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Research and Full Length Article:

Characterization of Rangeland Watershed of the Semi-arid Rangelands, Southeast Ethiopia

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Abstract. Characterization of watersheds was conducted in semiarid rangelands of Dalloma woreda, southeast Ethiopia during 2018-19 fiscal years. Data were collected using household surveys, field observations, and focus group discussion and key informant interviews. Both crop and livestock production (71%) and only livestock production (17%) ware the main activities to earn a living. Respondents ranked sale of livestock and livestock products (61%), sale of honey (20%) and sale of crops (10%) as the main source of income. The pastoral and agro-pastoral in the watershed mainly depends on the production of livestock as their main livelihood because of the suitability of the area for the production of livestock. Drought, the existence of pests, diseases and weeds, land degradation, the high price of input, shortage of improved seeds and shortage of land were a major constraint for crop production. Livestock feed shortage, disease, marketing, lack of improved genotype and low animal by product were the major constraint for livestock productions. Drought, bush encroachment, crop encroachment, overgrazing, over utilization, population increase, disease and inappropriate government policies were the main factors for degradation of rangelands. The result of this study showed that land degradation together with poverty is the most serious problem. Since the well-being of the local community is highly interrelated to the natural resources it has to be managed properly in a sustainable way. Majority of respondents showed the community in the watershed and natural resources management faces interlinked complex problems, implying the importance of integrating different approaches to address the problems in the watershed and improving the livelihood of the community. Thus, integrated watershed management program should be implemented to address different problems in the watershed so that both natural resources and livelihood of the local community can be optimized.

Key words: Baseline, Watersheds, Abdii Guracha watershed, Semi-arid rangeland, Ethiopia

Introduction

Watershed is defined as the geographical area drained by a watercourse and watershed management as any human action aimed at ensuring a sustainable use of watershed resources (FAO, 2011). Watershed is not simply the hydrological unit, but also a socio-political-ecological entity which plays a decisive role in determining the socio-economic security and it helps to support the livelihood of rural communities. Watershed resource degradation is a serious problem in the Ethiopian threatening agricultural development and rural livelihood. Since the economy of the country is agrarian in nature, the decline in agricultural productivity adversely affects the economic growth of the country (Amsalu, 2006; Worku and Tripathi, 2015). In Ethiopian lands are seriously eroded and becoming unsuitable to agriculture. Watershed management in Ethiopian therefore urgently needs improvement and conservation of their natural resource for sustainable development and improving food security (Worku and Tripathi, 2015).

The arid and semi-arid tropics, including Ethiopia are generally characterized by rainfall variability, low productivity, natural resource degradation, climate variability and low development of infrastructure. Large investment made on irrigated agriculture and technological development had little impact on dry areas. Therefore, it is imperative to manage and conserve water and soil resources in order to enhance productivity and improve the wellbeing of people (Wani *et al.*, 2008; WLRC, 2016). The watershed strategy is significant in conserving and managing scarce resources such as land and water to meet growing demand for food. In this context, watershed development programs have become engines of development, especially to reduce poverty, maintain food, fodder and fuel security with sustainable manner for huge population and seen as the lynchpin of rural development in dry regions (Wani *et al.*, 2011).

In Ethiopia, soil and water conservation program started in 1970. However, it achieved limited success due to its failure in addressing the problems of local people. This failure put a question mark on the continuation of watershed and management program in the country. Therefore the project got low priority in subsequent national planning. Reports also revealed that the practices of soil and water conservation project did not involve community participation, improper characterization of watersheds in appropriate application of soil and water conservation techniques, inadequate research support and poor technical understanding of field technicians (Worku and Tripathi, 2015; Amsalu, 2006). Improper characterization of watersheds and poor project planning and implementation is among the major reasons for poor performance of watershed management. Baseline characterization is important to measure project performance before making any changes to project processes. If we do not have baseline data then there is no way to evaluate whether a change is making a difference.

Watershed characterization is used during the project to indicate progress towards the goal and objectives and after the project to measure the amount of change. Despite the objective of an intervention, it is important to start by assessing and describing the current state and trends in the watershed. Biophysical features and resources in the watershed, the socio-economic conditions that determine the livelihoods of the watershed population and the institutions that operate in the watershed are among the date should be included in the survey (FAO, 2017). This allows those involved in the project to understand the initial livelihood, conditions of the people, biophysical of the areas and what needs to be done to reach the

goal of improving the livelihoods of the poor. Thus, baseline characterization builds necessary foundation for the plan and obtains proper information for effective planning, implementation and monitoring. Proper characterization of watersheds is a prerequisite for appropriate policy directions for enhancing productivity and sustainable development. Therefore, the main objective of the study was to characterize the watershed of semiarid rangelands of Bale Zone, southeast Ethiopia and generate the baseline information that could help to assess impact of upcoming interventions in the future.

