



Issue no: 1 | Vol no: 1 | February 2024: 1-18

Influence of prickly pear cactus (*Opuntia stricta*) on the socio-economic status of pastoral livelihoods of rangelands in the Northern Rift Valley of Kenya

Mugane Joseph⁽¹⁾ Muok Benard⁽²⁾ Bulli Peter⁽³⁾ 

Article History

Received: 2023-08-23

Accepted: 2023-11-30

Published: 2024-02-09

(1,2,3) Jaramogi Oginga Odinga University of Science and Technology, Kenya.

Email: muganekj@gmail.com

Cite this article in APA

Mugane, J., Muok, B., & Bulli, P. (2024). Influence of prickly pear cactus (*Opuntia stricta*) on the socio-economic status of pastoral livelihoods of rangelands in the Northern Rift Valley of Kenya. *Editon Consortium journal of Geography and environmental sciences*, 1(1), 1-18. <https://doi.org/10.51317/ecjges.v1i1.460>

Abstract

This study aimed to evaluate the influence of the prickly pear cactus on the socio-economic status of pastoral livelihoods of rangelands in the Northern Rift Valley of Kenya. The prickly pear cactus (*Opuntia stricta*) is one of the most widespread and naturalized invasive species in the arid and semi-arid areas of Kenya, with serious negative consequences on rural livelihoods and the environment. The invasiveness of *O. stricta* is due to its productive and competitive advantages under marginal conditions, limited availability of pests and pathogens, and high reproductive potential. A descriptive survey design was used in this study. In this study, the socio-economic impact of the prickly pear cactus was examined in two sites located in the northern rangeland of the Rift Valley in Kenya. A purposive sampling technique with semi-structured questionnaires administered through an Open Data Kit was used to generate the primary data. In order to examine the influence of *O. stricta* on the socio-economic status of livelihoods, the study used linear regression analysis. The study concluded that an increase in cactus thicket negatively affects the livelihoods of the pastoral communities. This study recommends that support to the local communities from the government, as well as other developing agencies operating within the region, is necessary for the effective management of the invasive species. Furthermore, development plans for the region must also take into account the socio-ecological impact of the prickly pear cactus in the region.

Key words: Kenya, pastoral livelihoods, prickly pear cactus (*Opuntia stricta*), rangelands, socio-economic status.



This article is distributed under the license of a [Creative Commons Attribution-Non Commercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/). It is permitted to be used, reproduced and distributed in line with Editon Consortium Publishing guidelines.

INTRODUCTION

Invasive species (IS) constitute one of the major global threats to ecosystems, natural habitats and biodiversity due to their high ecological and competitive ability as well as efficient reproduction and dispersal mechanisms. More than 751 invasive trees and shrub species have been reported globally (Rejmánek & Richardson, 2013). In new environments, invasive species prosper in the absence of predators or parasites that would regulate their relative abundance. They can occupy vacant niches and take advantage of ecologically stressed or disturbed marginal environments by changing resource availability, and this, in turn, increases their competitive ability in the new environment (Hanselka & Paschal, 1991). The cactus family, Cactaceae, is among the most widely introduced invasive species worldwide due to its popularity in the horticultural trade. Prickly pear cactus (*Opuntia stricta*), which is native to Central America, is the most commonly naturalized introduction in the arid and semi-arid lands (ASAL) of Kenya (Githae & Nyangito, 2010).

Successful invasiveness of the prickly pear cactus is due to its ability to survive well in dry periods, competitive advantage under disturbed conditions, low levels of parasites and high reproductive potential. It forms dense thickets through vegetative reproduction when detached cladodes become rooted in the ground and also through the spread of seeds of the fruit by various agents, including baboons, birds and large mammals (Omweri et al., 2016). The adaptive physiological mechanisms of the prickly pear cactus include Crassulacean Acid Metabolism (CAM), which is a photosynthetic adaptation to arid and semi-arid environments where drought and high temperature are the major environmental stresses. When the air temperature is lower, CAM plants take up CO₂ at night and close their stomata during the day. Moreover, *O. stricta* has a relatively shallow and horizontally spreading root system with high water use efficiency, hence favouring their proliferation during dry seasons.

LITERATURE REVIEW

Impacts of the invasive prickly pear cactus in the ASAL rangelands are mostly related to changes in livestock production, including the death of livestock, reduced forage, increased costs of management,

interference with grazing practices and reduced livestock yields with poor economic returns to farmers (Foxcroft et al., 2004). The prickly pear cactus also negatively impacts wildlife habitats, depletes soil and water resources and reduces the diversity of plants and animals. In addition, its effects on rural livelihoods are linked to the extra cost of management, reduced ecosystem productivity, threat to health and reduced utilities from natural resources (Githae & Nyangito, 2010).

Although *Opuntia sp.* is appreciated for both direct and indirect uses by many livelihoods in the world, it is hardly used in Kenya due to its characteristic spines and glochids that often cause injuries to both humans and animals. They are, instead, valued for their use as ornamental plants or as a live hedge. However, these uses cannot compensate for the overall negative impacts they portray. Once they escape into the environment, they usually adapt to various environmental conditions where they are widely established (Obiri, 2011). Despite the urgency in controlling the species, there are still various gaps that hinder its management in Kenya, including limited information on the description of the species because of variation in growth form, lack of information on proper management, poor monitoring, ineffective control measures and limited knowledge on alternative coping strategies. These impacts not only reduce the biodiversity threshold but also threaten food security and human well-being.

The prickly pear cactus was initially introduced into Kenya for ornamental and hedging purposes, but it escaped cultivation and spread over wide areas, including conservation areas, rangelands and agricultural areas. The consequence is a range of negative impacts that have not been systematically quantified to date (Githae, 2018). Despite being commercially valuable, this plant species has become invasive in the Arid and Semi- Arid Lands (ASALs) of Kenya. The plants distort rangelands ecosystem, displace native plant species, lower the value of pasture and browse conditions and prevents free movement of people, livestock and wildlife (Shackleton et al., 2017). Major negative impacts on livestock include loss of natural forage, blindness caused by characteristic spines of the plant which pierce eyes, and skin injuries. Moreover, injury to the

gastrointestinal lining by glochids is another common problem during dry periods when little or no other forage is available and when livestock try to feed on grass and small shrubs growing near or inside the cactus stands. As a result, the nutritional status of livestock in areas characterized by the invasiveness of the species deteriorates, making veterinary management more costly. The loss of productivity, stability and ecological functioning of affected lands hinder the economic development of communities, leading to reduced sustainable capacities of rangelands.

METHODOLOGY

Research Design

A descriptive survey design was used in this study due to the large amount of data collected on the socio-economic impact of the prickly pear cactus,

which caused rangeland degradation of the livelihoods of the local pastoralists.

Study area

The study was conducted in Baringo South Sub-county, which is within Baringo County. Baringo South Sub-county lies on 834 m above sea level. The area experiences very little rainfall all year long. The mean yearly temperature is 24.7 °C, and the annual rainfall is 553 mm. (Dodet et al., 2020). The main economic activities in the study area include rearing livestock in a pastoralist setup and subsistence crop farming. The livestock reared in these areas include cattle, sheep, goats, chickens and camels, and the main subsistence staple crops are maize and millet (KNBS, 2019). The vegetation of the survey area is a mixture of savannahs and grasslands, where the most common native trees belong to the genera *Vachellia* (formerly *Acacia*) and *Commiphora*.

