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Pastoralists' Perception and Attitude on Invasion of *Dichrostachys cinerea* (sickle bush) in the Grazing Lands of Monduli District, Tanzania

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Abstract

This study aimed to assess Maasai pastoralists' perception and attitude towards the spread and impacts of sickle bush (*Dichrostachys cinerea*) in their grazing lands. The study was conducted in three villages of Monduli district involving 156 randomly sampled households. Thirteen (13) purposively selected key informants (based on their merits) were interviewed and participant observation was also used in data collection. Quantitative data were analyzed by the SPSS software version 20, while qualitative ones were subjected to content analysis. Findings revealed that the current extent of the sickle bush has increased, with over 70% of the respondents proving this. About 82% of respondents revealed that the bush was present in their villages for a long time, although its invading effects have increased. Major reasons for this invasion were reported to include climate change and overgrazing. Furthermore, sickle bush was reported to take over the grazing lands. The bush is perceived as destructive by the Maasai community because it depletes the amount of forage for livestock grazing. It also provides suitable habitats for predators such as lions and enhances conflicts with livestock and humans.

Keywords

Climate change; Forage; Grazing lands; Livestock; Overgrazing; Invasive species; Maasai steppe

1. Introduction

Livestock keepers in most parts of sub-Saharan Africa depend on natural rangelands for grazing (Baars, 2002; de Glanville et al., 2009). The same is true for the people of Monduli district, who are mostly Maasai herders and depend on the existing pastures in

the grazing lands (Homewood et al., 2006). According to the TPP (Tanzania Partnership Program) report[1] of 2019, 79% of people in Monduli are livestock keepers who directly depend on natural pastures. The presence of healthy rangelands is, therefore, key for sustainable livestock production. Any change that affects the pastures and grazing land affects livestock herders directly (Mutandwa and Mupangwa, 2007). Healthy rangelands are characterized by a high proportion of herbaceous plants with a reduced proportion of woody plant species (Ward, 2005). The increased abundance of woody plant species in the rangelands degrades these lands, hence, reducing their potential for grazing (Tefera et al., 2007) and affecting negatively the livestock production (Bonaudo et al., 2014).

Recently, there has been *Dichrostachys cinerea* (sickle bush) taking over the grazing lands in the Monduli district (TNC, 2021). Vegetation surveys on this bush have been done elsewhere, including Ethiopia (Bussa and Shibru 2020), Zimbabwe (Mudzengi et al*.,* 2014) and South Africa (Randle et al*.,* 2018); but the surveys alone are not enough since primary information from rangeland custodians (usually herder communities) is very helpful when improvement of the grazing lands is required (Reed et al., 2011). Many times, researchers and development policies have not been keen to consider the experience and aspirations of pastoralists in improving grazing lands. This has led to many development interventions to fail (Galvin et al., 2001) Combining local knowledge and scientific measurements in rangelands can be very helpful in solving the problems that pastoralists are facing (Ayana and Oba 2008). According to Oba and Kaitira (2006), pastoralists are recognized for having sufficient knowledge of plant species that existed in the past. People also have knowledge about the changes occurring in their grazing lands, such as the increase in grazing pressure, invasion by invasive plants, bush take over, and climate change. They even know more palatable plants for livestock in their grazing lands. Thus, investigating pastoralists' perception and attitude will greatly contribute to the improvement of grazing lands ensuring sustainable livelihoods of the Maasai pastoralists in the study area. This study aimed at assessing pastoralist's perception and attitude on the invasion of sickle bush in the grazing lands of Monduli district. Specifically, the study has the following objectives: (i) Assessing the perception and attitude of pastoralists on extent and distribution of sickle bush; (ii) Assessing the perception and attitude of pastoralists on impacts and alternative uses of sickle bush.

2. Methodology

2.1 The Study Area

This study was conducted in the Monduli district in the Arusha region located in the north-eastern part of Tanzania having a latitude of 3°20′S and longitude of 36°15′E. The average annual rainfall of the district is below 600 mm per year. The majority of inhabitants of the Monduli district (97%) belong to the Maasai tribe (Kimaro et al., 2017), which is an Indigenous ethnic group of the Arusha region. Maasai are livestock-herding people (Homewood et al., 2006), and approximately 80% of people in this district earn their living by keeping livestock. The study involved three pastoral villages, *Naitolia, Mswakini juu*, and *Mswakini chini*, all located within the Kwakuchinja wildlife corridor separating the Manyara National Park and Tarangire National Park.

[1] TPP (Tanzania Partnership Program) report of 2019), https://pscd.isp.msu.edu/files/9815/7564/8031/TPP_Report_2019_final_accessible.pdf.