Material and Methods

Study area

The study was conducted at Dallomana districts in Abdi Guracha watershed of Gomgoma Kebele which is situated 13km away from Dalomana town in the Bale zone of southeastern Ethiopia (Fig 1) where soil erosion, gully formation and loss of rangeland and agricultural lands are a serious problem for production and productivities in this area. It is geographically bounded by Malkaamana, Naniga dhera, Hayaodaa, Chirii, Wabaro, and Barak kebele. Generally having 850 to 112 msl in altitude and covering the total area of 506 ha.

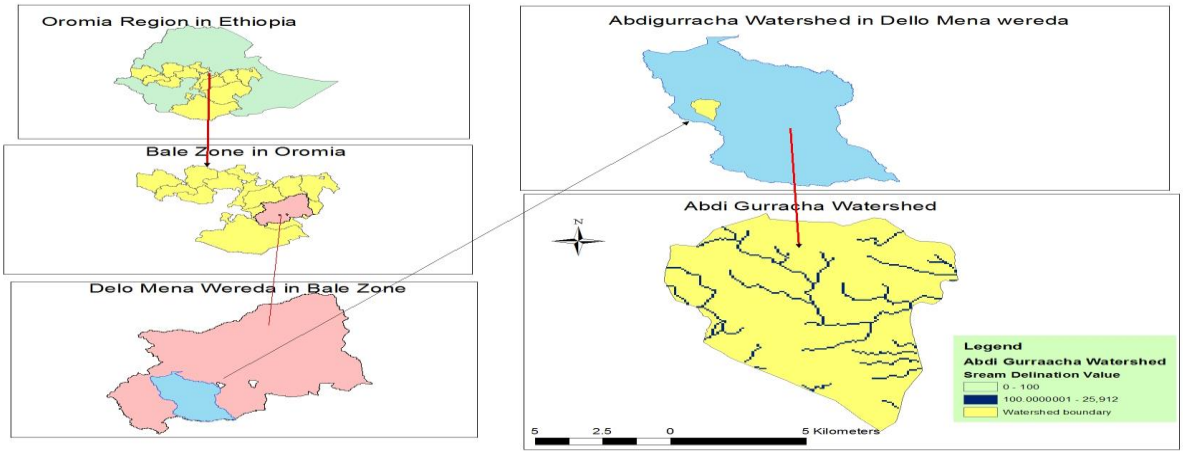

Fig. 1. Map ofAbdi Gurracha Watershed, rangelands in the lowlands of Bale, southeast Ethiopia

Socio-economic characterization

Study design and Sampling procedures

This study was descriptive-survey research design and the study district and the sample peasant association (Gomgoma peasant association) were selected purposively based on the researchers' prior knowledge. There are a total of 1200 (950 Male and 250 Female) household (HH) heads in the sample peasant association (DWAO, 2015). Of the total population of the study area, 20% was taken as an ideal sample of the HHs (Anantha *et al.*, 2010). In order to include both male and female household heads, proportional sampling techniques were used. Individual household head samples were chosen using simple random sampling technique.

Table 1. Sample size of households for the the study

Gender	Household heads No.	Sample size
Male headed	950	$x = \frac{950 \times 240}{1200} = 190$
Female headed	250	$x = \frac{250 \times 240}{1200} = 50$
Total	1200	240

Data Types and Data Collection

Multiple methods of data collection and both primary and secondary sources of data were utilized. The primary data is obtained via field visit, focus group discussion (FGD), and key informant interview (KII) and survey questionnaire. Secondary data were collected from annual reports and published and unpublished literature. The questionnaire was administered in Afan Oromo, the language of local community, and the data were subsequently translated into English. The participants of the FGD were identified, and the time and place of discussion was arranged based on the consensus of the participants. Hence, the participants agreed that the discussion should be held on Sunday because they reason out that other days are working days and market days.

The participants of the discussion were mainly development agents, elders, and women. Twelve FGD were conducted, and the five KIs were drawn among the people with technical expertise and active role community issue. Both structured and unstructured interviews were prepared for the peasant association leaders. Moreover, interview with KI mainly with the head of the district agricultural office and kebele, development agent, female and male community elders were conducted.

Biophysical characterization

Ethiopian Digital Elevation Model (DEM) including the watershed's administrative map, soils data, land use data and the river basin report were collected. Before analyzing the spatial input data, these data were projected into the same projections called UTM Zone 37N in ArcGIS. Then, the watershed was delineated from the Ethiopian DEM, which describes the elevation of any point in a given area at a specific spatial resolution as a digital file. In addition, field visit was conducted to collect different biophysical data. Field visit was conducted before and after satellite image classification activities were performed. First field visit was to understand the biophysical settings of the study area and, important spots were photographed and reference data was generated using handheld GPS. Second visit was to check the classification on the ground and to understand the socio-economic dynamics complemented with interviewing of local elders and other stakeholders. Land use is one of the important spatial data that characterizes the watershed and, in order to make this data more recent and up-to-date, ground truth checks up has been done as well as google earth was used. Furthermore, the relevant physiochemical properties of major soil types were obtained from the FAO digital soil map. Cloud-free satellite images and DEM were acquired from earthexplorer.usgs.gov data portals supported with aerial photos and topographic maps. Data for the vegetation of the study areas were collected from the study watersheds.