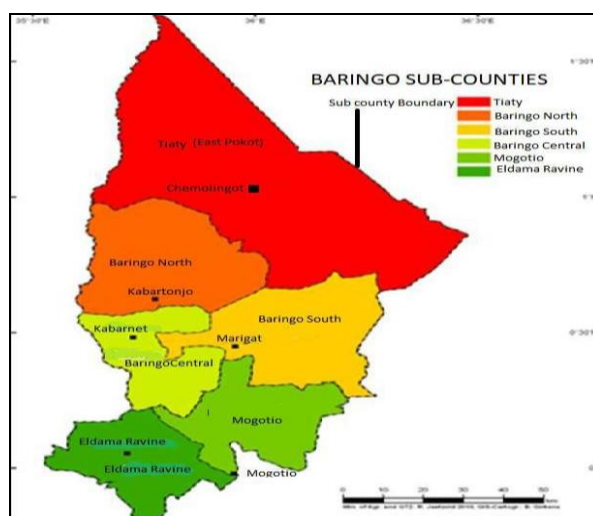


Figure 1. Baringo County Map (Source KNBS)

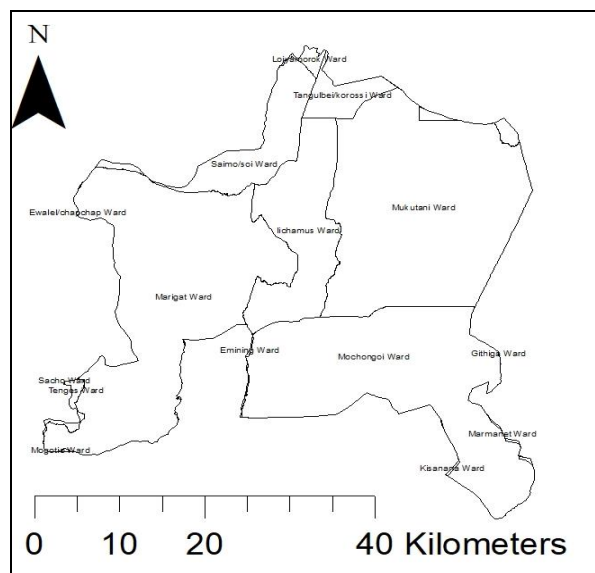


Figure 2. Baringo South sub-County map (Source IEBC Kenya)

Validity and Reliability of Research

For the purpose of ensuring validity, two University supervisors reviewed the questionnaire to determine if it effectively addressed the research objectives and questions. The test-retest method was used to test the research reliability. Assessing test-retest reliability required using the measure on a group of observations at one time, using it again on the same group of observations at a later time, and then comparing the two sets of scores. This typically was done by graphing the data in a scatterplot and computing Pearson’s correlation. In general, a test-retest correlation of +0.80 or greater was considered to indicate good reliability. Through the process of test-retest, inconsistencies were noted and corrected, thus ensuring the accuracy of the data.

Sampling

This study used a purposive sampling strategy approach for identifying and selecting information-rich cases related to pasture loss due to *O. stricta* invasion and how it impacts households within Ilchamus and Mukutani wards, which have a total population of 2,148 households (KNBS, 2019). The focus was on the head of each household as a lead source of information. The sample size was established using the Yamane formulae (Yamane, 1967).

Yamane formulae:

$$n = \frac{N}{1 + N(e)^2}$$

Where N (i.e., population size) = 2148 e - (Level of precision = 5%)

n (desired sample size) = $2148 / (1 + (N \times e^2)) = 337$ people

During the survey period, the heads of households were selected from among those with land ownership, livestock herds, crop farming activity, and source of water while taking into consideration their age, gender, education (literacy level), and source of income/employment.

Data Collection

The primary data was collected using the mobile data collection platform Open Data Kit (ODK) (Loola Bokonda et al., 2019). All the data collected were uploaded to the ODK aggregate, which acts as a database server containing a system protection unit. The server only admitted authorized persons (The researcher) protected with a key password and username. With the permission of the Sub-county commissioner of Baringo South, Key Informant Interviews (KII), Household Surveys and Focus Group Discussions (FGDs) were convened in coordination with the local area Chief and sub-chief. Responses were recorded manually into the data

collection forms/ tools and digitally into ODK (Open Data Kit) forms and audio tape. There were two research assistants (RAs), each per ward with three guides.

Data Analysis

Statistical Package for Social Sciences (SPSS) software was used in data cleaning and analysis. Descriptive statistics (means, frequencies, percentages) were employed to examine broad-scale relationships between participants' demographic variables and their responses. In order to examine the influence of *O. stricta* on the socio-economic status

of livelihoods, the study used linear regression analysis.

RESULTS AND DISCUSSIONS

Demographic Profile

Selection of respondents for the study was based on age, gender and level of education. Majority of the respondents were aged 51 to 65 years. The number of males was more than twice that of the females among the respondents. More than half of the respondents either received education up to the primary level or received formal education.

Table 1: Demographic Profile of the Respondents

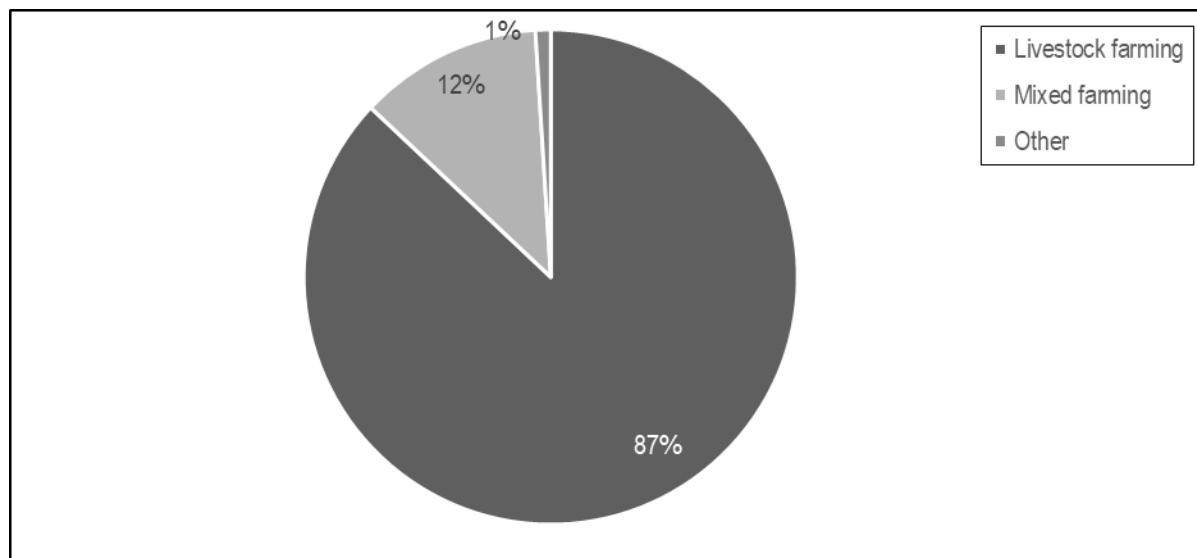
Variables	Parameters	Frequency	Percentage
Age of the respondents	35 years and below	20	6.6%
	36-50	98	32.2%
	51-65	142	46.7%
	66 and above	44	14.5%
	Total	304	100.0%
Gender of respondents	Male	205	67.4
	Female	99	32.6
	Total	304	100.0
Highest level of education	Below class 8	56	18.4
	Primary	89	29.3
	Secondary	47	15.5
	Tertiary / University	22	7.2
	No Education	90	29.6
	Total	304	100.0

Livelihoods

The main occupation of the households was livestock farming (Figure 3), which accounted for most of the income (Figure 4).