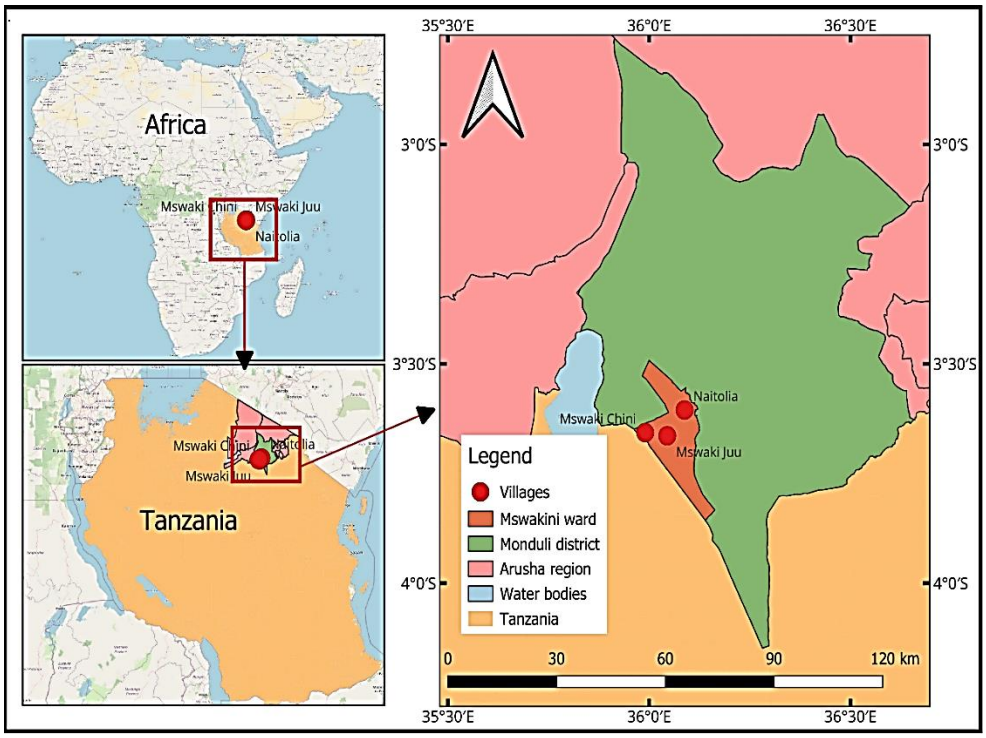

Figure 1: The map showing the location of the study villages

2.2 Research Design and Data Collection

The research design adopted was a cross-sectional survey in which data were collected at a single point in time, combining two approaches that were qualitative and quantitative in nature. A qualitative method was based on open-ended questions exploring the perceptions and attitudes of participants on the invasion of sickle bush, while the quantitative method consisted of close-ended questions, such as demographic data and years spent in the study area. Data on perception and attitude towards the sickle bush invasion in Monduli district was collected between January and March 2023 using structured questionnaires that were prepared using a Kobo toolbox[2] and pre-tested. The questionnaire data was supplemented by information collected from key informants using a questionnaire with open-ended questions. The selection of key informants was purposively done in each village. It included the village leaders, rangeland monitors, land planning leaders, religious leaders and pastoralists with big herds (Laigwanan); a total of 13 key informants were involved during this study. Further to key informants, participant observations were done to complement the two methods during the field survey. These methods were adopted because rapid assessment interviews with pastoralists were not much expensive and provided reliable information on rangeland trends (Jones et al., 2008). These methods were adopted because rapid assessment interviews with pastoralists were not much expensive and provided reliable information on rangeland trends (Jones et al., 2008). During data entry, coding was done for open-ended questions. At the time of data collection, the respondents were contacted face to face by using the Kiswahili language with a local Maasai translator for respondents who were not conversant with the Kiswahili language.

[2] Kobo Toolbox is an intuitive, powerful, and reliable software used to collect, analyze, and manage data for surveys, monitoring, evaluation, and research (https://www.kobotoolbox.org/)

2.3 Sampling and Sample Size

The sample size for the household survey was 156 households. The estimation of this sample size was inspired by the work of Theodory and Yamat (2014) and Kima et al. (2015). This was 10% of the household population in these three villages. The decision to adopt this sample size was due to its proven effectiveness in similar research content, its compatibility with the study objectives and the nature of the study area. The sample sizes from each village were as follows: Naitolia (n=45), Mswakini chini (n=61), and Mswakini juu (n=50). From each household, a single person (in most cases, head of the household) was interviewed. The villages were sampled purposively due to the presence of sickle bush, while the households were randomly selected for the questionnaire survey.

2.4 Data Analysis

The collected data from the household survey were downloaded from Saver; cleaned, coded in Microsoft Excel® spreadsheet and exported to Statistical Package for the Social Sciences (SPSS) version 20 for analysis. Descriptive statistics such as frequencies, means, and percentages were employed. Information collected from key informants was analyzed by filtering the discussion points to get the content in every particular context (content analysis). Most of these data were used to triangulate information generated through questionnaire surveys.

3. Results and Discussion

3.1 Demographic Information of the Surveyed Population

The average total family size of the studied households was eight (8) persons. The age of respondents in all villages varied between 18 and 86 with an average age of 41 years. The respondents were 50.6% females and 49.4% males. The high rate of female respondents is attributed to their availability at homesteads during data collection. This is because most Maasai women are housekeepers who, most of the time, remain at home, while different age groups of men are out for different activities related to herding (Omolo, 2010; Ongoro and Ogara, 2011; Admasu et al. 2010). About 89.7% of all the surveyed respondents were married, 5.8% were single, and 4.5% were widows. The education level of the respondents (Figure 2) shows a higher level of illiteracy among females compared to the males. About 39.2% of females have no access to formal education compared to 20.8% of males.

Results also show that 41.8% of females received primary education compared to 59.7% of males. Surprisingly, none of the surveyed population of females have access to tertiary education. The higher level of illiteracy among females in Maasai societies was also reported by Bobadoye et al. (2016). This tendency is associated with less access to information hindering their decision-making ability (Dong et al., 2007). According to Berger (2003), less education also affects the contribution of women in rangeland resources management. The latter may lead to long-term impacts on the society's well-being. Furthermore, illiteracy has been reported to increase the risk of poverty (Sulla and Zikhali, 2018).

3.2 Source of Income of the Surveyed Population

Results revealed about 99.4% of the surveyed respondents were the owners of livestock and only 0.6% did not own any livestock. The main economic activity for all the respondents was livestock keeping with 93.6% of the respondents depending on livestock keeping and small-scale farming as their source of income, while 5.1% were doing livestock keeping only (Figure 3).

