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Impacts of Watershed Interventions on the Status of Bush Encroachment, Rangeland Productivity and Herbaceous Species Composition in the Rangelands in Borena Pastoralist Dry Land Area

Galma Dabbaso Waariyo*

Borana zone Gomole woreda, Oromia region, Ethiopia , Department of Natural Resource Management, Bule Hora University, Bule Hora Ethiopia

Email: galmadabasowariyo5@gmail.com, Mobile: 0910172827/0967960847

Abstract

Rangeland systems of arid and semi-arid tropics are characterized by highly variable and low rainfall, low primary productivity, low population density, highly variable and low rainfall, lack of access to market and infrastructure and high transaction costs. Livestock production in these areas is also constrained by low productivity, degraded natural resources and widespread poverty. A watershed, or catchment, is defined as an area from which all water drains into a common outlet. The Borana pastoralists developed exceptionally efficient system of range land management strategies like fire regulated tree-grass dynamic and herd mobility appropriate to deal with the erratic rain fall in the dry lands. Description of study area: This study was under taken in pastoral districts of borana zone, more focus on Moyale, Dhas, Dillo, Dirre and Yabello districts of the Borana zone of Oromia Regional State. A vegetation survey was conducted at peak production seasons. The watershed was stratified into intervention watershed village (IWV) and non-intervention watershed village (NIWV). The data collected from the socioeconomic survey was summarized and analyzed using SPSS version **20.0** (Statistical package for social science) software. From results As a consequence pastoralists could get various advantages such as reducing the effects of diseases outbreak, cope with feed and water shortages. Conclusion The major livestock feed resources were natural pasture, bushes and shrubs, crop residues, crop aftermath and fallow land. Recommendations Reducing livestock number by providing market facilities and improving productivity per head could decrease the contribution of overgrazing and expansion of bush encroachment. Therefore the overall objective of the present study was to assess the impacts of watershed management on the status of bush encroachment, rangeland productivity and herbaceous species composition in the borana rangelands.

Keywords: Rangeland; Bush encroachment; Watershed management.

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* Corresponding author.

1. Introduction

Pastoralism, an ancient mode of mobile livestock production that makes the use of extensive grazing on rangelands, is an important economic and cultural way of life for millions of people in the arid and semi-arid areas of eastern Africa and the Horn [17].

Rangeland systems of arid and semi-arid tropics are characterized by highly variable and low rainfall, low primary productivity, low population density, highly variable and low rainfall, lack of access to market and infrastructure and high transaction costs [16, 26, 27].

Livestock production in these areas is also constrained by low productivity, degraded natural resources and widespread poverty. This situation is further aggravated by climate change and variability. Land degradation triggered by a phenomenon known as 'bush encroachment' has affected rangelands throughout the world. In Ethiopia, for example, bush encroachment severely restricts profitability of livestock farming and is considered to be one of the most extensive forms of rangeland degradation in arid and semi-arid regions [2, 5, 26]. The spread of bush encroachment in parts of East African rangelands is usually triggered by the suppression of fire [21,] heavy grazing pressure [8] and anthropogenic factors [3].

Forage production and water yield form a natural unit and reflect the interactions of soil, geology, climate, and vegetation by providing a 'common end product-runoff or stream [19, 24] .A watershed, or catchment, is defined as an area from which all water drains into a common outlet. Watershed is considered the management unit for many natural resource-related issues including land degradation, water conservation, etc. [9]. Watershed is not simply the hydrological unit but also sociopolitical-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people [28].

A watershed is the area of land that drains into a body of water such as a river, lake, stream or bay. It is separated from other watersheds by high points in the area such as hills or slopes. It includes not only the waterway itself but also the entire land area that drains to it. For example, the watershed of a lake would include not only the streams entering that lake but also the land area that drains into those streams and eventually the lake. Drainage basins generally refer to large watersheds that encompass the watersheds of many smaller rivers and streams [13].

Watershed management in the rangelands is designed to deal with the problem of how to use rangelands, not in terms of forage and livestock production alone, but on the basis, that forage production and water yield are interdependent and must therefore be considered together [24]. Comprehensively, bush encroachment is defined as the invasion and/or thickening of aggressive, thornyundesiredable woody species, resulting in an imbalance of the grass: bush ratio, a decrease in biodiversity, a decrease in herbaceous biomass, carrying capacity and concomitant economic losses [16] to local people and the nation at large.

