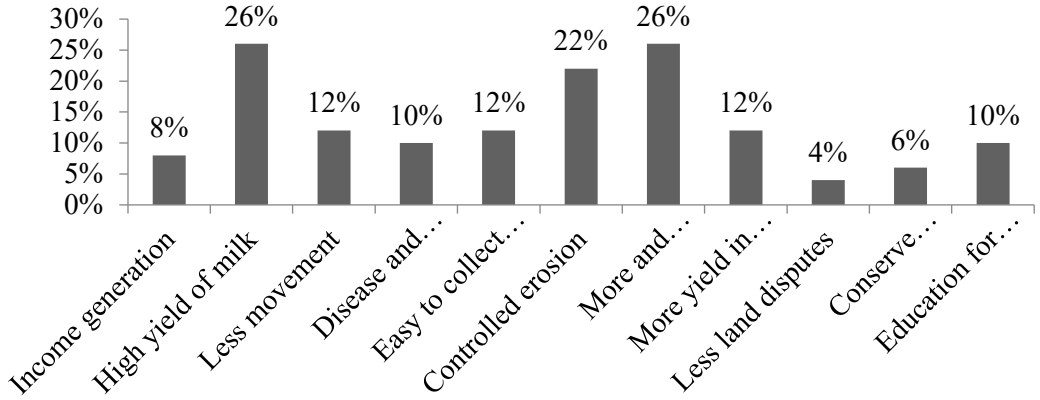

Figure 3. Significance of fencing

It has helped them deal with scarcity of pasture in the area. Seedlings germination differed with the age of enclosure. The younger enclosures (1-5 years old) had slightly lower seedling germination (2347), as compared to older enclosures; 6-10 years old 2400, 11-15 year old enclosures had an average of 2667 seedlings that germinated. The enclosures between one to fifteen years the average number of seedlings that germinated was increased with increase in the age of enclosures, but there was a slight decline in the trend with the enclosures above 15 years (average of 2053). In the enclosures there are more seedlings that germinated, compared with open areas.

Discussion[Conclusions/Implications]

The assumption of the present indicates that the paired sites were comparable and differences in native plant species richness, diversity and aboveground standing biomass measured between the paired enclosures and adjacent communal grazing lands were mainly caused by land-use change (that is, enclosure establishment) and not by inherent site variability. The results of the present study demonstrated the importance of enclosures in the restoration of degraded arid land.

Understanding soil seed bank of a particular habitat can assist to manage the composition and structure of existing vegetation and restore vegetation in many ways (Zaghloul, 2008). From the study, there were similarities in soil seed bank analysis and herbaceous cover in both the enclosures and open areas.

The enclosed areas are more productive as a result of having more cover, biomass, tree density and species richness. Enclosed areas have more soil seed bank. The results of study showed significant positive effects on soil properties and after enclosing the land. The percentage of N, P and K in enclosures had increased compared with the open grazed area. Enclosures are an important factor in the protection and vegetation recovery process. Enclosures are effective for rehabilitation if they are well managed. Therefore, I would encourage fencing for agricultural purposes, though areas with wildlife might be challenging. County government should discuss the significance of the enclosures with the local residents. The county

government should conduct a capacity building to seek alternative means of livelihood for the community. Reseeding with drought resistant or tolerant herbaceous plants should be considered. Documentation to preserve indigenous knowledge in situ and ex situ is needed. The results of the present study can be shared with policy makers and agricultural development planners and can be shared during open forums like "barazas" and agricultural events like shows**.** County government to implement water harvesting and conservation.

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