Data Analysis

The quantitative data collected through questionnaire based survey were entered into the statistical Package for Social Sciences (SPSS) computer program and analyzed using descriptive statistics based on the objectives of the baseline survey. The qualitative data were analyzed by categorizing in to different thematic areas by discussion of the ideas, opinion, and concepts of data to be collected and narrating each topic separately. For documentation and analytical purposes descriptive statistics (the mean, percentage, totals and frequencies) and cross tabulation techniques were used. Indices (weighted averages) were developed to obtain the aggregate ranking of the major feed resources utilized in the study area and calculated as: Index=sum of [(4×number of responses for 1^{st} rank+3×number of responses for 2^{nd}

rank+2×number of responses for 3rd rank+1× number of responses for 4th)]/(4×total responses for 1st rank+3×total responses for 2nd rank+2×total responses for 3rd rank+1×total responses for 4th rank). In addition, the watershed was delineated from the Ethiopian DEM, the collected data on biophysical characteristics of the watershed was analyzed using simple descriptive statistics, and using software such as ArcGIS 10.3 and ERDAS Imagine 2015 versions.

Results and Discussions

Demographic characteristics

Demographic characteristics of the HHs include sex, age, family size, education status and marital status. Among the sampled HHs interviewed about 88% were male headed while 12% were female headed HHs. Most of the respondents were male and Muslim, as males were the head of the family and strong cultural practice prevented females responding on behalf of the family. If children don't reach for taking the responsibility of leading the HHs and not get children, widowed females forced to lead the HH. In terms of marital status, 92% of the HH heads was married, however; about 1%, 4% and 3% of the HH heads were divorced, widowed and never married, respectively (Fig. 2).

Household size and characteristics are directly related to the supply and demand as well as impact on watershed which in turn direct or indirect influence adopting integrated watershed management and also important in understanding the farming system of given watershed. Mean family size was 9.15±4.64 (±SD) persons/HH. Age is one of the important characteristics of the community work done particularly in agriculture because the use of child labor on the farms is quite high.

Age range was 17–68 years (mean 42.4 ± 8.69) (Table 2). It was observed that HH were actively involved in farming practices and decision making in farm and life matters. Respondents are divided into 3 age groups (i.e. up to 15, 16 to 60, and >60 years of age). The idea behind these classes is that the middle group (16-60 years) is the most productive age group. Table 2 indicated that the distribution of respondents with respect to these age groups. Higher age category within the family were 16-55 which was 3.16 (SD=1.64) (Table 2). This category is economically active with high economic contribution to food security and livelihood efforts at HH level.

Educational level of a HH represents the development of character or mental power which helps them in raising their understanding, and level of acceptance or receptivity to new farming techniques. Education also contributes to decision-making processes that alter the paths people take in life. Table 2 indicated that, the majority of respondents were found between 1-4 grades which cover 38.4% followed by 5-8 grades which cover 26.4%. About 12.3% of the interviewed respondents were illiterates (Table 3). According to CSA (2017), the figure in study area is still better compared to national average rural illiteracy rate (38.2%).

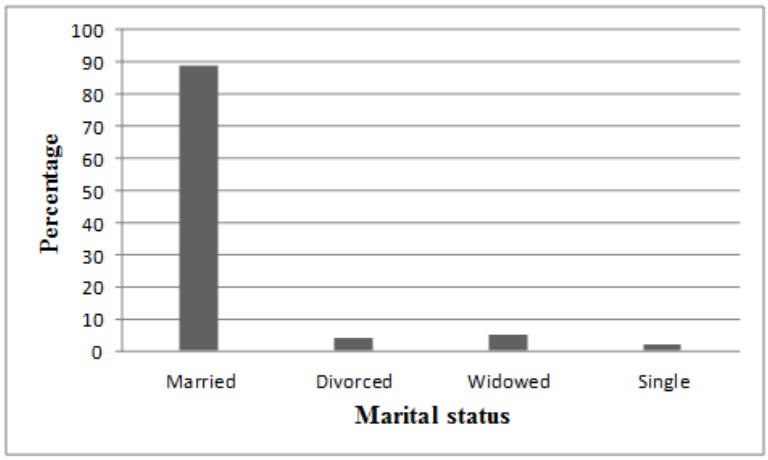

Fig. 2. Marital status of respondents

Table 2. Family size, age and age category of the respondents

Characteristics	Mean	Stand Dev	Min	Max
Total family size	9.15	4.42	0.00	20
Household age	42.4	8.69	17.00	68.00
Age categories				
Persons below 5 yrs	1.92	1.58	2	9
Persons 5-11 yrs	1.89	1.38	4	5
Persons 11-15 yrs	1.9	1.58	2	4
Persons 16-55 yrs	3.16	1.64	2	6
Persons 56-65 yrs	0.23	0.45	1	5
Persons above 65 yrs	0.2	0.58	2	3