The Borana pastoralists developed exceptionally efficient system of range land management strategies like fire regulated tree-grass dynamic and herd mobility appropriate to deal with the erratic rain fall in the dry lands .They classify their rangelands into Kalo, Worra and Foora land use units (Kalo is grazing land for calves, Worra for lactating livestock and Foora for dry livestock [12].

According to Gemedo Dalle and his colleagues 2006, encroachment of woody plants varies with these land use units and/or sites across different districts in the Borana lowlands, as well as high woody plants density has negative impact on herbaceous biomass production and soil nutrients availability.

According [25, 22] savannah grasslands are threatened by bush encroachment particularly through the suppression of herbaceous biomass production and probably also by reduced biodiversity. Response of different bush encroachment controlled method demonstrated by [5] promoted herbaceous species richness in terms of herbaceous plant biomass and restoration of plant biodiversity.

Participatory watershed management program is, therefore, considered as an effective tool for addressing many of the problems faced by pastoral areas and recognized as potential engine for agriculture growth and development in fragile and marginal rangeland areas [11, 24]. Management of natural resources at watershed scale produces multiple benefits in terms of increasing food and feed production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns [24, 23] The overall objective of the present study was to assess the impacts of watershed management on the status of bush encroachment, rangeland productivity and herbaceous species composition in the borana rangelands.

2. Materials and Methods

Description of study area: This study was under taken in pastoral districts of borana zone, more focus on Moyale, Dhas, Dillo, Dirre and Yabello districts of the Borana zone of Oromia Regional State. The pastoral rangeland of borana is found in the southern part of Ethiopia, lying between 3036‟ 600 38‟ N and 36043‟- 410 40‟ E geographical grids in the Southern part of the Regional State of Oromia, it has a spatial area of 69,373.3 km2 (about 7.6-12.3% and 19.5% of the total land area of Ethiopia and Oromia, respectively (ORDPEDB, 2000).

The area is characterized by an arid to semi-arid climate and bimodal rainfall pattern in which a long rainy season occurring between March and May (*ganna*) and the long rainy season are usually from September to November (*hagaya).*The rainfall is erratic and recurrent drought is a common phenomenon in the study area. According to the estimate of the district's (, BzLO, 2013), 8874,571 ha of the land area are cultivable. The grazing land consists of about 292,028 ha; bushes and shrubs cover 11147,000 ha; The livestock population is estimated to be 267,374 cattle, 248,793 goats, 497,011 sheep, 451,329 camels, 11106 mules, 56,648 donkeys and1 833 horses (, BzLO,2013). According to [8] variations in soil properties are common throughout the bottomland and upland sites with important implications for vegetation productivity.