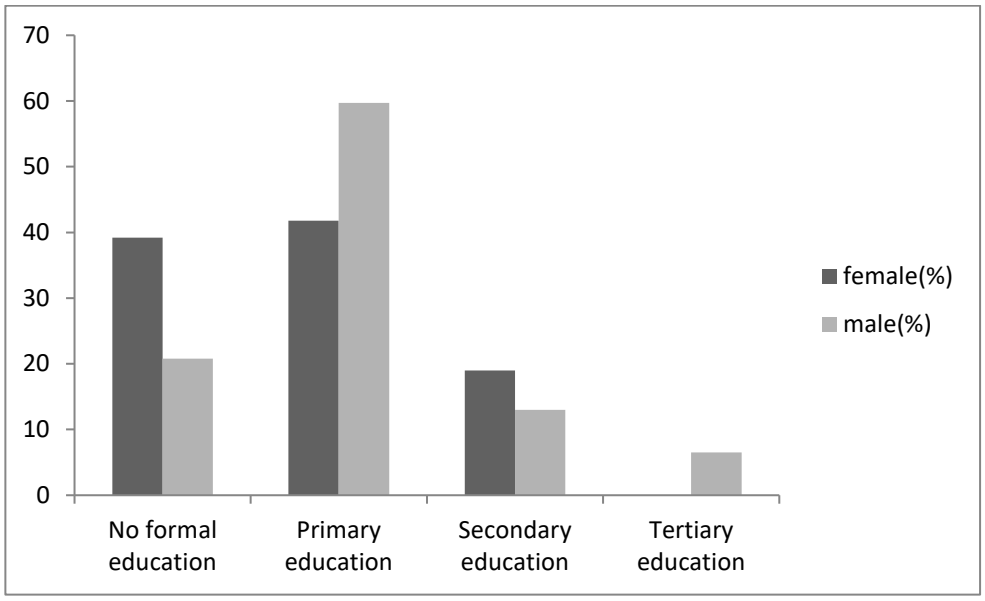

Figure 2: Education level of the respondents

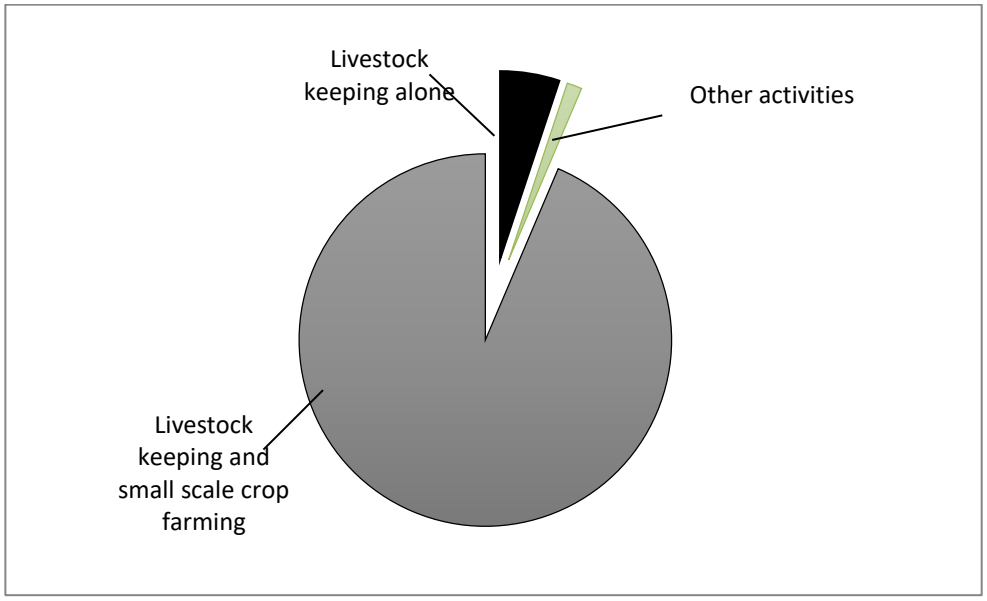

Figure 3: Economic activities of the respondents

This shows that the Maasai community of Monduli district is livestock-dependent, similar to what has been reported by Homewood et al. (2006), Mubezi (2011) and Theodory and Yamat (2014). The majority of the respondents reported a continuous reduction of forage for their animals. They further reported that the reduction of forage has led to a considerable death of animals, especially during prolonged dry seasons. One of the key informants from Naitolia village (58 years) was recorded saying, "*I lost almost thirty cattle during the previous dry season; I have only three cattle now, few goats and sheep, which are not enough to cover my family's economic and social demands"*. This scarcity of forage has even forced most of the pastoralists to start engaging in crop farming, which was not a tradition in the past years. However, the returns from crop farming were reported to be low due to poor land conditions not favouring arable farming. The same was also reported by Chimonyo et al. (2000) and Gyde et al. (2007) who proved the unsuitability of rangelands for crop farming.

3.3 Condition of the Grazing Lands in the Study Area

During this study, different tools were used to assess the perception of the community on the grazing land condition, including the vegetation type. About 78.8% of the respondents reported that, previously, their grazing lands were dominated by edible herbaceous plant species. And, 94.9% of the respondents said that herbaceous plants were mostly preferred by livestock (see Table 1). The dominant plants that were said to exist in the past included *Themeda triandra* (Ol-kujita onyokie), *Cynodon dactlyon* (Ol-Murua) and *Cencrus sps* (O-sankash and Ol-o-gor oingok). These key forage species have decreased tremendously, and are no longer available as proved through personal observation. It was also confirmed by one of the key informants (65 years old) in Mswakini chini village, "*We used to roof our houses with* Themeda triandra *(red oat grass) and* Hyparrhenia rufa *(giant thatching grass) that were plenty, but now they are found nowhere in our grazing lands*". Observation has also proved the presence of sickle bush and some other undesirable plant species dominating the grazing lands of these villages (Figure 4). This change in species composition has also been reported by Tokozwayo et al. (2018) where the pastoralists revealed that they have been noticing the replacement of palatable plants with bushes due to overgrazing.

Figure 4: Pictorial representation of sickle bush in the grazing land of Mswakini Juu and Naitolia villages, Monduli, Tanzania. Photographs were taken in February, 2023 (Photo credit: E. Mguluka)

These changes in plant composition and structure have made livestock keepers in Monduli District alter the types of livestock, from more cattle to more goats, as reported by 90.4% of the respondents. It is revealed that they regarded goats as the best option because goats can browse woody plants. Goats are browsers and, therefore, easily adapt to climate change and have lower nutritional demands compared to cattle. This fact has also been reported elsewhere by Peacock (2005), Aziz (2010) and Marchant (2016). Economically, this phenomenon actually leads to a decline in herders' livelihoods, since the economic returns from goats are smaller compared to larger animals like cattle (Dovie et al., 2006). Furthermore, keeping more than one species of livestock (diversification) is a safe way of combating economic risks caused by climate change (Dovie et al., 2006). Traditionally, Maasai pastoralists consider cattle herds as their live banks (ATM machines), which is their means of savings (Kassahun et al., 2008; Quinlan et al., 2016). So, the forced reduction of cattle due to invasion of sickle bush challenges cultural traditions, because in Maasai societies, cattle hold a greater significance than goats (Quinlan et al., 2016). Cattle have many other social and cultural functions in the pastoral society, in addition to economic value. This change in livestock portfolio has also

been reported by Abule (2008) and Yassin (2019), who investigated the impacts of bush invasion in Ethiopia where pastoralists shifted from rearing more cattle to more camels and goats.

Table 1: Pasture availability compared to 10-20 years ago and the type of plants that were mostly available and preferred in the grazing lands

Variable	*Rating*	*Number of responses*	*Percent (%)*
Perception of plant availability	Not changing	1	0.7
	Decreasing	149	95.5
	Increasing	6	3.8
	Total	*156*	*100*
	Plant structure		
Type of plants that were mostly available in the grazing lands	Herbaceous plants	123	78.8
	Woody plants	33	21.2
	Total	*156*	*100*
Type of plants that were mostly preferred by livestock	Herbaceous plants	148	94.9
	Woody plants	8	5.1
TOTAL		*156*	*100*

3.4 Challenges Faced by Pastoralists in the Grazing Area

Pastoralists reported different challenges grouped into five major categories, including livestock diseases, bush invasion, shortage of forage, livestock theft, predation by wild animals, and shortage of water. Among these, a shortage of forage was frequently reported by 24% respondents (Table 2). The reasons for the forage shortage were claimed to be caused by the effects of climate change, invasion by bushes, mainly sickle bush (*Dichrostachys cinerea*), and an increase in the population of people and livestock. This is in agreement with what was reported by Opiyo (2014). The less frequently reported challenge was livestock theft (6%), where most of the respondents revealed that there was enough security in the villages.

Table 2: Challenges faced by pastoralists in the grazing area

Variable		*Number of responses*	*Per cent (%)*
The challenges	Livestock diseases	72	17
	Bush encroachment	69	16
	Shortage of forage	101	24
	Livestock theft	26	6
	Predation by wild animals	74	17
	Shortage of water	86	20
	Total	*428*	*100.0*

3.5 Sickle Bush Evolution in the Study Area

The Maasai community of the study area names this bush plant as *Endundulu* or *Ndundulu* in the Maasai language. About 82% of the respondents said that the bush was present in their localities a long time ago. However, 13% claimed to have started hearing about it recently, and the remaining 5% have no idea (Figure 5). Those who claimed it to be new in their place said that it comes from neighbouring Tarangire National Park and Manyara Ranch. These results suggest that the plant is native to this place, as also reported by Orwa et al. (2009).