Source: Survey data (2018)

Table 3. Education status of the respondents

Education level	Frequency	Percentage
Read and write	4	1.8
First cycle (1-4 grade level)	92	38.4
Second cycle (5-8 grade level)	62	26
High school (9-10 grade level)	29	12
Kuran	23	9.5
Illiterate	30	12.3
Total	240	100

Source: Survey data (2018)

Major economic activities and Sources of income

Table 4 presented the main economic activities and income sources of the respondents. Majority of respondents (71%) involved in both crop and livestock production to earn a living, whereas only 17% of the respondents practices only livestock farming (Table 4). The rest dealt with only crop farming, only livestock farming, or a combination of crop farming with petty trade. Crop and livestock production accounted for more than three quarters of the income sources of the local community. Rangeland degradation related livestock productivity decline and crop based government policy forced pastoralist

to adopt crop production. The number of the pastoralists' engaging in rain fed crop production increasing from time to time.

Table 4 presented the main source of income in the watershed. Sale of livestock and livestock products was the main source of income for pastoralists and agro-pastoralists in the study areas. The dependence on the sale of livestock and livestock product as the main source of income was well documented for other pastoral areas of Ethiopia (Teshome *et al.*, 2010; Mohammed *et al.*, 2018; and the East African countries (Ndikumana *et al.*, 2001). The cash income generated from sale of livestock had a dominant role to settle expenses like purchase of grain and medical services for the members of the family. Pastoralists'' sell small ruminants, dairy products, crops, honey and non-timber products to cover expenses and to meet their immediate cash needs and to settle expense like buying clothes, grain, industrial products for home consumption.

Table 4. Main economic activities and sources of income

Main activities	**Frequency**	**Percentage**
Crop and livestock farming	171	71
Livestock husbandry	40	17
Petty trade	4	2
Crop production	22	9
Wage employment	3	1
Sources of income		
Sale of livestock and livestock products	146	61
Sale of crops	25	10
Honey	47	20
Timber and forest products	5	2
Petty trade	8	3
Wage employment	9	4

Source: Survey data (2018)

Farm characteristics and Land use type

In economic terms, land is the basic factors of production together with capital, labor and management ability. Hence, land is a very useful and critical resource for the any production systems including the pastoral, agro-pastorals and farmers. Mean size of the cultivated land was around 1.52 ha (ha) with maximum size reaches up to 12.6 ha (Table 5). It has been observed that the distance between the farmland and a homestead were one of the factors in land degradation particularly in maintaining soil and water conservation measure and field monitoring. Mean distance of the crop lands from their residence is 0.5 hrs with maximum 1.24 hrs (Table 5). Table 6 presented the category of the fertility status of farm plots. The result of this study indicates that about 40% are categorized as having good fertility status while about 35% and 26% of the plots have poor and good fertility respectively (Table 6). This calls a need for fertility improvement intervention.

Crop production and Productivity of major crops

Table 6 presented major crops grown in the study watershed and their productivity. Major farming system in the study area is mixed farming i.e. crop cultivation and livestock production. Of the total interviewed respondents, about 47% of the area is allocated for grazing while about 36% of the area allocated for crop production (Table 6). Homestead

development in the watershed was very low and only about 8% of the total land area were allocated for homestead development (Table 6). About 48% of interviewed respondents participated in maize production while about 39% of the pastoralists were grown sorghum (Table 6). Crop production system is dominated by cereal crops like barley, sorghum and maize.

Table 5. Farm land characteristics

Land characteristics	Max	Mean	SD
Plot distance from residence (hrs)	1.24	0.5	1.2
Farm size (ha)	12.6	1.52	1.38

Source: Survey data (2018)

Table 6. Plot level characteristics and primary purpose of land

Plot level characteristics	Frequency	Percentage
Plot ownership		
Owned	230	96
Shared in	6	3
Shared out	4	2
Fertility Status		
Poor	83	35
Medium	95	40
Good	62	26
Major crops grown		
Type of crops grown		
Haricot bean	11	5
Sesame	14	6
Maize	116	48
Barley	6	3
Sorghum	93	39
Primary purpose of land		
Homestead development	18	8
Crop production rain fed	86	36
Grazing land	113	47
Forest/ woodland	9	4
Mixed land	14	6

Source: Survey result (2018)

Land is a major determinant of the farm income, and control over land has a strong association with the adoption of new farming techniques. Farm productivity is closely related to the size of the farm (Bagherian *et al.*, 2016). The most common livelihood activity of HHs is agro-pastoral (mix of crop and livestock production). The choice of livelihoods strategies and agro-pastorals' land management practices, and land use methods has impact on health of the watershed in terms of its continued productivity and sustainable with of the livelihood strategies. As indicated in Fig 3, the land types in the watershed ware woodland, bushland, grassland, shrubby grassland, bare land, cultivated and settlement. Bush land and cropland ranked 1st and 2nd types of the land in the study area

while settlement land and shrubby grassland ranked 3rd and 4th ranks (Fig 3).