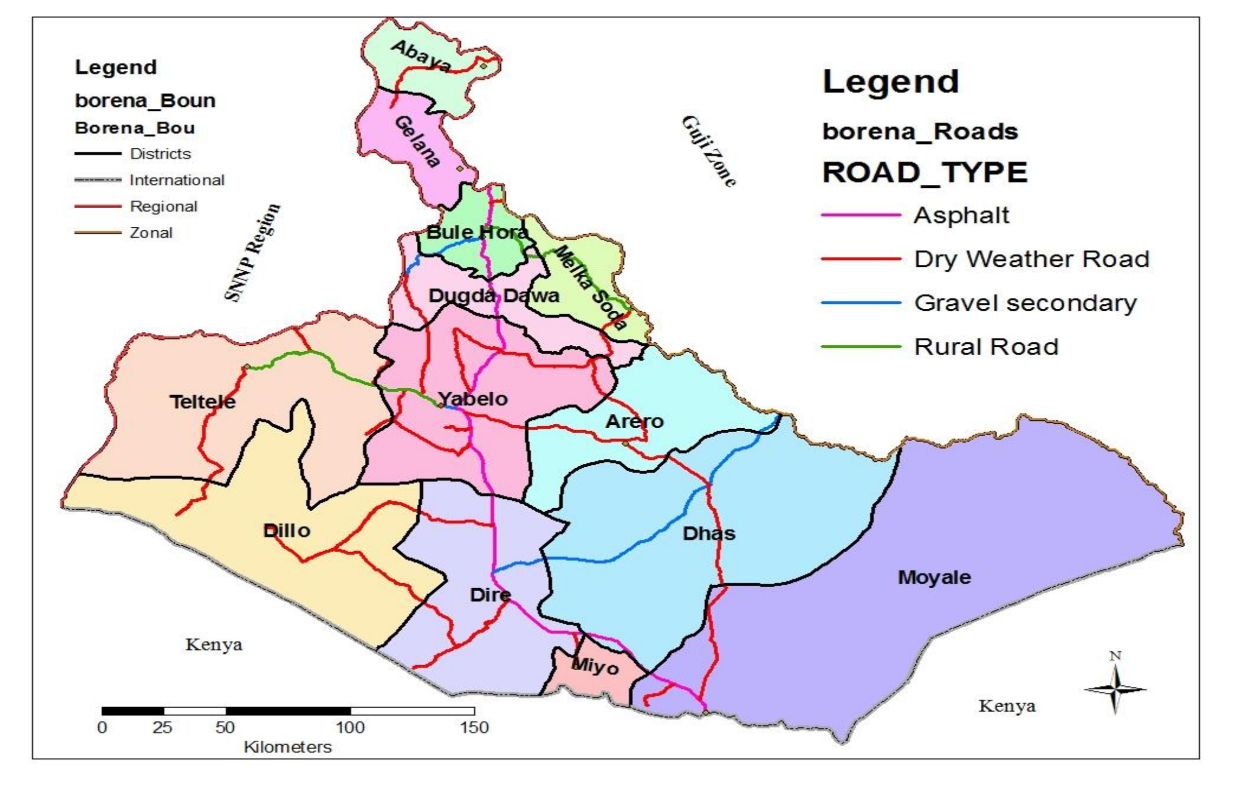

Figure 1

Source borana zone Agriculture and natural resource offices 2013.

2.1. Sampling procedure and methods of data collection

2.1.1. Selection of sampling sites

The impacts of watershed development programs on vegetation condition and productivity, and status of bush encroachment were examined through, field observations, vegetation assessment and holding interviews with the local people using various PRA (Participatory Rural Appraisal) techniques such as key informant interview and focus group discussion, households survey and vegetation sampling.

The watershed was stratified into intervention watershed village (IWV) and non-intervention watershed village (NIWV). Accordingly, the sites were selected purposely through discussion with watershed and land use experts from district pastoral office and NGOs engaged in watershed development programs in borana zone.

A total of 12 transects, 6 in each management unit, was established in both communal grazing area and rangeland managed under the watershed program. Then each management unit was further being stratified into three elevation zones: lowland (1250-1500m), Medium land (1500-1650) and upper land (1650-2000 ml). Three transect was selected in each elevation zone in all areas. An altimeter was used to measure the elevations of the sampling sites. The history of the rangelands indicated that the different elevation ranges had been subjected to differing grazing pressures, with the bottomlands considered as heavily grazed transects because of their proximity to watering points, whereas the medium and top lands were regarded as moderate and lightly grazed sites, respectively. GPS was used to measure the elevation of the sampling zones (sites). In each of the two zones, three (3) parallel transects was established in both management units forming a total of 12 (6 in watershed management unit and 6 in communally managed area or non-watershed management unit) transects.