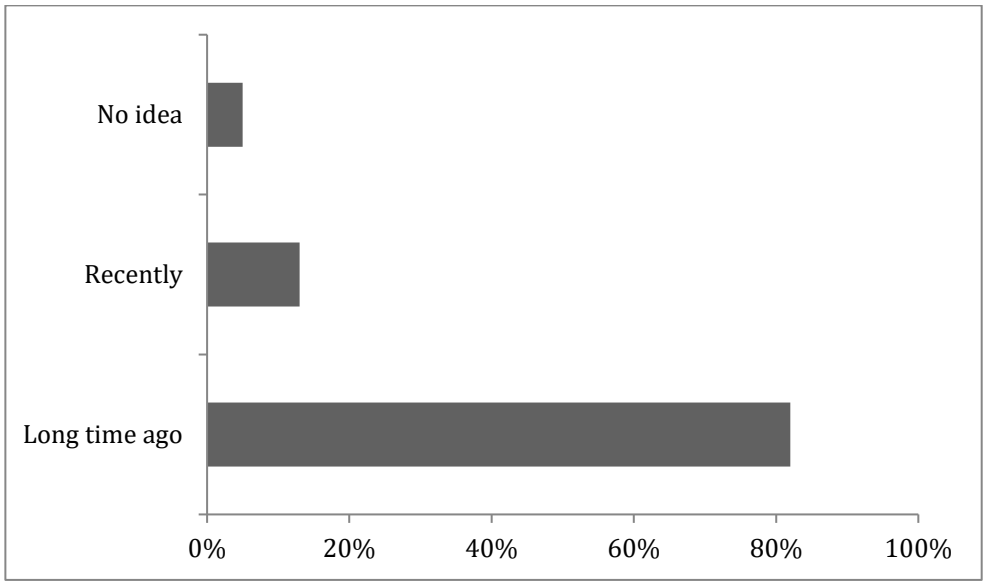

Figure 5: Sickle bush Evolution in the Study Area

Though the invading effects of this plant have been increasing recently, about 78.8% of the respondents reported this plant as continuously increasing in extent. Reasons for the increase include the effects of climate change, overgrazing and other unknown factors (Figure 6). Some of the reported factors are in agreement with the findings by Yusuf et al. (2011), who reported the factors, like climate change, fire suppression, overgrazing, and changes in land use practices, as prime causes for bush invasion.

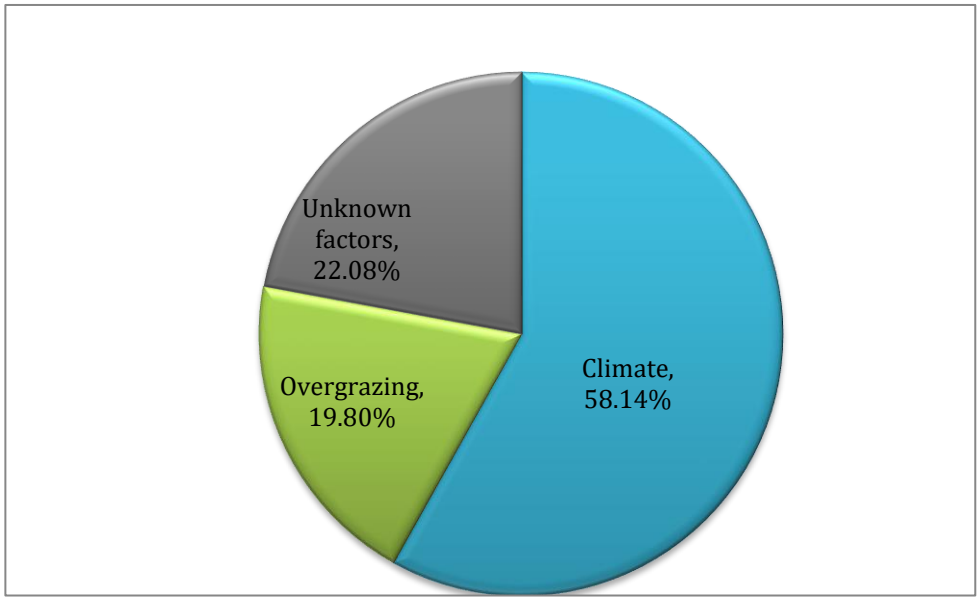

Figure 6: Factors for an increasing extent of the sickle bush in the study area

3.6 Perception on Extent and Distribution of Sickle Bush

About 78.8% of the respondents revealed that the current extent of the sickle bush is larger compared to the previous 10-20 years as shown in table 3. It means that the bush has been increasing similar to reported case by The Nature Conservancy (TNC, 2021).

Table 3: Current extent of the sickle bush *(Dichrostachys cinerea)* compared to 10-20 years ago in the study area

Variable	*Rating*	*Number of responses*	*Percentage (%)*
The current extent of sickle bush encroachment	Don't know	4	2.6
	Smaller	29	18.6
	Higher	123	78.8
Total		*156*	*100*

The rapid increase may be due to the rapid reproduction of this plant through seeds and lateral roots. This was noted by one of the key informants (58 years old) who was quoted saying, *"This plant produces a lot of roots that develop into new plants."* According to Orwa et al. (2009) and Mudzengi et al. (2014), these plants tend to have a lot of lateral roots, which are capable of undergoing prolific reproduction from the root suckers. Participant observation also confirmed the presence of many lateral roots extending from a single plant. More observation revealed that this plant has mainly invaded in Naitolia's grazing lands, particularly in Engusero, in the Randillen area within the grazing lands of Mswakini juu village, in some parts of Mswakini chini's grazing land and inside Manyara ranch nearby these villages.

Figure 6: Pictorial representation of sickle bush in the grazing land of the Mswakini juu village, Monduli district, Tanzania. Photograph was taken in February, 2023 (Photo credit: P. Laizer).

3.7 Communities' Attitude towards the Presence of Sickle Bush in the Study Area

Table 4 shows the attitude of the respondents towards the presence of sickle bush in the grazing lands of their respective villages. A large proportion showed a negative

attitude towards this plant (52% of the female respondents and 66% of males). When comparing the attitude among females and males, most females had a positive attitude (48%) than males (26%). This was due to the claimed use of sickle bush as a source of firewood and as an ingredient for washing gourds by women.

Table 4: The attitude towards the presence of sickle bush in the grazing lands

Gender	*Attitude*					
	Positive		*Negative*		*Neutral*	
	Responses (n)	*Percentage (%)*	*Responses (n)*	*Percentage (%)*	*Responses (n)*	*Percentage (%)*
Females	38	48	41	49	2	3
Males	26	34	51	66	0	0

This difference in attitude may be due to less exposure of women to grazing activity and less exposure of men to domestic activities (Tulu & Dawa, 2010), such as firewood fetching. According to Rudman et al. (2007), expressed attitudes are a result of encountered events.

3.8 Perception towards the Importance and Utilization of Sickle Bush in the Study Area

Most of the surveyed respondents (59%) said that this plant is not important in their grazing lands (Table 5).

Table 5: Importance of sickle bush in the grazing lands

Variable	*Rating*	*Number of responses*	*Percentage (%)*
Importance of sickle bush in the grazing lands	Not important	92	59
	Important	52	33.3
	Very important	12	7.7
Total		*156*	*100*

The reasons for it being 'not important' were grouped into three categories which were: (i) Hiding wild animals, (ii) Affecting herbaceous pasture production, (iii) Difficult penetration of both animals and humans (Figure 7). These impacts caused by this plant are similar to what was reported by Dalle et al. (2006) when researching the impacts of this woody plants on pastoralists. The majority of those who claimed it to be 'important' said that they used the plant as a source of firewood for domestic cooking.