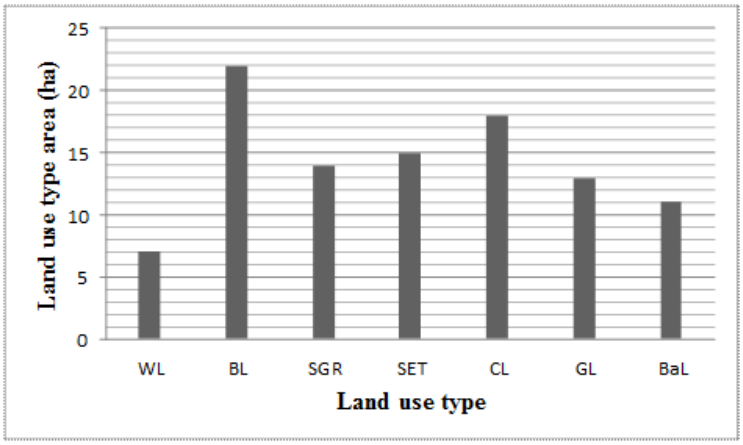

Fig. 3. Land use type characteristic of watershed in hector

Nb: WL woodland, BL bushland, GL grassland, SGR shrubby grassland, BaL bareland, CL cultivation, SET settlement

Table 7 present the crop productivity of the major crops in the study area. The overall average productivity were 5.22 quintals per hectare which is too small compared to the national average 15.6 quintals per hectare (CSA, 2015). The figure obtained in this watershed is higher the figure reported from Bakaye (3.19) and lower than that of Kumbi watershed (8.4). The most likely reasons for low productivity were drought, disease, low input utilization and level of soil degradation that is apparent in most of the watershed.

According to the survey result, crop production was one of the income source at household level. The mean gross income from major crop production was 44.4$ with the maximum and lowest farm income mean was 348.2 and 9.63$ respectively (Tab 7). Table 8 presented the major constraint for crop production in the study area were land drought, the existence of pests, diseases and weeds, land degradation, high price of input, shortage of improved seeds and shortage of land.

Table 7. Average crop productivity and on farm income from major crops in the study area

Crop productivity	Max.	Mean± SD
Average crop productivity/ha	6	5.22±1.07
Farm income from major crops	348.2 $	51.7±9.63$

Source: Survey data (2018)

Table 8. Problem analysis, constraint for crop production in the watershed

Constraint	Rank
Shortage of land	5
Insects, disease, pest's	2
Drought	1
Land degradation	3
Lack of agricultural inputs	4
Shortage of improved crop varieties	7
High price of input	6

Source: Survey data (2018)

Topography of the Watershed

The baseline survey, mapping and delineation results indicated that in watershed covering 506 ha (Fig 4) divided into different sub watershed which help in planning and understanding from which surface runoff potential enters the river or its tributaries and also cause for land degradation as well as gully formation in the area. The effects of topography on land degradation depends on the effects of slope steepens and slope length. Slope was identified from each cell of a raster surface. For percent rise, the range is 0 to essentially infinity. A flat surface is 0 percent, a 45 degree surface is 100 percent, and as the surface becomes more vertical, the percent rise becomes increasingly larger. Wani *et al.* (2003) reported that ground flat slope is important when considering overall transportation of soil particles. The size and shape of the drainage area generally its slope majorly affect runoff rate and velocity. Line feature class of contours was also created from a raster surface. Fig. 4 shows the slope and contour line of the watershed.