Appendix 1:- Layout for sample site establishment

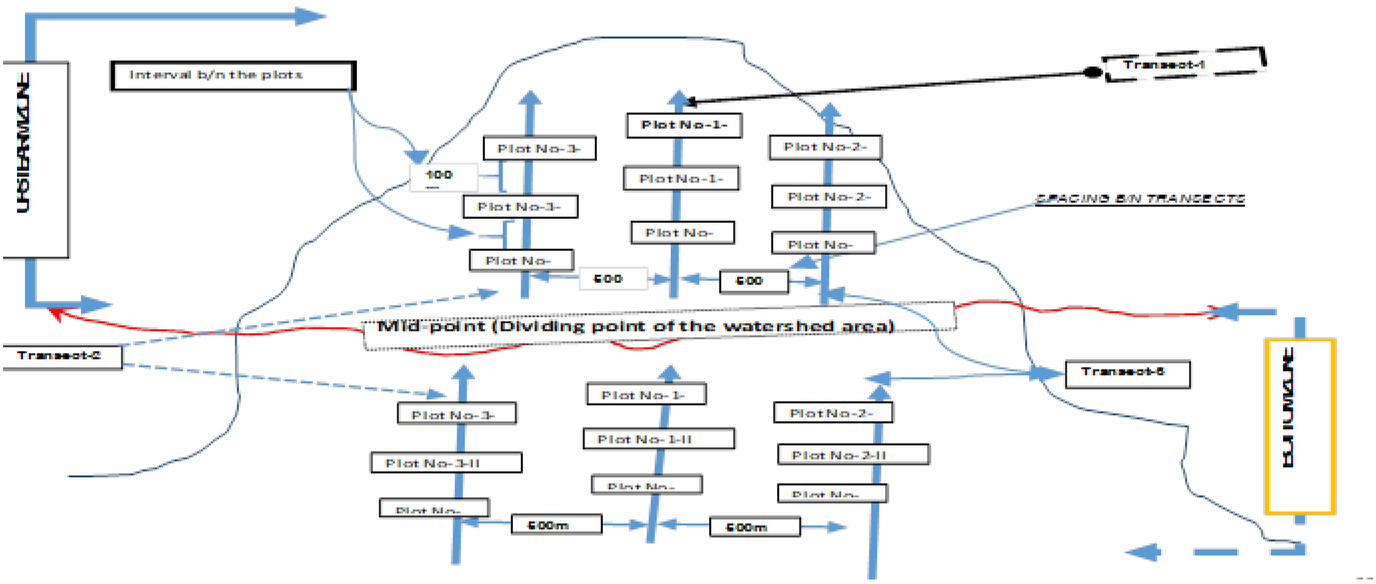

Figure 2

2.1.2. Assessment of the Rangeland vegetation

A vegetation survey was conducted at peak production seasons. This period was selected because most species were expected to be at the full flowering stage Data on diversity of the woody vegetation and vegetation cover was collected in each management unit using quadrates of 20m x 20 m (400m^2) size that distributed along transects [18,29].

Aspects, altitude, latitude and longitude for each sample site were recorded using Garmin GPS-72. Frequency and abundance of trees and shrubs was summarized on 20mx20m (400m^2) plot and 1mx1m (1m^2) plot was used for herbaceous species. Unless identified without doubt, plant specimens were carefully collected, pressed and dried using plant presses and taken to Yabello Dry land Agricultural Research Center for botanical identification. Identification was performed by botanist using flora identification books [6] .A maximum score of 10 points each was given for 3 of the factors (grass composition, basal cover and litter cover) and a maximum score of 5 points each for the remaining 4 factors (number of seedlings, age distribution, soil erosion and soil compaction), summing to a maximum possible score of 50 points. The total rating was interpreted as follows: very poor (≤ 10); poor (11–20); fair (21–30); good (31–40); and excellent (41–50) points.

2.1.3. Assessment of the Woody vegetation layer

In each sample plot (400 m^2), all woody plant species with diameter at breast height (DBH; 1.30 m above the ground) and shrubs was identified and counted to investigate the woody vegetation density and composition. The height was measured by hypsometer while the diameter of trees was measured with the use of a caliper, respectively. The density of woody plants (trees and/shrubs) was enumerated in each plot and an area with less than 5 tress/shrubs were given 0 points and that with more than 50 trees/shrubs scores 10 points other estimates falling in between these limits. Frequency and abundance of trees and shrubs was summarized on 20mx20m (400m^2) plot and herbaceous species on 1mx1m (1m^2) plot to estimate species richness for herbaceous and woody vegetation, and estimate diversity of woody plant.

2.1.4.. Statistical Analysis

The data collected from the socioeconomic survey was summarized and analyzed using SPSS version **20.0** (Statistical package for social science) software. Results were presented mainly using descriptive statistics like mean, percentage, standard deviation and graphs. T-tests were carried out as appropriate to assess the statistical significance or otherwise of particular comparisons.