Many responses on the uses of the bush were given and grouped into six categories as shown in figure 8. Among these responses, the source of fuel was frequently reported (33.33%) followed by no use (24.2%). Respondents claimed this bush to be useless because the advantages provided, such as firewood, are also provided by other useful plants in the area. The negative impacts it brings are huge compared to the advantages. For instance, one key informant (37 years old) from Mswakini juu village claimed that there are so many plants which give out better fuel and nutritious fodder than sickle bush.

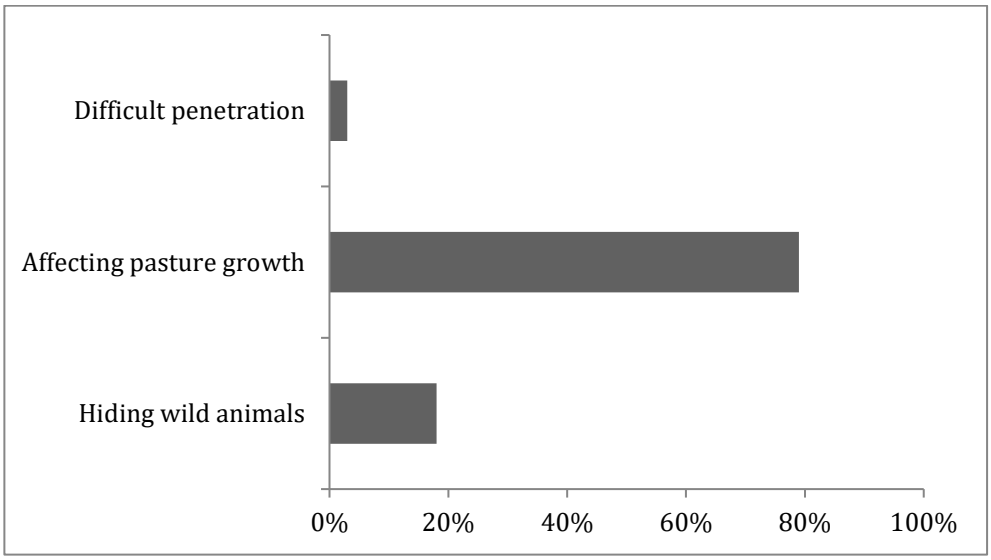

Figure 7: Reasons for sickle bush not being Important

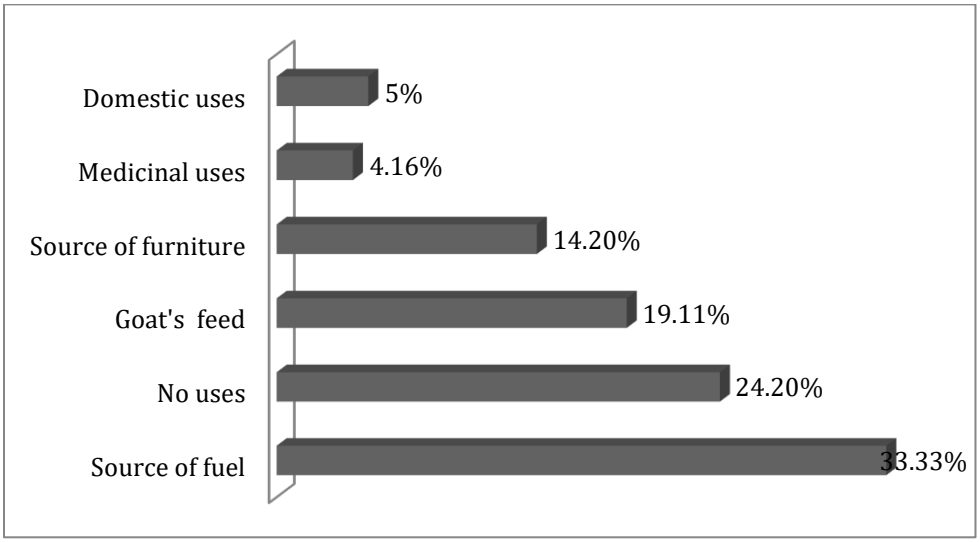

Figure 8: Local uses of sickle bush in the study area

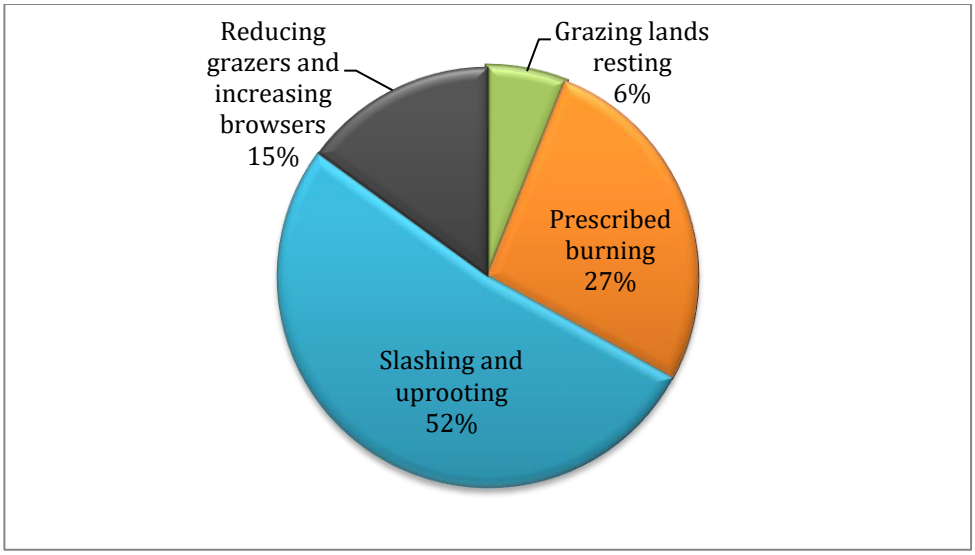

Figure 9: Proposed management of sickle bush by local community

3.9 Integrated Management of Sickle Bush

Maasai herders suggested several mechanisms to manage the bush. About 58% recommended slashing and uprooting the plant to kill the roots. But, mechanical de-bushing needs appropriate information from research to ensure the sustainability of these grazing lands (Yassin, 2019). Other respondents thought prescribed burning could be better as the bush has invaded a larger area of grazing land; this has also been suggested in the study by Oluwole & Sikhalazo (2008). According to Belayneh & Tessema (2017), the use of fire is the best way of preventing open grasslands from bush invasion than managing bushes in grasslands. Since the bush is edible by browsers, others recommended to increase the number of goats and reducing cattle. Other studies have suggested the alternative use of sickle bush as a medicinal plant (Martínez and Estévez, 2020), as it has been reported to cure malaria, diabetes and diarrhea, and to help the childbirth (Subramaniam & Jaganathan, 2021). Though, further studies are important to ensure effective use of it as a medicinal plant (Shikangalah & Mapani, 2020).