Figure 3. Household Head Occupation



Other = trade and in-kind aid*

Figure 4. Main Sources of Household Income (%)

Mixed farming and other activities accounted for a relatively smaller proportion.

Goats account for the majority of the livestock, followed by sheep, cattle, chickens, and camels (Table 2).

Table 2: Livestock Ownership

Livestock types	Minimum	Maximum	Mean ± Stdev
Cattle	0	230	37±3
Sheep	0	400	45±9
Goat	7	655	58±6
Camel	0	10	1±0
Chicken	0	120	34±4

The main water source for households and livestock was a water pan or dam, followed by the river, well, and water bowser or truck in-kind (Figure 5).

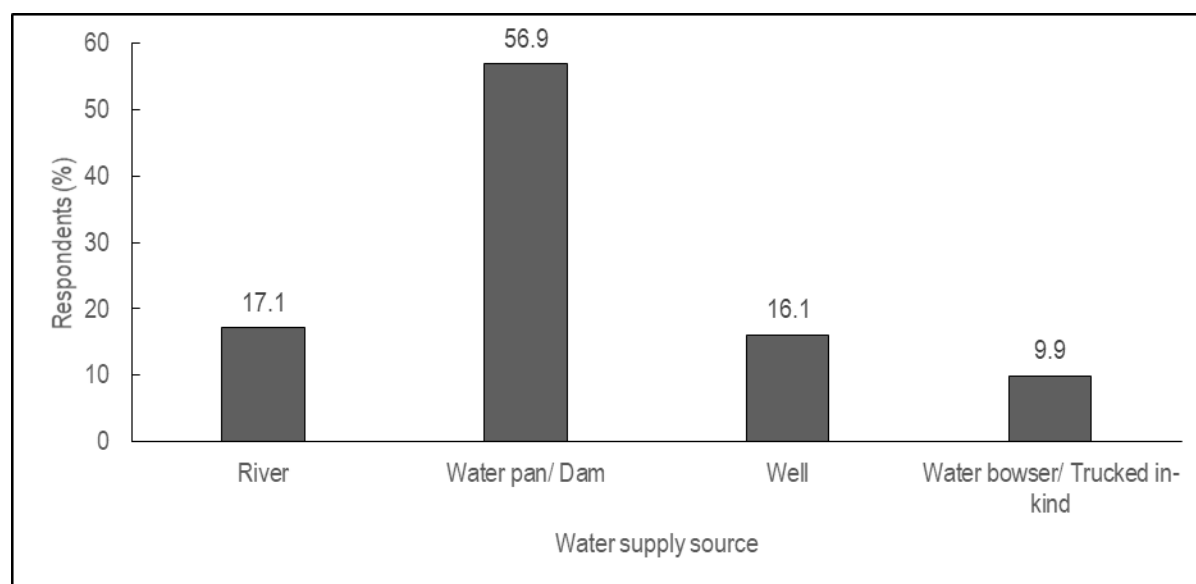


Figure 5. Water Supply/ Sources for the Household and Livestock

The majority of the respondents lived in the study area for more than 30 years, while a quarter lived in the study area between 20 to 30 years, and only six per cent spent 20 years or less in the study area

(Figure 6). In total, almost 99 per cent of the respondents had been residents of the study area for more than 10 years.

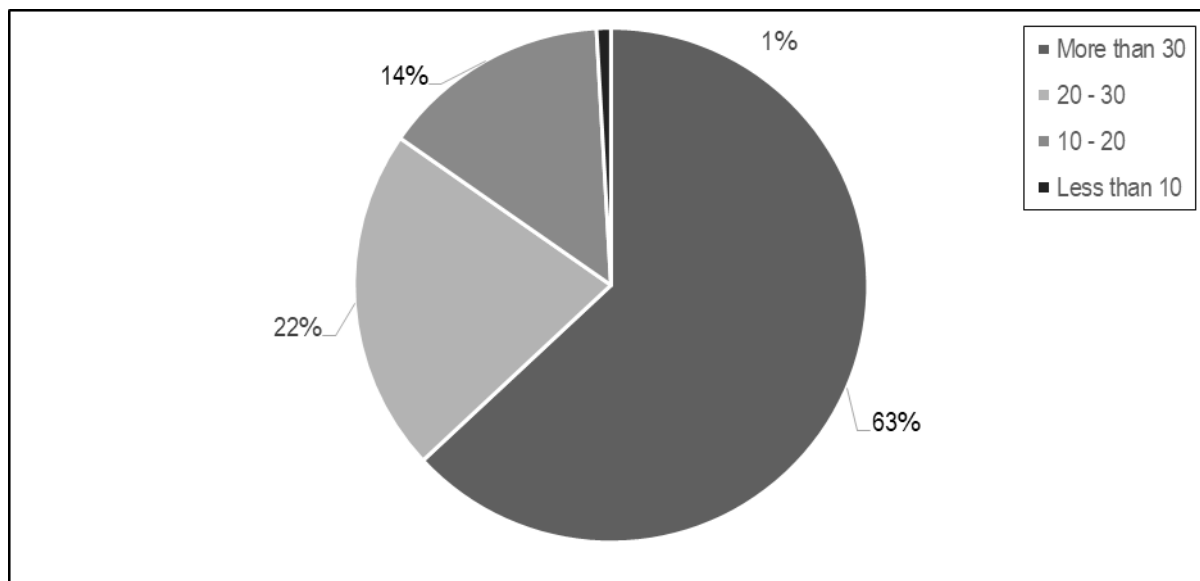
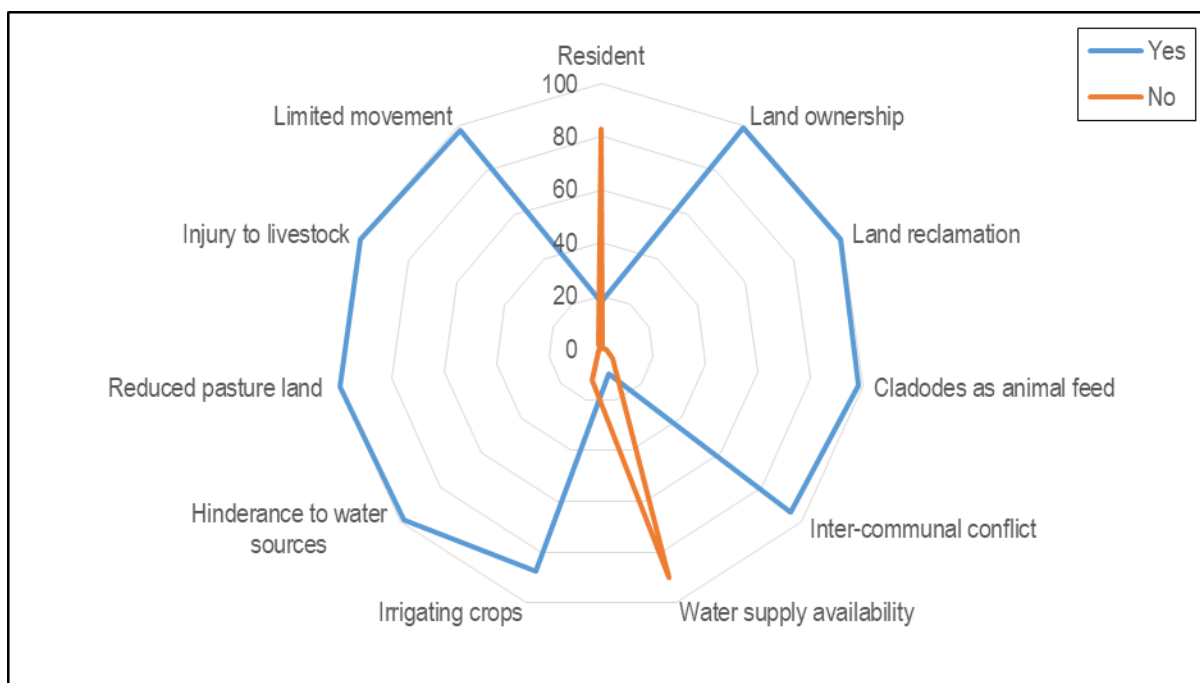


Figure 6. Years Lived in Study Area by Respondents (%)

The majority of the respondents had not lived in other villages or wards besides the study area, and early, every household owned land for crop growing and livestock keeping (Figure 7).