For the land condition and biomass assessment, all the parameters considered were subjected to ANOVA using the GLM procedure of the Statistical Analysis System (SAS and Minitab 7). The mean data of sample quadrates' (1m^2) from each transect was used for analysis by sorting the data into management units (with watershed program and non-watershed program and land positions (lower and upper land) for comparative analysis. For statistically different parameters ($p<0.05$), means were separated using LSD. The data for range factors and herbaceous vegetation species richness, biomass production, composition and density of woody layer, woody vegetation diversity was analyses separated. The data for range condition factors was log transformed if they are not normal before the factors subjected to analysis. Shannon and the Weiner diversity index were calculated to provide the diversity of woody vegetation.

Shannon and Wiener (1949) index of species diversity was applied to quantify species diversity and richness.

The relative Equitability (evenness) of the species in each cluster was also calculated

- Diversity: 'H' = $-\sum_{k=0}^{n}(\mathrm{Pi}\ln\mathrm{Pi})$
- , Where 'H' = the Shannon and Wiener diversity

Index, 'Pi' = the proportion Es of individuals abundance of the i^{th} species, and 'ln'

= the natural legalism to base e ($\log_e$)

- Equitability(evenness): J = H/Hmax

Where "J" is the species evenness "H" Shannon and Wiener diversity index and "Hmax"

Are lnS, where S is the number of species.

$$H = -\sum_{i=1}^{S} \frac{n_i}{N} \times \ln \frac{n_i}{N}$$

Typically, the Shannon index in real ecosystems ranges between 1.5 and 3.5 (MacDonald, 2003, p. 409) Shannon and Weiner diversity index

2.2. Results and Discussion

2.2.1. Characteristics of the households

The mean age of the studied households of the intervention watershed village (IWV) and non- intervention watershed village (NIWV) was 41 and 45, respectively. Majority (71.1%) of the respondents were male. As in many pastoral areas of Ethiopia, males were noticeably the head of the family and thus strong cultural practice limited females to speak on the behalf of the family [1, 15]. The majority of the respondents did not get any kind of formal education. Only five percent of the studied household's attained at least primary school. However, significant proportion of the respondents attended at least short-term training on farming skills (Table 1). This situation may exert adverse impact on technology transfer and hamper the effectiveness of the interventions being made in the district, which emphasized the need for education improvement in the area.

Table 1: Household Characteristics of the respondents

Variable	IWV (n=35)		NIWV (n=35)		Overall (n=70)	
	Mean + SD		Mean + SD		Mean + SD	
Family size	7.25+1.88		6.74 + 1.22		7.0+1.59	
Level of Education	Frequency	%	Frequency	%	Frequency	%
Can't read and write	11	31.4	33	94.3	44	62.9
Read and write	22	62.9	2	5.7	24	34.3
Primary school	2	5.7	0	0	2	2.9
Training on livestock and/or crop production						
None	10	28.6	7	20	17	24.3
Short term	23	65.7	28	80	51	72.8
Pastorals training center	2	5.7	0	0	2	2.9

SD= standard deviation, IWV=intervention watershed village and NIWV=non- intervention watershed village n=number

2.2.2. Size and Composition Livestock

Pastoralists in the study area do keep a mixture of livestock species mainly cattle, goats, sheep and camels in that order of importance. As a consequence pastoralists could get various advantages such as reducing the effects of diseases outbreak, cope with feed and water shortages. Furthermore, variety outputs could be obtained from the diversification of animal species. This is in line with the reports from the other pastoral areas of Ethiopia and the East African countries**[26,20]** .Cattle were the dominant livestock species in the study area followed by goats, and sheep, (Table 2).The high standard deviation in mean ownership indicates that there is considerable variation in livestock ownership among the households.