4. Conclusions and Recommendations

The results have shown that the sickle bush is a native plant that has currently been increasing in extent in the studied villages. This increase in extent has been attributed to climate change, overgrazing, and other unknown factors. Takeover by the bush has created several problems for Maasai pastoralists, including reduction of forage production and, subsequently, economic and social well-being. The invasion by sickle bush has forced pastoralists to change the type of animals to keep, from more cattle to more goats, due to changes in plant species composition. Economically, this change may cause a decline in herders' livelihoods because the economic returns from goats are shorter compared to cattle. Moreover, cattle have more social and cultural functions in pastoral society compared to goats. The bushes also hide predator animals, which kill the livestock and threaten people's safety. Generally, this bush is negatively perceived by pastoralists; and integrated management to reduce the bush on their grazing lands is inevitable. Hence, the management may be facilitated by further research on its ecology and interaction with other plants in the grazing lands. Interventions involving pastoral communities are very important and urgent to aid the restoration of these grazing lands. Moreover, proper grazing practices are important in the villages to avoid further takeover by this plant in non-invaded areas.

5. Acknowledgements

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6. References

Abule, E. (2008). Bush encroachment: a major threat to pastoralists' livelihood in Ethiopia. The 21st International Grassland Congress/8th International Rangeland Congress, Hohhot, China, June 29 through July 5, 2008. Proceedings edited by Organizing Committee of 2008 IGC/IRC Conference Published by Guangdong People's Publishing House. Retrieved from: https://uknowledge.uky.edu/igc/21/6-1/12.

Admasu, T., Abule, E., & Tessema, Z. K. (2010). Livestock-rangeland management practices and community perceptions towards rangeland degradation in South Omo zone of Southern Ethiopia. *Livestock Research for Rural Development*, *22*(1).

Angassa, A., & Oba, G. (2008). Herder perceptions on impacts of range enclosures, crop farming, fire ban and bush encroachment on the rangelands of Borana, southern Ethiopia. *Human Ecology, 36,* 201–215. https://doi.org/10.1007/s10745-007-9156-z.

Aziz, M. A. (2010). Present status of the world goat populations and their productivity. *Lohmann Information*, *45*(2), 42–52. Retrieved from: https://www.researchgate.net/publication/266525065_Present_status_of_the_world_goat_populations_and_their_productivity.

Baars, R. M. T. (2000). Costs and Returns of Camels, Cattle and Small Ruminants in Pastoral Herds in Eastern Ethiopia'. *Tropical Animal Health and Production, 32,* 113 - 26. https://doi.org/10.1023/A:1005282719931.

Belayneh, A., & Tessema, Z. K. (2017). Mechanisms of bush encroachment and its inter-connection with rangeland degradation in semi-arid African ecosystems : a review. *Journal of Arid Land*, *9*, 299–312. https://doi.org/10.1007/s40333-016-0023-x.

Berger, R. (2003). Conflict over Natural Resources among Pastoralists in Northern Kenya: A Look At Recent Initiatives in Conflict Resolution. *Journal of International Develoment*, *15*(2), 245–257. https://doi.org/10.1002/jid.985.

Bobadoye, A., Ogara, W., Ouma G., & Onono, J. (2016). Assessing Climate Change Adaptation Strategies among Rural Maasai Pastoralists in Kenya. *American Journal of Rural Development*, *4*(6), 120–128. Retrieved from: http://hdl.handle.net/11295/100726.

Bonaudo, T., Bendahan, A.B., Sabatier, R., Ryschawy, J., Bellon, S., Leger, F., Magda, D., & Tichit, M. (2014). Agroecological principles for the redesign of integrated crop–livestock systems. *European Journal of Agronomy, 57,* 43–51. https://doi.org/10.1016/j.eja.2013.09.010.

Bussa, B., & Shibru, S. (2020). Effects of Sicklebush (*Dichrostachys cinerea* (L.) wight and arn. shrub) encroachment on floristic and vegetation structure in semi-arid savannah of southern Ethiopia. *Journal of Environment and Earth Science*, *10*, 1-11. http://doi.org/10.7176/JEES/10-8-01.

Chimonyo, M., Kusina N.T, Hamudikuwanda, H., Nyoni, O., & Ncube, I. (2000). Effects of dietary supplementation and work stress on ovarian activity in non-lactating Mashona cows in a smallholder farming area of Zimbabwe. *Animal Science*, *70*(2), 317–323. https://doi.org/10.1017/S1357729800054771.

Dalle, G., Maass, B.L., & Isselstein, J. (2006). Encroachment of woody plants and their impact on pastoral livestock production in the Borana lowlands, Southern Oromia, Ethiopia. *African Journal of Ecology, 44*(2), 237–246. https://doi.org/10.1111/j.1365-2028.2006.00638.x.

de Glanville, W. A., Davis, A., Allan, K. J., Buza, J., Claxton, J. R., Crump, J. A., Halliday, J. E. B., Johnson, P. C. D., Kibona, T. J., Mmbaga, B. T., Swai, E. S., Uzzell, C. B., Yoder, J., Sharp, J., & Cleaveland, S. (2020). Classification and characterisation of livestock production systems in northern Tanzania. *PLoS ONE*, *15*(12), December. https://doi.org/10.1371/journal.pone.0229478.

Dong, S. K., Lassoie J. P., Yan, Z. L.,Sharma, E., Shrestha, K. K., & Pariya, D. (2007). Indigenous rangeland resource management in the mountainous areas of northern Nepal: A case study from the Rasuwa District. *Rangeland Journal*, *29(*2), 149–160. https://doi.org/10.1071/RJ07033.

Dovie, D. B. K., Shackleton, C. M., & Witkowski, E. T. F. (2006). Valuation of communal area livestock benefits, rural livelihoods and related policy issues. *Land Use Policy, 23,* 260–271. https://doi.org/10.1016/j.landusepol.2004.08.004

Gadzirayi, C. T., Mutandwa, E., & Mupangwa, J. F. (2007). Veld condition trend of grazing areas. *Rangelands, 29*(1), 17-21. https://doi.org/10.2111/1551-501X(2007)29[17:VCTOGA]2.0.CO;2.

Galvin, K. A., Boone, R. B., Smith, N. M., & Lynn, S. J. (2001). Impacts of climate variability on East African pastoralists: Linking social science and remote sensing. *Climate Research, 19*, 161-172. https://doi.org//10.3354/cr019161

Gyde, L. H. (2007). Accounting for the World's Rangelands. *Rangelands, 29*(1), 3-10. https://doi.org/10.2111/1551-501X(2007)29[3:AFTWR]2.0.CO;2.

Homewood, K., Trench, P., Randall, S., Lynen, G., & Bishop, B. (2006). Livestock health and socio-economic impacts of a veterinary intervention in Maasailand: infection-and treatment vaccine against East Coast fever. *Agricultural System, 89*, 248 - 271. https://doi.org/10.1016/j.agsy.2005.09.004.

Jones, J. P. G., Andriamarovololona., M. M., Hockley, N., Gibbons, J. M., & Milner-Gulland, E. J. (2008). Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. *Journal of Applied Ecology, 45,* 1205-1212. https://doi.org/10.1111/j.1365-2664.2008.01487.x.

Kassahun, A., Snyman, H. A., & Smit., G. N. (2008). Impact of rangeland degradation on the pastoral production systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia. *Journal of Arid Environments*, *72*(7), 1265–1281. https://doi.org/10.1016/j.jaridenv.2008.01.002.