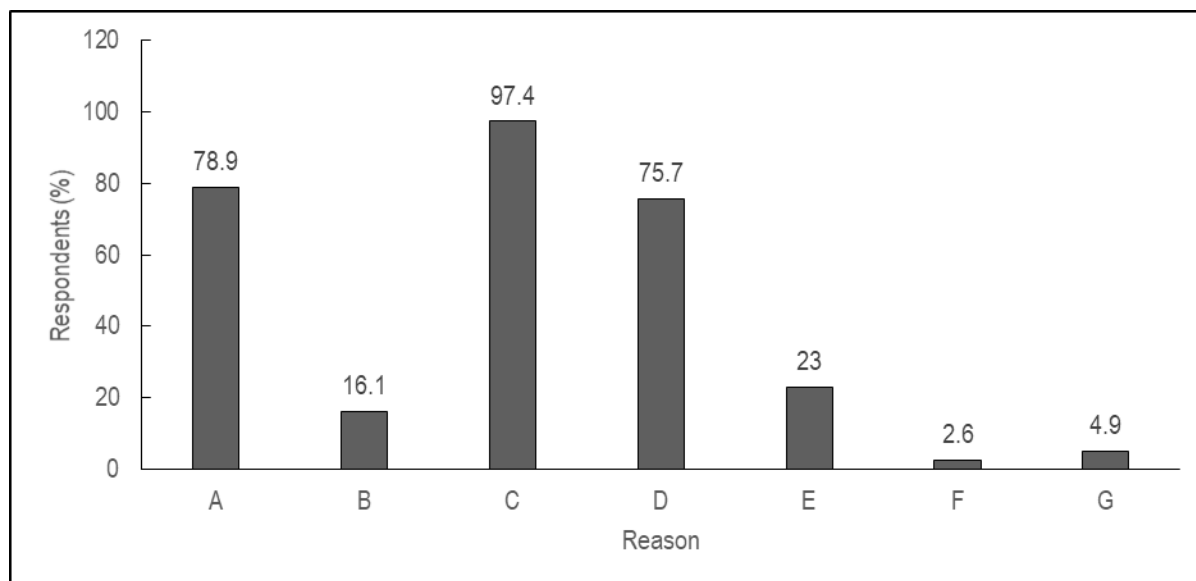
Response	Resident	Land ownership	Land reclamation	Cladodes as animal feed	Inter-communal conflict	Water supply availability	Irrigating crops	Hindrance to water source	Reduced pasture land	Injury to livestock	Limited movement

								s			
Yes	17.4	99	99.3	98	94.4	9.9	87.5	98.7	99.7	99.7	98
No	82.6	1	0.7	2	5.6	90.1	12.5	1.3	0.3	0.3	2

Figure 7. Impact of Prickly Pear Cactus on Livelihoods and Well-Being of Pastoralists

To understand the reasons for settlement in the study area, the respondents were grouped based on the reasons for their decision to settle in the study site (Figure 8). Pasture was the reason for the overwhelming majority of the respondents, followed by schooling for children, escape from inter-

communal violence, natural disasters such as drought and famine, work, and land degradation. Approximately five per cent of the respondents also mentioned displacement as a result of floods from River Endau and waterlogging from Lake Baringo.



Key: A = Children education; B = Job; C = Pasture for livestock; D = Intercommunal violence; E = Natural disasters; F = Land degradation; and G = Others, including floods from river Endau, insecurity, and water logging from Lake Baringo.

Figure 8. Reasons Why Respondents Settled in Study Site

Housing was comprised of permanent, semi-permanent or temporary accommodation structures, with most being semi-permanent (Figure 9).

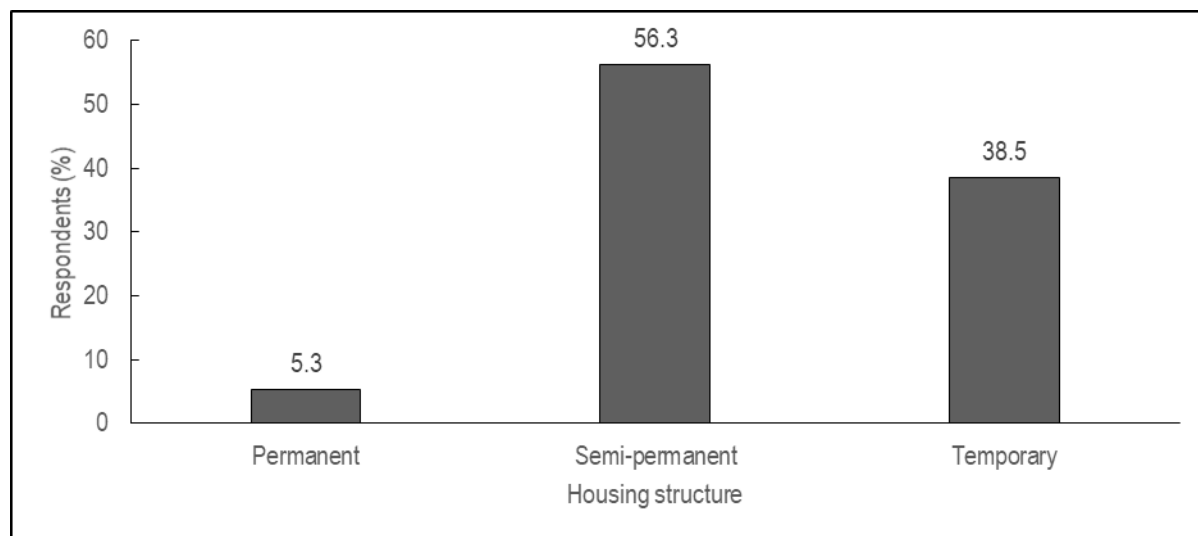


Figure 9. Housing Structures in Study Site

Inter-communal conflict, including animal rustling, was the major security challenge in the area. Additional challenges faced by the communities

included long distances from health centres as well as grazing areas and the d availability of reliable sources of water (Figure 10).