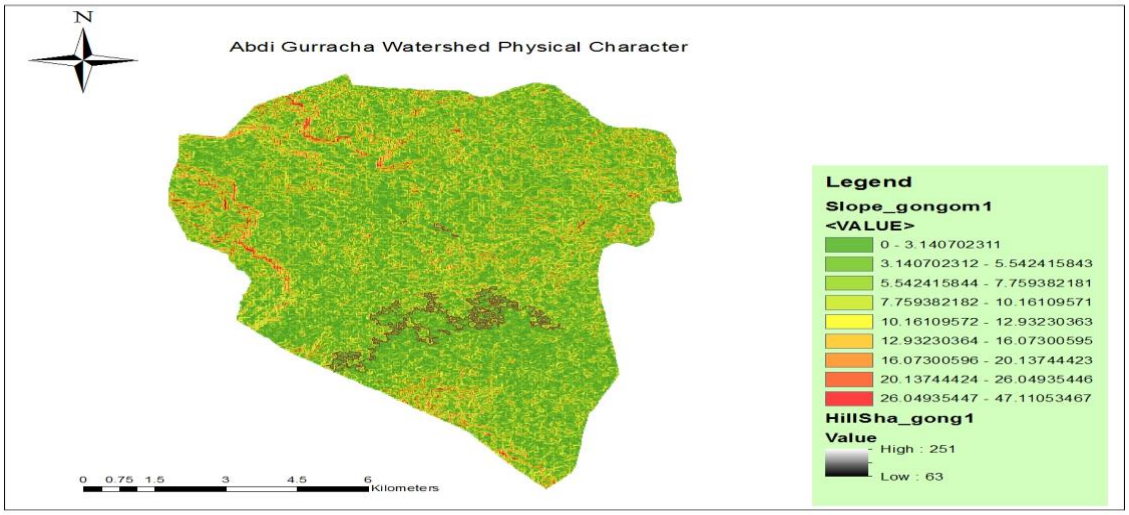

Fig. 4. Physical characteristics of slope class map in the Abdi Guracha watershed of semiarid rangelands southeast Ethiopia

Watershed soil erosion characteristic

Soil erosion is the important data used for the analysis of land degradation analysis. In assessing physical soil degradation, sheet, rill and gully erosion process were considered for analysis. According to Mussa *et al.* (2016) reported that rangeland degradation encompasses the whole environment. The result this study indicated that, soil erosion is regarded as one of the major and most widespread forms of land degradation, which is a severe limitation to sustainable agricultural land use. The results of this study showed that rill erosion cover large portion which is 46.3% and gully erosion which covered 31.3% of soil erosion type occurred and sheet erosion which covered (19.4%). According to Mulugeta *et al.* (2017) report rill erosion is a result of surface runoff and associated sheet wash, which selectively removes fine material and organic matter that are very important determinants of land productivity. In the watershed the gully type was severely increased both in length and density over time. Most gullies were on the woodland dominating landscape and along the natural drainage routes. Therefore, to overcome such problems improved individual responsibility around the issue of soil degradation very important.

Sustainable watershed management

Table 9 presented HHs response on the sustainable watershed management. About 77% of the HH were not participated in the soil and water conservation practices, and

about 55% planted perennial grass/shrubs (Table 9). But, no one participated in the agroforestry practices. We have tried to observe the extent of sustainable land management technologies at the plot from perspectives like mechanical measures, vegetative/biological techniques and agroforestry practices. As the participants of focus group discussion (FGD), and key informant interview (KII) said the practices of soil and watershed conservations are common during the campaigns of the government. But, the motivation of the community to conduct soil and water conservation (SWC) practices on their small plots of land commonly called 'Kalo'' is not common. Therefore, awareness creation should be conducted to the community to conduct the SWC by their own for sustainable improvement of their lands.

Table 9. Plot level sustainable land management practices across watersheds

Sustainable land management practices	Frequency	Percent
Have you made soil and water conservation structures in last 3-5 years?		
Yes	184	77
No	56	33
Have you planted perennial grass/shrubs?		
Yes	134	56
No	106	44
Have you practiced agroforestry practices?		
Yes	0	0
No	240	100

Source: Survey data (2018)

Livestock holding

Cattle, sheep, goat, camel and equines are the common livestock types in the study watersheds. Cattle are kept for draft power, meat, milk and milk products and as a store of wealth. Equines play beneficial roles for HHs as they are used to transport humans, farm products, farm inputs and other services. Similarly, sheep and goat are reared for the sake of meat and as a source of monetary income by selling live animals and eggs. Mean numbers of livestock owned were 12.85 Tropical Livestock Unit (TLU) per household (Table 10).

Table 10. Major farm animals' potential in the watershed

Livestock types	Min	Max	Mean (in no.)	Mean (in TLU)
Cow	4	16	6	6
Ox	1	13	4	2.4
Calf	3	23	2	0.4
Sheep	0	18	13	0.13
Goat	6	50	18	1.62
Camel	0	15	4	2.8
Donkey	0	3	1	0.5
Total				13.85

Source: Survey data (2018)

Livestock feed system

Natural grazing, forest grazing, browse, standing hay and crop residues were the major feed resources for livestock in the study area (Table 11). Grazing was the main form of feed utilisation, and grazing lands were communal and grazed continuously

throughout the year. Natural pasture was available to animals for about 6 months, mainly from Mar-June (main rainy season) and Sep-Oct (short rainy season). All HHs experienced a critical feed shortage during both the short and long dry seasons. Although the availability of crop residues was low, straw from different cereals were fed mainly during the dry season. As most of the land was covered with woody vegetation, trees and shrubs were important sources of livestock feed throughout the year.