Kima, S. A., Okhimamhe, A. A., Kiema, A., Zampaligre, N., & Sule, I .(2015). Adapting to the impacts of climate change in the sub-humid zone of Burkina Faso, West Africa: Perceptions of agro-pastoralists. *Pastoralism*, *5*(1). https://doi.org/10.1186/s13570-015-0034-9.

Kimaro, E. G., Mor, S. M., & Toribio, J. L. (2018). Climate change perception and impacts on cattle production in pastoral communities of northern Tanzania. *Pastoralism: Res. Policy Pract., 8*(19). https://doi.org/10.1186/s13570-018-0125-5.

Kimaro, E. G., Mor, S. M., Gwakisa, P., & Toribio, J. A. (2017). Seasonal occurrence of Theileria parva infection and management practices amongst Maasai pastoralist communities in Monduli District, Northern Tanzania. *Veterinary Parasitology*, *246*(August), 43 - 52. https://doi.org/10.1016/j.vetpar.2017.08.023.

Kraaij, T., & Ward, D. (2006). Effects of rain, nitrogen, fire, and grazing on tree recruitment and early survival in bush-encroached savannah. *South Africa Plant Ecology, 186,* 235 - 246. https://doi.org/10.1007/s11258-006-9125-4.

Ladio, A. H., & Lozada, M. (2009). Human ecology, ethnobotany and traditional practices in rural populations inhabiting the Monte region: resilience and ecological knowledge. *Journal of Arid Environments, 73*, 222-227. https://doi.org/10.1016/j.jaridenv.2008.02.006.

Marchant, R. (2006). This document is discoverable and free to researchers across the globe due to the work of AgEcon Search. Help ensure our sustainability. Actors influencing the price of agricultural products and stability count. *AgEcon Search*, *11*. Retrieved from: http://ageconsearch.umn.edu/.

Martínez, S. S., & Estévez, A. J. (2020). El Marabú (Dichrostachys cinerea) como planta medicinal. *Journal of Animal Production,* 32(3). Retrieved from: https://revistas.reduc.edu.cu/index.php/rpa/article/view/e3526.

Mubezi, F. (2011). Prolonged Drought and Socio-Cultural and Economic Livelihoods of the Pastoral Communities of Tanzania. Unpublished Thesis Submitted as a Partial Fulfillment of MSc. Development Policy, Mzumbe University, Tanzania. 98pp. http://dx.doi.org/10.13140/RG.2.1.1601.6805.

Mudzengi, C., Kativu, S., & Dahwa, E. (2014). Effects of *Dichrostachys cinerea* (l) Wight & Arn (Fabaceae) on herbaceous species in a semi-arid rangeland in Zimbabwe. *Nature & Conservation, 7*, 51–60. https://doi.org/10.3897/natureconservation.7.5264.

Mutandwa, E., & Mupangwa, J. F. (2007). Veld Condition Trend of Why poor livestock production in the tropic. *Rangelands*, *29*(1), 17 - 21. https://doi.org/10.2111/1551-501X(2007)29[17:VCTOGA]2.0.CO;2.

Oba, G. and Kaitira, L.M. (2006). Herder Knowledge of Landscape Assessments in Arid Rangelands in Northern Tanzania. *Journal of Arid Environments*, *66*, 168-186. https://doi.org/10.1016/j.jaridenv.2005.10.020.

Oluwole, F. A., & Sikhalazo, D. (2008). Land degradation evaluation in a game reserve in Eastern Cape of South Africa: soil properties and vegetation cover. *Scientific Research and Essays*, *3*(3), 111-119. Retrieved from: http://www.academicjournals.org/SRE/PDF/pdf2008/Mar/Fatunbi%20and%20Dube%20.pdf.

Omolo, N. A. (2010). Gender and climate change induced conflict in pastoral communities: Case study of Turkana in Northwestern Kenya. *African Journal of Conflict Resolution, 102*: 81-102. https://doi.org/10.4314/ajcr.v10i2.63312.

Ongoro, E. B., & Ogara ,W. O. (2011). the Niche of Sociology in the Climate Change Debate. *The Professional Journal, 3,* 21-26. Retrieved from: http://profiles.uonbi.ac.ke/boruru/publications/niche-sociology-climate-change-debate.

Opiyo, E. O. (2014). Climate variability and change on vulnerability and adaptation among Turkana pastoralists in north-western Kenya. A PhD thesis submitted to the Department of Rangeland Management, University of Nairobi. Retrieved from: http://hdl.handle.net/11295/77661.

Orwa, C. A., Mutua, K. R., Jamnadass, R., & Anthony, S. (2009). Agro-forestry Database: a tree reference and selection guide version 4.0. Retrieved from: https://www.researchgate.net/publication/258996453_Agroforestree_Database_A_Tree_Reference_and_Selection_Guide_version_40.

Peacock, C. P. (2005). Goats - A pathway out of poverty. *Small Ruminant Research, 60*(1), 179-186. https://doi.org/10.1016/j.smallrumres.2005.06.011.

Quinlan, R. J., Rumas, I., Naisikye, G., Quinlan, M. B., & Yoder, J. (2016). Searching for the symbolic value of cattle: Tropical livestock units, market price, and cultural value of Maasai livestock. *Ethnobiology Letters*, *7*(1), 76–86. https://doi.org/10.14237/ebl.7.1.2016.621.

Randle, M., Stevens, N., & Midgley, G. (2018). Comparing the differential effects of canopy shading by Sickle bushand Terminalia sericea on grass biomass. *South African Journal of Botany, 119*, 271–277. https://doi.org/10.1016/j.sajb.2018.09.026.

Reed, M. S., Buenemann, M., Atlhopheng, J., AkhtarSchuster, M., Bachmann, F., Bastin, G., Bigas, H., Chanda, R., Dougill, A. J., Essahli, W., Evely, A. C., Fleskens, N., & Geeson, J. H. (2011). Cross-scale monitoring and assessment of land degradation and sustainable land management: a methodological framework for knowledge management. *Land Degradation & Development, 22,* 261 - 271. https://doi.org/10.1002/ldr.1087.

Rudman, L. A., Phelan, J. E., & Heppen, J. B. (2007). Developmental Sources of Implicit Attitudes. *Personality and Social Psychology Bulletin*, *33*(12), 1700-1713. https://doi.org/10.1111/j.0963-7214.2004.00279.x.

Shikangalah, R., & Mapani, B. (2020). A review of bush encroachment in Namibia: from a problem to an opportunity?. *Journal of Rangeland Science*, *10*(3), 251-266. Retrieved from: https://www.researchgate.net/publication/340887405_A_review_on_bush_encroachment_in_Namibia_From_a_problem_to_an_opportunity.

Subramaniam, S., & Jaganathan, D. (2021). A Comprehensive Review on Dichrostachys cinerea Plant description. *Journal of University of Shanghai for Science and Technology*, *23*(9), 1298–1312. http://dx.doi.org/10.51201/JUSST/21/09686

Sulla, V., & Zikhali, P. (2018). Overcoming Poverty and Inequality in South Africa: An assessment of Drivers, Constraints and Opportunities. World Bank Group, Washington, DC. Retrieved from: https://documents.worldbank.org/curated/en/530481521735906534/pdf/124521-REV-OUO-South-Africa-Poverty-and-Inequality-Assessment-Report-2018-FINAL-WEB.pdf.