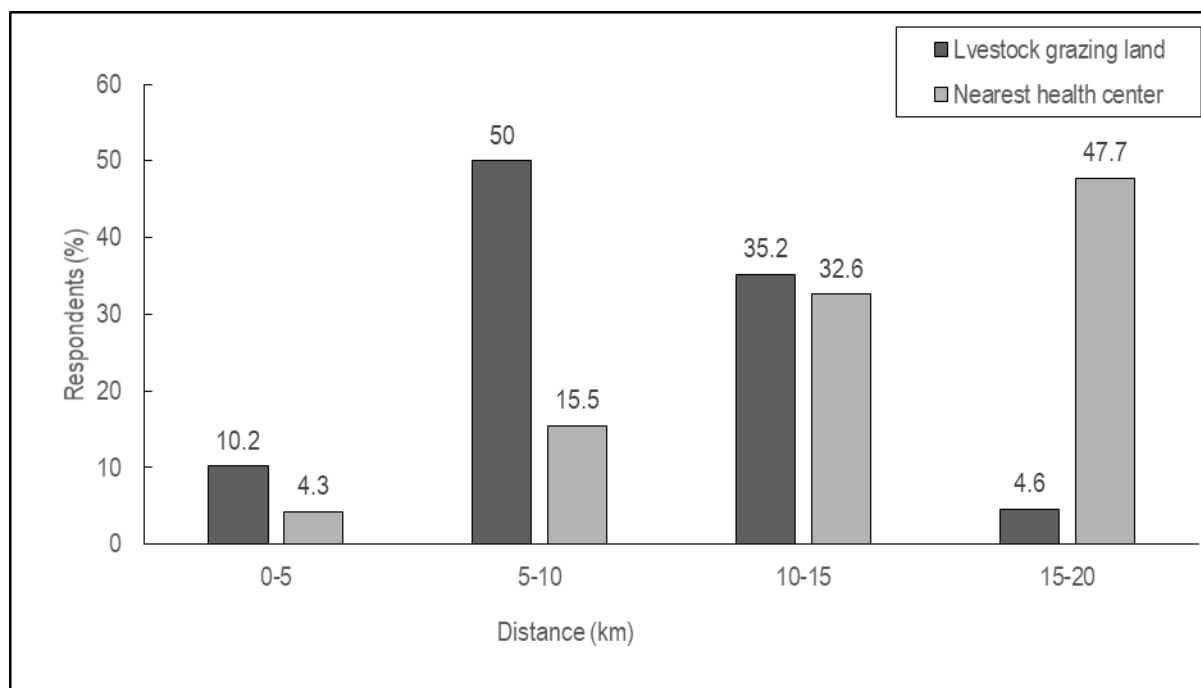


Figure 10. Distance to Health Centres and Impact of Prickly Pear Cactus on Access to Livestock Grazing

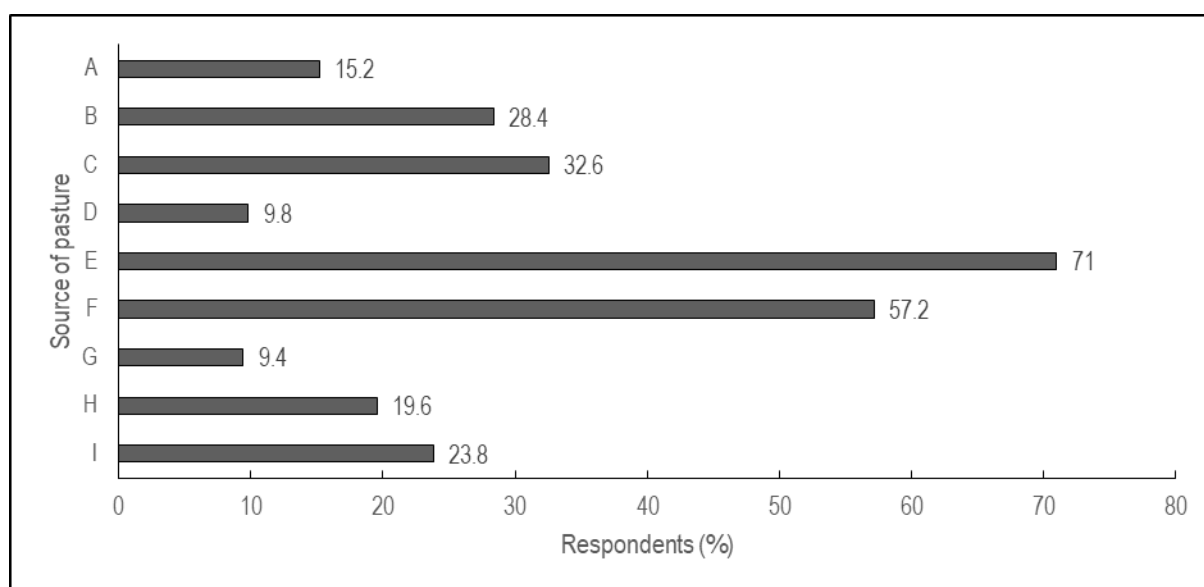
Fig

Impact on Socio-Economic Status of Pastoral Livelihoods

Inter-Communal Relationship

Although inter-communal conflict was reportedly a major security challenge in the study area, only three per cent of conflicts could be attributed to the invasiveness of the prickly pear cactus. Thus, the possibility of additional contributing factors to the lack of cohesiveness among the community could not be ruled out. Based on the significant coefficient of concentration of cactus thicket ($p < 0.05$), an increase in the thicket increases the likelihood of conflict among the pastoral communities. Although

Shackleton et al. (2017) and Foxcroft et al. (2004) reported a negative impact of prickly pear cactus on the livelihoods of pastoral communities as a result of conflicts over limited resources such as water, pasture and productive land, they did not clearly state whether there were other factors in addition to the invasiveness of the prickly pear cactus. Moreover, the attraction of wild animals like elephants to the fruit of cacti growing in grazing areas, especially communal lands, is also a factor in the uptick in negative interactions between the pastoralists and the wildlife.



Key: A = Cladodes; B = Hippo grass; C = Hay grass; D = Sesbania tree leaves; E = Leaves from lowei tree; F = Crop residue; G = Water reeds from Lake Baringo; H = Maize stovers; I = Purchased animal feeds (supplements)

Figure 11. Alternative Source of Pasture Due to Diminishing of Rush Vegetation Caused by *O. stricta* Invasion

Access to Water Resources

An increase in cactus thicket significantly increased inaccessibility to water resources ($p < 0.05$) (Table 3). Similar to the inter-communal relationship, only three per cent of the inaccessibility to water resources could be attributed to the difficulties involved with access to water resources to invasiveness by the prickly pear cactus. In a study on gender roles and child nutrition in livestock farming systems in developing countries, Tangka et al. (2000) reported that invasive alien cactus such as *O. stricta* was a disadvantage to women who had to take their

animals to the water sources for drinking since they were likely to spend more time in the rangelands as they trekked longer distances in search of water; and thus, negatively affecting their spare time for child health care and disrupting the normal feeding habits of under five-year-olds. This finding is also consistent with the previous report on the negative impacts of *O. stricta* on the movement of livestock and humans in Madagascar (Larsson, 2004), where it significantly contributed to the time taken by livestock to access vital resources such as water and pasture. Similar negative socio-ecological impacts

were also previously reported in East Africa by Shackleton et al. (2017). Search for resources such as pasture and water often increases the risk of inter-communal conflicts.