Strategies for coping with feed shortages included: migration to high forest areas during the December to February; and has always had excellent dry season grazing in forest/wooded areas. Livestock are moved there to escape the sun/heat particularly in the lowland areas for 3-6 months. However, during the wet season nearly all livestock are moved out of the PA to Berak and Nanega Dheera. Vast grassland mixed with bushes and woodland Wet season grazing, found in Naniga Dheera, on the way to Barak (Hurufa Gogowe) are the important grazing lands for livestock in the watershed.

In addition, vast grazing lands found in Barak such as Dimaa Sole, Qeeramsa, Waqdabar, Qanqana, Hara Golbo, Dhugiicha, Buriirri and Sadeeta are also important grazing lands. Though it is important for cattle to move to the cooler environment of the forest during the dry season, the goats would happily browse around the settlement. However because the two are normally grazed together, the goats are taken with the cattle to the forest. This is usually done by the men (perhaps with one wife) while his (other) wife is left at the homestead looking after young, weak and lactating cows.

Table 12 presents the perception of the respondent on the major constraint for livestock productions. Pair wise ranking methods was employed to assess the main constraints existed in the watershed. Livestock feed shortage, disease, marketing, lack of improved genotype and low animal by product are the common in the study area. It can be concluded that to overcame such problem awareness creation on rangeland restoration, conservation of feed resource, introduction of drought tolerant improved forage technology, introduce improved forages, feed system and management like feed trumping techniques and multiplication improved forage from small to large scale farming for the community is important.

Table 11. Characteristics of respondent on livestock feed system in the watershed

Categories	Frequency	Percent (%)
Source of animal feed		
Natural grazing land	143	60
Forest grazing	61	25
Standing hay (enclosure)	27	11
Crop residue	9	4
Feel enough animal feed		
I believe that feed is enough	229	95
I believe that feed is not enough	11	5
Feed shortage season		
Dry season	84	35
Wet season	126	52
All year	30	13
Reason for animal feed shortage		
Population growth	63	26
Degradation of grazing land	122	51
Agricultural expansion	8	3
Drought	34	14
Agricultural expansion	13	5

Source: Survey data (2018)

Table 12. Constraints of livestock production

Constraints	**Rank**
Livestock feed shortage	1
Disease	2
Water	3
Marketing	5
Lack of improved genotype	4

Source: Survey data (2018)

Causes of rangeland degradation

Majority of the respondents (97%) perceived the presence of the rangeland degradation (Table 14). Table 13 presented responsible factors for degradation of rangelands. Majority of the respondents (83%) ranked climate related factors firs among drivers of rangeland degradation. According to focus group discussion (FGD), and key informant interview (KII) participants, climate-related factors explained in terms of increased temperature, recurrent drought, and rainfall variability. Bush encroachment and crop encroachment took the second and third ranks. Overgrazing, overutilization, population increase, disease and inappropriate government policies took the fourth, fifth, sixth, seventh and eighth rank respectively. The discussion with FGD and KII also suggested that rainfall and water resources have reduced over time due to climate change and temperatures increased. Further, several respondents commented that they are now experiencing drought on a regular basis particularly in the lowland areas. The FGD discussion and KII interview suggested that rainfall and water resources have reduced over time due to climate change and increased temperatures.

Table 13. Causes of rangeland degradation and biodiversity loss in the study area

Causes of rangeland degradation	Rank
Climate change	1
Disease	7
Bush encroachment	2
Crop encroachment	3
Inappropriate government policies	8
Overgrazing	4
Population increase	6
Overutilization	5

Source: Survey data (2018)

Table 14. Perception and awareness of rangeland degradation and institutions in the study areas (out of 240 respondance)

Categories	Frequency	Percentage
Do you think there is degradation of rangeland resources?	233	97
Would you say you face biodiversity depletion?	220	92
Are you aware of any Policy or Act dealing with grazing resources management?	9	4
Are you aware of any project dealing with grazing resources management?	182	75.8
Are you aware of any Government or NGO institution dealing with grazing issues in your village?	229	95
Are you aware of any local institution dealing with grazing in your village?	11	5
Are you aware of any Policy or Act dealing with biodiversity conservation?	18	7.5
Are you aware of any project dealing with biodiversity conservation?	6	2.5
Are you aware of any local institution dealing with biodiversity management in your village?	12	5
Are you aware of any Government or NGO institution dealing with biodiversity issues in your village?	3	1.3

Source: Survey data (2018)

Impact of rangeland degradation

Table 15 presented the impact of rangeland degradation. Biodiversity loss, decline of livestock per household, low performance of livestock, livelihood income diversification, conflict on resources and change in livestock composition are the major impacts of rangeland degradation (Table 15). Majority of respondents ranked biodiversity loss first among the impacts of rangeland degradation. Drought, over-harvesting and overgrazing are among the major factors responsible for biodiversity losses raised by the participants from FGD and KII. The participants mentioned the importance of the biodiversity in their livelihoods.