Table 2: Mean numbers of livestock by species owned per household in the study area

Livestock species	IWV	NIWV	Overall
	Mean + SD	Mean + SD	Mean + SD
Cattle	$15.03+3.6^{a}$	$12.4+6.0^{b}$	13.7+5.1b
Goats	$10.7+3.5^{b}$	$7.9+4.3^{a}$	9.3+4.1b
Sheep	$6.8+2.8^{a}$	$4.1+3.0^{c}$	5.4+3.2b
Chicken	$2.5+2.2^{a}$	$1.4+1.5^{b}$	$1.95+1.94^{b}$
Camel	$1.7+1.2^{b}$	$1.2+0.9^{a}$	1.4+1.1a
Donkey	$1.0+0.6^{a}$	$0.7+0.6^{b}$	0.9+0.6b

SD: standard deviation, IWV= intervention watershed village, and NIWV= non -intervention watershed village

2.2.3. Feed resources, feeding and management

In semi-arid areas of Borana, communal grazing lands were the major feed resources. Grazing lands were composed of indigenous species of grasses, legumes and browse species.The forage and fodder availability of different land resources in the study area are presented in Table 4. Regarding the sources of animal feed respondents, used natural pasture (75.7%) followed by bushes and shrubs (17.2%) and crop residue (7.15%)**.** This result indicated that pastoralists of the study area had less access of crop residue. According to the focus group discussion grasses and legumes could support animals for three months in the year the browse might stay for about six months.

Table 3: The major feed sources (%)

Feed sources	IWV		NIWV		Overall (N=70)	
	No	%	No	%	No	%
Natural pasture(grass)	27	77.1	26	74	53	75.7
Bushes and shrubs	5	14.3	7	20	12	17.2
crop residue	3	8.5	2	5.7	5	7.1
Total	35	100	35	100	70	100

IWV= intervention watershed village NIWV= non- intervention watershed village N= number

Feed shortage was common in the study area. Based on focus group discussion, during rainy season animals grazed around settlement areas and during dry season animals feed mostly on traditionally enclosed pasture land called *Kalo*. Moreover in dry season branches and leaves of woody plants were used wherever available. Degradation of grazing land and transformation to bush encroachment and agriculture had affected the availability of feed resources in the study area. All respondents practiced mobility during the time of feed shortage in other areas where pasture and water would be available. This occurs mainly from the months of December to March. Much (88.6 %) of the respondents did not supplement their animals. but few of the respondents (11.4 %) had supplemented their livestock with hay and crop residue. This result indicated that the study area pastoralists highly relied on natural pasture, bushes and shrubs.

2.3. Pastoralist perception about the rangeland condition, its productivity management

Policies needed for enhancing rangeland management would be successful if they were based on the watershed program and indigenous knowledge of the community. The traditional rangeland management system, in the area, involved classification of the grazing area into open grazing areas and reserve pasture areas (*Kalo*). The classification helped as means of supplement feed for animals that stayed around the village during feed shortage. During dry season when feed shortage was crucial, closed areas were used as emergency feed resource. However the utilization of closed pasture had to be approved by local elites called Jarsa Reera appointed for that purpose by the community.

Regarding the condition of the rangeland in the study area, the communal grazing land was overgrazed and degraded. About 97 % of the respondents recognized that rangeland condition was in poor condition. It was also observed a decline in total biomass production in the study area during recent years. The respondents indicated different reasons for the worsening situation (Table 5).Increased livestock population pressure, bad climatic factors including drought and declining trend in traditional rangeland management system as the main reasons for the reduction in range condition and productivity. The range condition in the area, currently, has shown reduction with increasing encroachment by undesirable woody and non-woody species.

Table 4: Reasons for poor rangeland condition and decline in rangeland productivity in the area

Parameter	**Reasons**	**HH Ranking**			Index value*	Rank
		1st	2nd	3rd		
		Weighted rank				
Poor rangeland condition	Declining traditional rangeland management system	195	4	3	0.48	1
	Increased livestock population	9	122	6	0.33	2
	Bad climatic factors including drought	6	14	61	0.19	3
Decline in rangeland productivity	Recurrent drought	177	14	4	0.46	1
	Expansion of woody plants	21	116	5	0.34	2
	Overgrazing	12	10	61	0.20	3

The major factors' affecting the productivity of rangelands is presented as follows. Majority of the respondents (95%) indicated that the productivity of rangeland was declining (Figure 2). The main factors attributed to decline in rangelands productivity were recurrent drought, Expansion of woody plants and Overgrazing in order of significance (Table 5).