Table 3. Effect of Prickly Pear Cactus on Livelihoods

Parameter	Concentration of cactus thicket								
	Unstandardize d coefficient B	Standardize d coefficient SE	Beta	t- value	p- value	95.0 % CI for B - lower	95.0 % CI for B - upper	R- squar e	Adj R- squar e
Inter- communal relationships and livestock welfare	0.206	0.064	0.18 3	3.22 9	0.00 1	0.080	0.331	0.033	0.03
Accessibility of water sources	-0.065	0.032	0.14 8	- 2.02 3	0.04 4	- 0.036	0.090	0.032	- 0.031
Reduction of pasture fields	0.035	0.016	0.06 6	2.30 2	0.02 2	0.013	0.065	0.043	0.041
Colonization of crop, grazing, or pasture land	0.597	0.140	0.23 8	4.25 7	0.00 0	0.321	0.873	0.057	0.053
Colonization of indigenous plants on rangelands	0.283	0.094	0.17 1	3.01 0	0.00 3	0.098	0.468	0.029	0.026
Colonization of farming land	0.191	0.099	0.11 0	1.92 5	0.05 5	0- .004	0.386	0.012	0.009
Increase in livestock injuries and diseases	0.190	0.070	0.26 3	2.71 2	0.00 7	0.040	0.340	0.074	0.071

Livestock access to water sources	0.426	0.203	0.169	2.099	0.037	0.316	0.536	0.035	0.032
Budget of farmers for livestock treatment	0.211	0.103	0.120	2.045	0.042	0.061	0.361	0.045	0.042

Impact on Crop and Pasture Fields

Although nearly all the respondents observed a reduction in their pasture lands (Figure 12), only four per cent of the reduction could be attributed to *O. stricta* invasion (Table 3). An increase in the concentration of cactus thicket significantly contributed to the reduction of pasture fields. According to Shackleton et al. (2017), the cost associated with the negative impacts of *O. stricta* invasiveness far outweighs the benefits in the form

of revenue through horticulture, provision of food, medicinal products and fodder. This negative impact also extended to crop fields. In contrast to our finding, Priolo et al. (2007) and Einkamerer et al. (2009) recommended *O. stricta* as an excellent livestock feed with ameliorated feed nutritional value and animal performance compared to most pastures without taking into consideration the negative socio-ecological impacts of the prickly pear cactus.

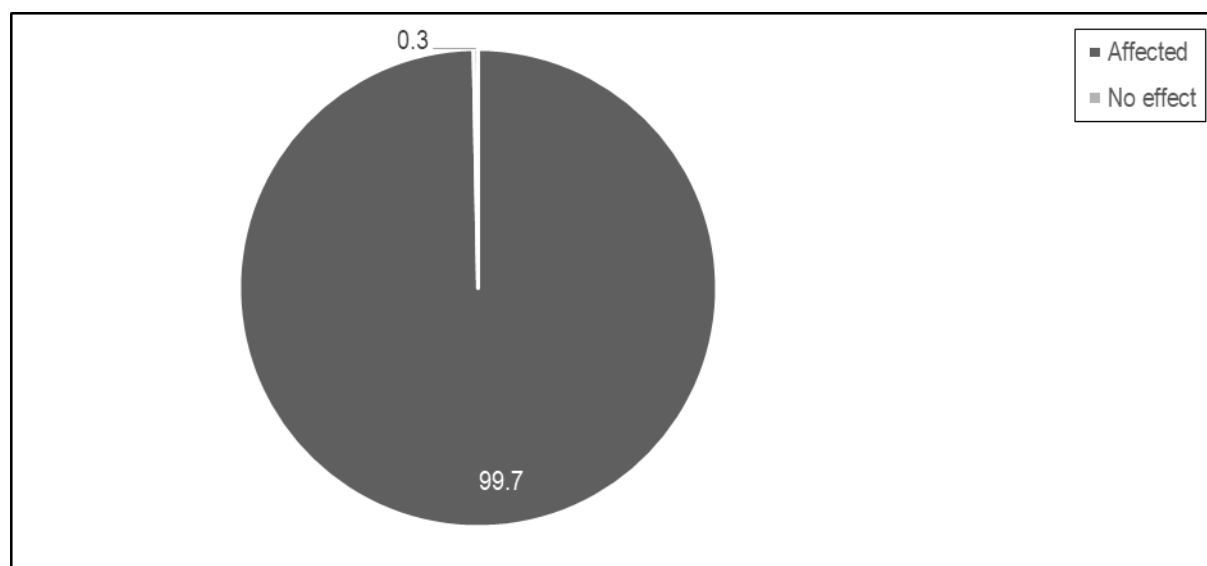


Figure 12. Effects of O. Stricta on Pasture Fields

Impact on Grazing Land, Biodiversity and Farm Land

The increase in cactus thicket significantly increased the likelihood of displacement of grass, biodiversity and pasture in affected areas ($p < 0.05$) (Table 3). This finding agrees with prior reports on the negative effect of introduced invasive plant species on grazing, pasture land, livestock health and other

ecological processes (Novoa et al., 2015). Larsson (2004) also reported that the prickly pear cactus was the most problematic invasive *Opuntia* species responsible for reduced fodder production on the island of southern Madagascar, leading to reduced fodder production.

In a similar study by Shackleton et al. (2017), the majority of respondents not only complained of the negative effects of invasive species of plants on indigenous plants but also expressed fear for their livelihoods as a result of the invasive species. Many pastoralists complained about the negative impacts of reductions in native plant populations caused by *O. stricta*. Similarly, Wasike (2022) also noted that

the ornamental plant brought by the British colonialists to Kenya in the middle of the century has been killing indigenous vegetation, especially grasses and bushes, thus creating food shortages for livestock and wild animals. These challenges are being further exacerbated by the ability of the species to adapt and grow under arid conditions of limited water and high temperatures.

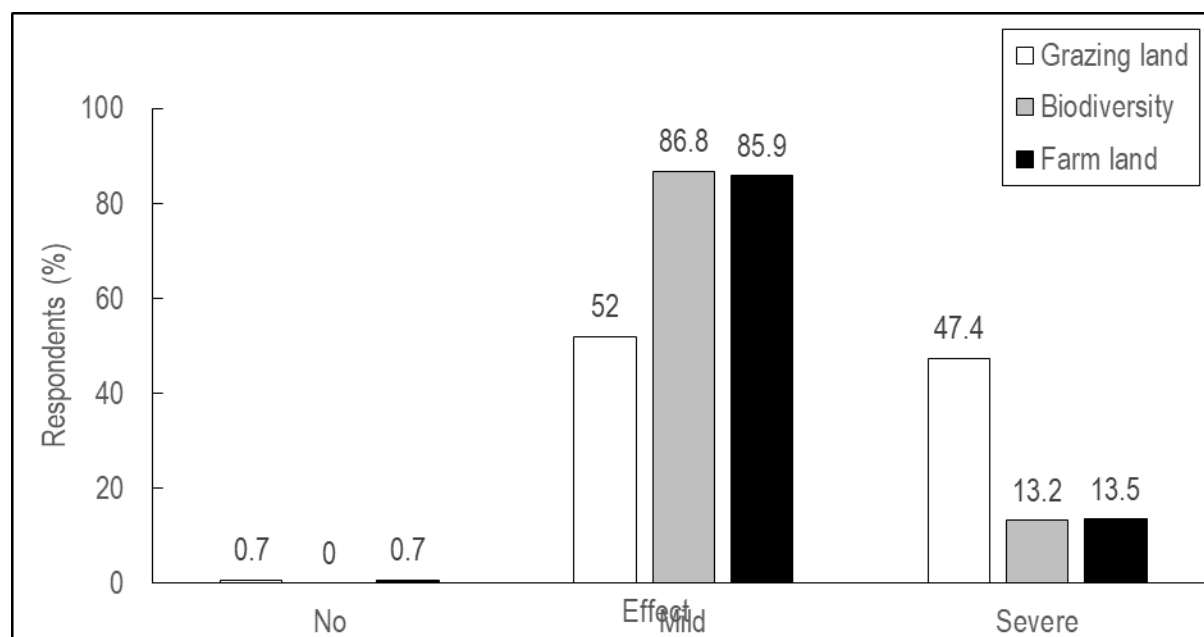


Figure 13. Effect of *O. stricta* Invasiveness on Grazing Land, Biodiversity, and Farm Land

Impact on Health and Well-Being of Livestock

Although the overwhelming majority of the respondents reported injuries to their livestock, only seven per cent of the injuries could be attributed to prickly pear cactus spines and glochids. According to the respondents, an increase in the concentration of the cactus thicket led to a significant increase in livestock injuries and diseases ($p < 0.05$). This is consistent with the findings of Shackleton et al. (2017), who had negative socio-ecological impacts of the invasive alien cactus *O. stricta*, particularly with respect to the health of livestock. The prickly pear cactus was blamed by locals for health challenges as well as the loss of livestock (Shackleton et al. (2017). Novoa et al. (2015) also reported the negative impacts of invasive cactus species on the movement of humans, livestock and wildlife. Furthermore, *O. stricta* contributed to the reduced value of grazing land, which consequently affected the health of livestock as well as ecological

and biological processes essential to the health of soils. Similar findings were also reported in southern Madagascar Larsson (2004), leading to the recommendation of enhanced collective measures to eliminate and manage *O. stricta* for sustainable livestock and human health.