Tanzania Partnership Program. (2019). *Annual Report of 2019*. TPP. Retrieved from: https://pscd.isp.msu.edu/files/9815/7564/8031/TPP_Report_2019_final_accessible.pdf.

Tefera, S., Snyman, H. A, & Smit, G. N. (2007). Rangeland dynamics of southern Ethiopia: (2). Assessment of woody vegetation structure in relation to land use and distance from water in semi-arid Borana rangelands. *Journal of Environmental Management, 85*(2), 443–452. https://doi.org/10.1016/j.jenvman.2006.10.008.

Theodory, T., & Yamat, L. (2014). Climate Change and Socio-Economic Vulnerability among Maasai Pastoral Communities in Northern Tanzania. *Journal of Policy and Leadership*, *2*(x), 1–19. http://dx.doi.org/10.13140/RG.2.1.1601.6805.

TNC (The Nature Conservancy) (2021). Clearing a way for healthier grass in Tanzania. Stories in Africa, September 19, 2021. Retrieved from: https://www.nature.org/en-us/about-us/where-we-work/africa/stories-in-africa/invasives-removal-tanzania/.

Tokozwayo, S., Mopipi, U. K, Timpong-Jones, E. C., Gulwa, T., & Thubela, N. (2018). Pastoralists' perceptions on the impact of Vachellia karroo encroachment in communal rangelands of the Eastern Cape, South Africa. *Journal of Agricultural Extension and Rural Development, 10*(11), 222–233. https://doi.org/10.5897/JAERD2018.1001.

Ward, D. (2005). Do we understand the causes of bush encroachment in African savannas? *African Journal of Rangeland and Forage Science, 22,* 101 - 105. Retrieved from: http://www.lrrd.org/lrrd22/1/tere22005.htm.

Yassin, I. M. (2019). Bush Encroachment in Borana Rangeland in the Case of Southern Ethiopia: Causes, Impacts and Management Implications. *International Journal of Agriculture Innovations and Research*, *7*(4), 2319–1473. Retrieved from: https://ijair.org/administrator/components/com_jresearch/files/publications/IJAIR_2953_FINAL.pdf.

Yusuf, H., Treydte, A. C., Demissew, S., & Woldu, Z. (2011). Assessment of woody species encroachment in the grasslands of Nechisar National Park, Ethiopia. *African Journal of Ecology, 49,* 397–409. https://doi.org/10.1111/j.1365-2028.2011.01271.x.

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Author's Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*
Conceived and designed the research or analysis	Yes	Yes	Yes
Collected the data	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	No
Wrote the article/paper	Yes	No	No
Critical revision of the article/paper	Yes	Yes	Yes
Editing of the article/paper	Yes	Yes	Yes
Supervision	No	Yes	Yes
Project Administration	No	No	Yes
Funding Acquisition	No	No	Yes
Overall Contribution Proportion (%)	40	30	30

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. Some contexts of animals are also indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents, with the documentation of their Indigenous Knowledge. Some other contexts of Indigenous Peoples or Indigenous Knowledge are indirectly covered through literature review. Therefore, a prior consent or Self-Declaration in this regard is not filed by the researcher and first author to support this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment or field studies. The contexts of plants were only indirectly covered through literature review. Thus, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

(Optional) Research Involving Local Community Participants (Non-Indigenous)
The author(s) solemnly declare(s) that this research has involved local community participants or respondents belonging to non-Indigenous peoples. Yet, this study did not involve any child in any form directly or indirectly. The contexts of different humans, people, populations, men/women/children and ethnic people are also indirectly covered through literature review. Therefore, prior informed consent (PIC)

of the respondents was taken under this study before the face-to-face interviews and interactions.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

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To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Ethical Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/pp0201.

INFORMATION AND CONSENT FORM
This form was translated into Swahili language for the respondents

Research Title : Pastoralists' Perceptions and Attitudes on Invasion of *Dichrostachys cinerea* (sickle bush) in Maasai Lands of Monduli District, Tanzania.

»

Researcher : Emelia Edwin Mguluka
Sokoine University of Agriculture

Research Supervisor : *Antony Zozimus Sangeda*
Sokoine University of Agriculture

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A) INFORMATION TO PARTICIPANTS

1. Objectives of the research

The aim of this study is to assess the Pastoralist's perception and attitude on the invasion of Sickle bush in the Maasai lands of Monduli district, specifically, the study had the following objectives (i) Assessing the perception and attitude of pastoralists on Sickle bush extent and distribution (ii). Assessing the perception and attitude of pastoralists on Sickle bush impacts and uses.

2. Participation in research

The researcher will ask you several pertinent questions. This interview will be recorded in written form and should last about 40-60 minutes. The location and timing of the interview will be determined by you, depending on your availability and convenience.

3. Risks and disadvantages

There is no particular risk involved in this project. You may however refuse to answer any question at any time or even terminate the interview.

4. Advantanges and benefits

You will receive intangible benefits even if you refuse to answer some questions or decide to terminate the interview. You will also contribute to a better understanding of the perceptions and attitudes of Maasai pastoralists on the invasion of sickle bush in Monduli district.

5. Confidentiality

Personal information you give us will be kept confidential. No information identifying you in any way will be published.Additionally , each participant in the research will be assigned a code and only the researcher will know your identity.

6. Right of withdrawal

Your participation in this project is entirely voluntary and you can at any time withdraw from the research on simple verbal notice and without having to justify your decision, without consequence to you. If you decide to opt out of the research, please contact the researcher at the telephone number or email listed below. At your request, all information concerning you can also be destroyed. However, after the outbreak of the publishing process, it is impossible to destroy the analyzes and results on the data collected.

7. Dissemination

A summary report of the research will be disseminated, and you will receive a summary report of project finding in your choice of languages. This summary report will be sent by email to all the participants. The purpose of this dissemination is to educate further the participants.

B) CONSENT

Declaration of the participant

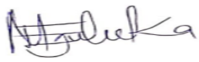
- I understand that I can take some time to think before agreeing or not to participate in the research.
- I can ask the research team questions and ask for satisfactory answers.
- I understand that by participating in this research project, I do not relinquish any of my rights, including my right to terminate the interview at any time.
- I have read this information and consent form and agree to participate in the research project.
- I agree that the interviews be recorded in written form by the researcher: Yes ( ) No ( )

Signature of the participant : _____ Date : _____

Surname : _____ First name : _____

Researcher engagement

I explained to the participant the conditions for participation in the research project. I answered to the best of my knowledge the questions asked and I made sure of the participant's understanding. I, along with the research team, agree to abide by what was agreed to in this information and consent form.

Signature of the researcher :  Date : 20/01/2023

Surname : Mguluka First name : Emelia

If you have any questions regarding this study, or to withdraw from the research, please contact Ms. Emelia Mguluka at (+255 686 985 549) or by e-mail at emeliaemguluka@gmail.com

If you have any concerns about your rights or about the responsibilities of researchers concerning your participation in this project, you can contact the Tanzania Parternership Program coordinator from Sokoinne University of Agriculture by email at sikimera@sua.ac.tz