2.3.1. Status of Bush Encroachment and its controlling activities in the study area

The major factor affecting the productivity of rangeland in the study area was bush encroachment. The results of qualitative in-depth interviews and discussion with pastoralist groups indicated that in the past Borana rangeland including *Yabello woreda* was not affected by encroachment. Before Gada of Jilo Aagaa (1976-1984) rangelands was in a good conditions and pastoralist control bushes and undesirable species using prescribed burning. Encroachments of bushes were started during Gadaa of Jiloo Aagaa (1976-1984). Since then the cover, types and density and abundance of bushes have been increased from time to time. The most abundant tree was *Acacia melliphera*. It suppressed the grass species and even hinders the growth of grasses and makes the lower ground susceptible to wind and water erosion. According to the respondents and personal observation, the woody species that are recorded to be encroaching include shrub and trees of *Acacia* family (Table 6).

Table 5: Encroaching plant species in study area

No	Woody plant species	Local name	Family	LF	Des	Type
1.	Acacia brevispica Harms	*Hammareessa*	*Fabaceae*	*S*	LD	I
2.	Acacia drepanolobium	*Fuleensa*	*Fabaceae*	*S*	LD	I
3.	Acacia bussei	*Hallo*	*Fabaceae*	*T*	LD	I
4.	Acacia etabaica Schweinf.	*Alqabeessa*	*Fabaceae*	*T*	ID	NI
5.	Acacia nilotica	*Burquqqee*	*Fabaceae*	*T*	HD	NI
6.	Acacia mellifera	*Saphansa gurraacha*	*Fabaceae*	*T/S*	LD	I
7.	Acacia oerfota	*Waangaa*	*Fabaceae*	*S*	LD	I
8.	Acacia tortilis	*Dhaddacha*	*Fabaceae*	*T*	HD	I
9.	Acacia reficiens	*Sigirsoo*	*Fabaceae*	*S*	LD	I
10.	Acacia senegal	Hidhaadhoo	*Fabaceae*	S	ID	NI
11.	*Acacia seyal*	Waacuu diimaa	*Fabaceae*	S	LD	I
12.	Helichrysum glumaceum	Darguu	*Fabaceae*	S	D	I

LF=Life form Des= Desirability; HD = highly desirable (Decreaser); ID = Intermediately Desirable (Increaser); LD = Less desirable (Invader); Tree (T), Shrubs (S), Tree or Shrubs (T/S). Invasive (I) and Non-invasive (NI)

The encroached type of plant included trees, shrubs and tree/shrubs regarding type of the bushes, most of them were invasive species and few were non-invasive species. For instance, *Acacia drepanolobium, Acacia brevispica Harms, Acacia reficiens, Acacia melliphera and others are the most invasive species. Other than this some non-invasive species included Acacia seyal, Acacia nilotica and many others.*

2.3.2. Bush clearing

About 43% of the respondents in non -intervention watershed village and 57% in intervention watershed village suggested bush clearing as means of minimizing bush encroachment and to increase productivity of the rangeland. This idea is supported by the work of [25] who indicated trees and shrubs are known to concentrate nutrients in soil beneath the canopy as a result of litter decomposition. This increases soil fertility, and provides an additional mechanism whereby grass production may be stimulated after woody vegetation is cleared.

Table 6: Solutions suggested by pastoralists to control bush encroachment

Mechanism	Percent respondents		Mean
	IWV	NIWV	
Bush clearings	57	43	50
Fire	49	37	43
Herd diversification	34	25	29.5
Government and NGOs Support	28	9	18.5
Area closer	14	6	10

IWV= intervention watershed village NIWV= nonintervention watershed village

But some of the pastoralists argued that manual bush clearing was tedious and needed intensive human labor. As a result it was not much successful insignificant compared to the severity and size of the problem. On top of that the stumps re-sprout and recovered after a short period of time. [14] Also mentioned that on a site dominated by Acacia species a large number of seedlings germinated and survived in an area cleared of vegetation, but that of few were found in non-uncleared area. Clearing has been found to result in marked changes in grass species composition [4] There was a marked decrease in certain desirable species, and also an increase in certain unpalatable species .On the other hand, bush clearing improved range condition by increasing basal cover of perennial grasses and improving soil condition [7,4] .