Financial Impact

An increase in the concentration of cactus thicket significantly increased the cost of livestock treatment ($p < 0.05$), as reported by the overwhelming majority of the respondents. However, only four per cent of the reported increase in the cost of treatment could be attributed to *O. stricta* invasion (Table 3). Goats feeding on *O. stricta* in Laikipia County exhibited poor health, with wounds on various body parts and diarrhoea, according to a study by Ncebere et al. (2021). Other health issues included the presence of spines on the skin throughout the body, which caused pain, swelling, and ulcerative wounds on affected

parts. Internal lesions were also observed in all subcutaneous tissues, together with common cases of stomatitis, cheilitis, gingivitis, glossitis, abomasitis, rumen, reticulum, omasum thinning and loss of papillae, relatively rare cases of esophagitis, and duodenitis. Carcasses had gelatinous fat and muscular atrophy. Other gross lesions were generalized viscera atrophy, oedema, subcutaneous emphysema, lymphadenopathy, abscesses, ascites, hydrothorax, and hydro pericardium. The abomasum wall and its mucosal folds were swollen with oedema, haemorrhages, and scattered foci of abscesses. Histopathology confirmed the main lesions in all affected goats were foreign-body granulomas, which were located in all organs with gross lesions. As a result, most farmers incurred

more costs on treatment at an increased frequency, as is the case in this study (Figure 16).

As far as the effect of injuries and diseases on livestock was concerned in this study, the majority of the respondents reported a greater effect on mouth parts and body skin (Figure 14). The number of times respondents treated their animals due to physical and internal injuries caused by *O. stricta* spines ranged between 1 to 3 times per month in most households (Figure 15). More than 95 per cent of the respondents treated their animals once or twice as a result of the injuries, with the frequent treatments negatively affecting their budget compared to 5 years ago (Figure 16).

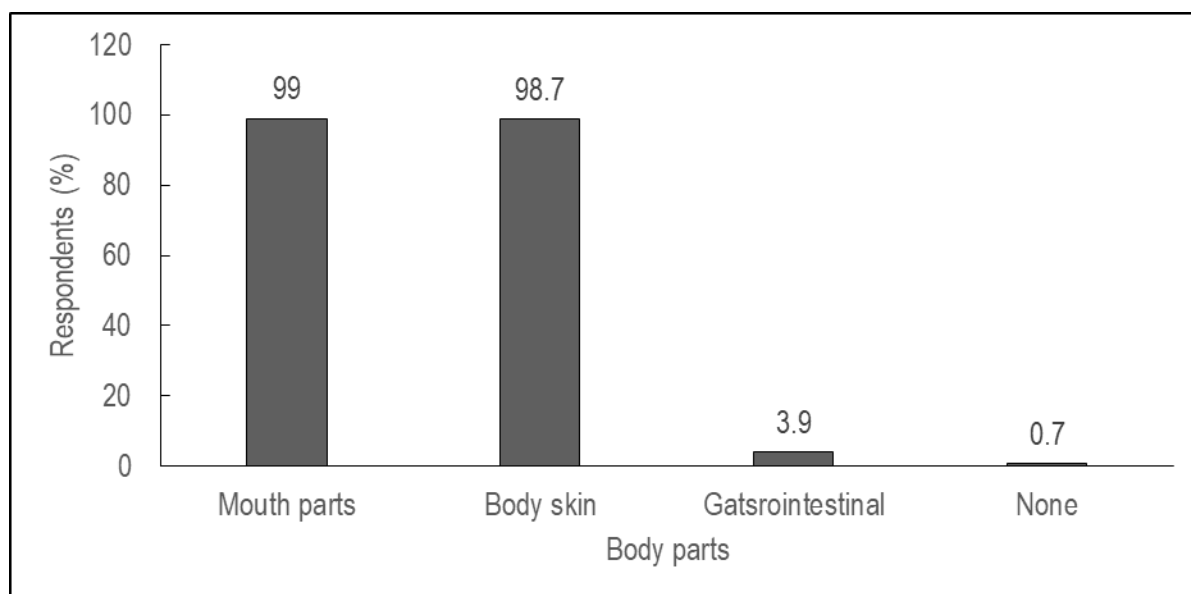


Figure 14. Effect of Expansion of *O. stricta* Growth on Livestock Well-Being

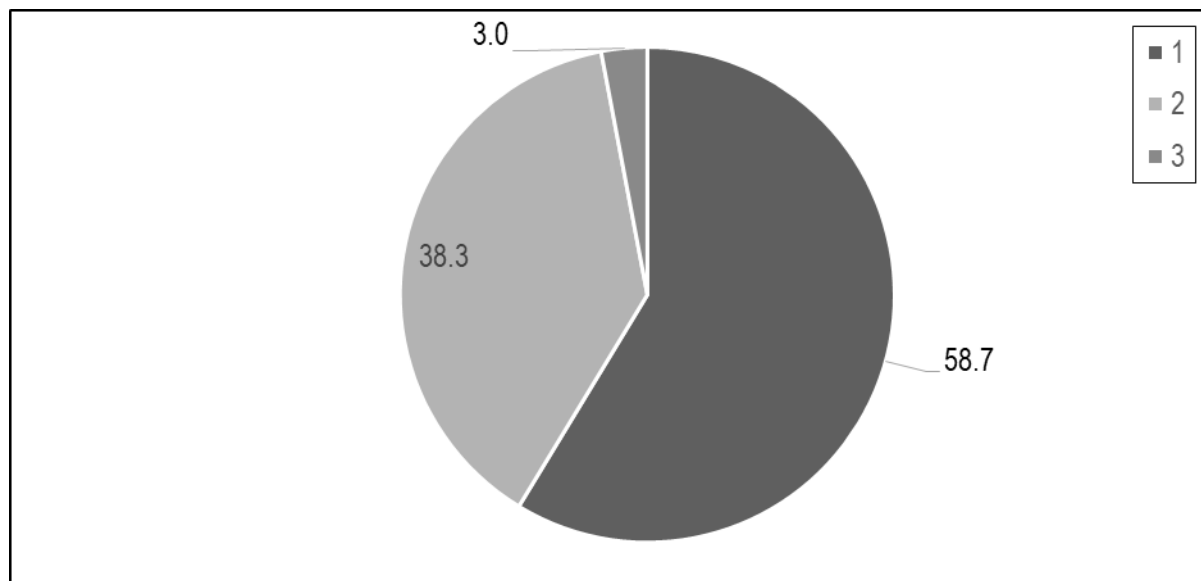


Figure 15. Number of Times per Month Respondents Treated Their Animals Due to Physical and Internal Injuries Caused by *O. stricta* Spines

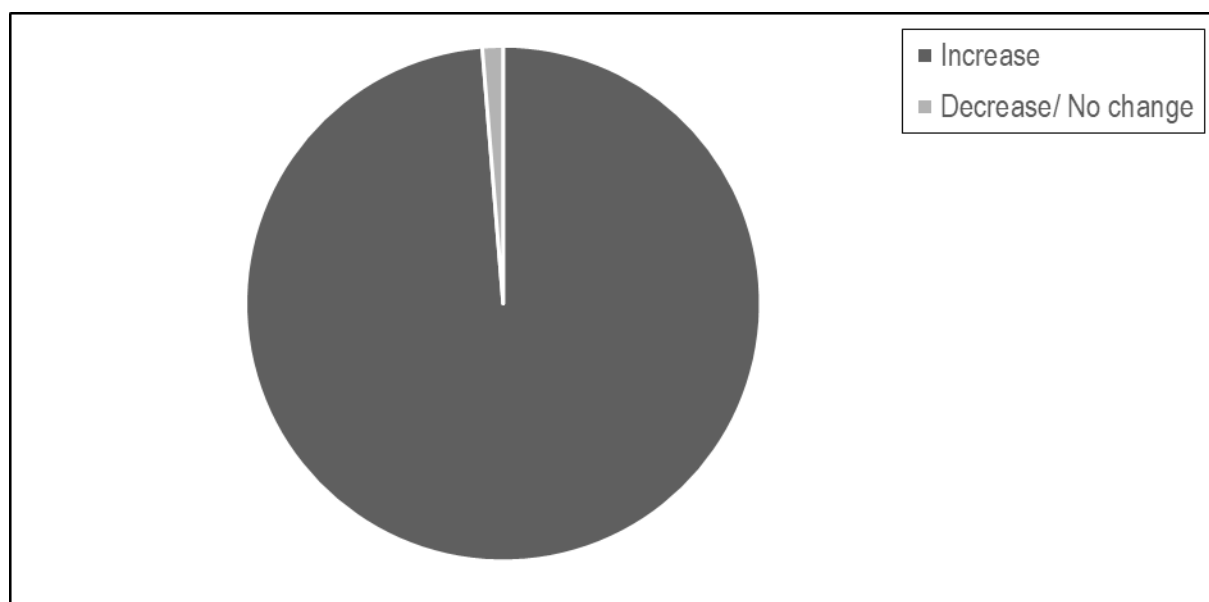


Figure 16. How Monthly Budget for Animal Treatment was affected by *O. stricta* as Compared to 5 Years Ago

CONCLUSIONS

Strengthening support to the local communities in the management of invasive plant species will not only enhance the eradication of the cactus plants but will also strengthen the resilience of the local pastoral communities to climate change. Furthermore, addressing the challenges posed by the cactus plants could minimize the risks of inter-

communal conflicts and animal rustling as a result of inaccessibility to sources of water and degradation of pasture land. In addition, reduced incidence of livestock injuries and diseases could also reduce the cost of livestock treatment.

To manage the invasive plant species effectively, timing for eradication of the cactus thicket is

essential. Moreover, a collaboration involving the government, other development agencies, and the local pastoral communities is necessary for the effective reclamation of land lost to invasive plant species. It is also imperative for extensive packages to cover strategies such as sustainable strategies for alternative sources of feed for livestock and improving market access to produce of the local

communities. It is also essential to prioritize mixed farming while minimizing over-reliance on livestock as a source of livelihood. There is also a need to promote livestock insurance policies that are especially essential for cushioning the local communities during drought periods and other unpredictable scenarios.

REFERENCES

- Dodet, G., Piolle, J. F., Quilfen, Y., Abdalla, S., Accensi, M., Arduin, F., & Passaro, M. (2020). The Sea State CCI dataset v1: Towards a sea state climate data record based on satellite observations. *Earth System Science Data*, 12(3), 1929-1951.
- Einkamerer, O. B., de-Waal, H. O., Combrinck, W. J., & Fair, M. D. (2009). Feed utilization and growth of Dorper wethers on *Opuntia*-based diets. *South African Journal of Animal Science*, 39, 53-57.
- Foxcroft, L. C., Rouget, M., Richardson, D. M., & Mac Fadyen, S. (2004). Reconstructing 50 years of *Opuntia stricta* invasion in the Kruger National Park, South Africa: environmental determinants and propagule pressure. *Diversity and Distributions*, 10(5-6), pp. 427-437.
- Githae, E. W. (2018). *Status of (Opuntia) Invasions in the Arid and Semi-arid Lands of Kenya*.
- Githae, E. W., & Nyangito, M. M. (2010). *Current status on the Occurrence, Utilization and Management of Cactus Pear (Opuntia spp.) in Kenya*. Improved utilization of cactus pear for food, feed, soil and water conservation and other products in Africa, 29.
- Hanselka, C. W., & Paschal, J. C. (1991). *Prickly Pear Cactus: A Texas Rangeland Enigma*.
- Kenya National Bureau of Statistics (KNBS 2019). https://www.knbs.or.ke/? Page_odi = 3142#
- Larsson, P. (2004). *Introduced (Opuntia spp.) in Southern Madagascar: Problems and Opportunities*. Minor Field Studies-International Office, Swedish University of Agricultural Sciences, (285).
- Loola Bokonda, P., Ouazzani-Touhami, K., & Souissi, N. (2019). *Mobile Data Collection Using Open Data Kit*. In International Conference Europe Middle East & North Africa Information Systems and Technologies to Support Learning (pp. 543-550). Springer, Cham.
- Ncebere, J. M., Mbuthia, P. G., Waruiru, R. M., & Gathumbi, P. K. (2021). Gross and histopathology of goats feeding on *Opuntia stricta* in Laikipia County, Kenya. *Veterinary Medicine International*.
- Novoa, A., Le Roux, J. J., Robertson, M. P., Wilson, J. R. U., & Richardson, D. M. (2015). Introduced and invasive cactus species: a global review. *Aob Plants*. <https://doi:10.1093/aobpla/plu078>
- Obiri, J. F. (2011). Invasive plant species and their disaster effects in dry tropical forests and rangelands of Kenya and Tanzania. *Jàmá: Journal of Disaster Risk Studies*, 3(2), 417-428.
- Omweri, A. H., Rimberia, F. K., Mwangi, S. G., & Sila, D. N. (2016). Morphological characterization and distribution of cactus species (*Cactaceae*) in arid and semi-arid lands of Kenya. *International Journal of Agronomy and Agricultural Research*, 9(1), 182-191.
- Priolo, A., Ben Salem, H., & Morand-Fehr, P. (2007). Advanced nutrition and feeding strategies to improve sheep and goat production. *CIHEAM-IAMZ. Rangelands Archives*, 13(3), 109-111.
- Rejmánek, M., & Richardson, D. M. (2013). Trees and shrubs as invasive alien species- 2013 update of the global database. *Diversity and Distributions*, 19(8), 1093-1094.
- Shackleton, R. T., Witt, A. B. R., & Piroris, F. M. (2017). Distribution and socio-ecological impacts of the invasive alien cactus *Opuntia stricta* in eastern Africa. *Bio Invasions*, 19, 2427-2441.
- Tangka, F. K., Jabbar, M. A., & Shapiro, B. I. (2000). *Gender Roles and Child Nutrition in Livestock Production Systems in Developing Countries: A Critical Review*. Socio-economics and Policy Research Working Paper 27 (ILRI) International Livestock Research Institute.

Editon Consortium Journal of Business and Management Studies

- Wasike, A. (2022). *Women in Kenya Declare War on Invasive Colonial-era Plant Species*.
<https://www.aa.com.tr/en/africa/-women-in-kenya-declare-war-on-invasive-colonial-era-plant-species/2591290>
- Yamane, T. (1967). *Statistics: An Introductory Analysis*, 2nd Ed: Harper and Row.