2.3.3. Biomass production in different management units

The above ground dry matter (DM) biomass production contributed by grass and forbs (plant groups) were compared in different management units (intervention watershed village and non-intervention watershed village). The above ground total DM biomass production was significantly ($P<0.05$) affected by the management units (Table 15). However; land positions within the management units had no significant effect on grass, forbs and total dry matter biomass production (Table 15). The highest total DM biomass production was from the managed land units (intervention watershed village) or where there was no grazing pressure and human interference and the least total DM biomass was from open (non- intervention watershed village) or unmanaged land. This study is in agreement with the results of [17] who suggested that light disturbance could help reduce the cover of dead shoot and facilitate the re-growth of plants [20] also indicated that the proportion of biomass reached its peak values at un-grazed areas and then started to decline along the degradation gradient.

Table 7: Dry matter biomass production (t/ha) of the management units in the study district

Parameters	Management units		
	IWV	NIWAV	P-value
	Mean ±SE	Mean ±SE	
Total Grasses	$0.89+0.11^{a}$	$0.76+0.11^{b}$	0.38
Highly desirable	$0.16+0.02^{a}$	$0.13+0.02^{b}$	0.38
Intermediate	$0.53+0.06^{a}$	$0.45+0.06^{b}$	0.38
Least desirable	$0.21+0.03^{a}$	$0.18+0.03^{b}$	0.38
Forbs	**$0.26+0.31^{b}$**	**$0.15+0.31^{a}$**	**0.03**
Total biomass	**$1.14+0.11^{a}$**	**$0.91+0.11^{b}$**	**0.16**

Means with different superscript letters in a row are significantly (P < 0.05) different SE: standard error, IWV= intervention watershed village and NIWV= non -intervention watershed village

Total above ground DM biomass, DM biomass of grass, DM biomass of highly, DM biomass of intermediate and DM biomass of less desirable grasses was significantly highest (P<0.05) in the intervention watershed village while the lowest was recorded in the non- intervention watershed sites. On the other hand, significantly (P<0.05) lower DM of forbs biomass was observed in intervention watershed than the non- intervention watershed village.

2.4. Conclusion

This study was under taken in pastoral districts of borana zone, more focus on Moyale, Dhas, Dillo, Dirre and Yabello districts of the Borana zone of Oromia Regional State. The aims of the study were to assess the impacts of watershed interventions on the status of bush encroachment, rangeland productivity and herbaceous species composition in rangelands. For the study of rangeland condition, the district was classified into IWV and NIWV rangeland management unit. Data on grass species composition, basal and litter cover, soil erosion, and soil compaction effect were collected.

The mean age of the studied households of the intervention watershed village (IWV) and non-intervention watershed village (NIWV) was 41 and 45, respectively and the level of education is low. Smallholder animal production was the main occupation of the people. The grazing land holding of the area included communal grazing and private grazing. Cattle are the dominant livestock followed by small ruminant (goats and sheep), donkeys and camels. Female stocks of cattle and goats are dominant in both village rangeland management units because male stocks are sold at earlier ages and male are retained as replacement breeding stock. In addition, ownership of large number of cows was considered as prestige and wealth ranking by the community.

The major livestock feed resources were natural pasture, bushes and shrubs, crop residues, crop aftermath and fallow land. Natural pasture was the major sources of livestock feed. As there was no surplus feed during the dry season, natural pasture, browse plants and communal grazing land were important. All households experienced a critical feed shortage during both the short and long dry seasons. Strategies for coping with feed shortages included use of alternative feed sources like browse trees, enclosures and crop residues.

3. Recommendation

The following recommendations are made based on the results

- Bush encroachment could be mitigated implementing integrate management methods. But implementation of different activities like burning and mechanical bush clearing should be supported by efficient monitoring system
- Reducing livestock number by providing market facilities and improving productivity per head could decrease the contribution of overgrazing and expansion of bush encroachment.
- The communities and other stakeholders should give attention in the rehabilitation and possible reestablishment of degraded rangelands through watershed developments so as to improve its biodiversity and productivity conservations
- The pastoralist should be conscious to diversify their livestock species more so that browsers can utilize the available woody plants as a feed source and also contribute to the efforts to control expansion of bush encroachment.

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