The vegetation cover plays great contribution in interception of the rainfall, keeping sediment loss and managing soil fertility (WLRC, 2016; Mussa *et al.*, 2017). Herbaceous species such as *Arisida vestita, Aristida adscensionis, Cyprus obtusiflorus, Themeda triandra, Sporobuls pyramidalis, Setaria verticillata, Setaria incrassate, Panicum maximum and Crotolaria incana* were among the common species reported during discussion. In addition, the discussion with FGD and KII shows the presence of the

Acacia bussie, Acacia seyal, Acacia tortilis Acacia nilotica Calotropis procera, Commiphora species, Grewia species, Phyllanthus sepialis and other shrubs. However, most of the indigenous trees are exposed to deforestation for firewood, charcoal making, construction and agricultural expansion. According FAO (2011), globally around 13 million hectors of forest were converted to other uses or loss through natural as well as anthropogenic activities that cause reeducation in forest area coverage and indigenous species.

Rangeland degradation leads to the decline of livestock per household, and the increase in human population and encroachment of crop lands to feed increasing human population forced the community to decrease the livestock per household (Mussa *et al.*, 2017). Livestock grazing on a very poor/degraded rangelands result in low productivity of the livestock. The result of this study is in line with the study conducted in pastoral areas of Ethiopia (Abate *et al.*, 2010; Mussa *et al.*, 2017). Compositions of livestock in the lowlands of the Bale zone are changing their livestock composition to adapt or use the advantage of the changed rangeland vegetation composition. Previous cattle herder are showing complete shift from dependence on grazer to the browsers such as goats and camels.

Table 15. Impact of rangeland degradation as ranked by respondents in the study area

Impacts	Frequency	Percentage (%)
Biodiversity loss	133	55.5
Decline of livestock per household	40	16.5
Low performance of livestock	22	9
Livelihood income diversification	19	**8**
Conflict on resources	18	7.5
Change in livestock composition	8	3.5
Total	240	100

About 91.7% of the interviewed HHs showed presence of high biodiversity depletion. They were not aware of any local communities were aware of the policy dealing with biodiversity conservation especially in the high forest areas, but not practiced in their areas. In contrast to the policy dealing with the biodiversity conservation, they were not aware of any policy dealing with grazing resources management. However, the local government practicing bush encroachments control as one of the strategies for managing rangeland resources. Establishing local institutions working on rangeland management is very crucial. NGO helps are requested by the local communities to complement the work of the governments limited with the resources. Almost all of the local community reported the lack of any NGO institution and project dealing with biodiversity conservation in the watershed. There is also no any local institution dealing with biodiversity management in the watershed.

Alternative income sources

In the watershed, livestock production is a reliable occupation, and livestock is the source of their livelihoods and source of self-reliance. The result indicates that livestock production was an important source of cash to enhance the income of pastoral HHs compared to income from crop production. Total mean annual gross income from livestock production is 71$ per HH and the average maximum gross income is 673$. Like other pastoral communities in Ethiopia, beekeeping is

integral agricultural activities practiced in the area and contributes as a source of income for the household.

In the study area, only 1.7% of HHs were used beekeeping as a source of income. However, it could serve as a tool to combat the problem of food insecurity since it is less affected by drought than other agricultural activities. It could also create means of income and job opportunities to the landless youngsters due to shortage of the land. Therefore, by providing intensive training in beekeeping with intensive supervision, it would be possible to increase honey production and increase income of the poor pastoral community. Thus, livestock production source of income but as source of food and manure for soil fertility management practices. On the other hand, the major challenges related to livestock include shortage of fodder, expansion of farm land, and shortage of water and lack of adequate veterinary service.

Alternative Livelihood Options

In the watershed, HHs diversified their income source by engaging in agricultural and non-agricultural income generating activities. The most common agricultural sources of income are sales of crops, livestock products, land rent, etc. The non-agricultural sources include income from non/off-farm income activities, and other such as gift and remittance. Thus, the annual income of the sample HHs has been estimated using the cash income of the HHs received. About 77.6%, 16.3%, 15% and 2.3% of the HHs have generated their alternative livelihood options from selling of livestock trading, selling of honey, petty trade and remittance respectively. Regarding the status of their alternative livelihood, about 36.8% of the HHs annual income from sealing honey and fattening cattle has improved whereas about 63.2 of the HHs annual income were not improved. However, the survey result indicated that most of the income generated activity in the watersheds agreed that their annual income has not improved.

Access to infrastructure and services

The success of either micro or macro watershed development is highly dependent on the availability, accessibility and functionality of the institutions, infrastructure and services at the village level. They play a significant role in the proper implementation and sustainability of the watersheds at village level. Moreover, access to infrastructure and services play a key role in the effort to combat poverty. Here we assess the basic infrastructure and social services such as access to extension services, health services, access to markets, access to credit and access to transport and access to water.

The effectiveness of the different agricultural inputs, soil and water conservation activities and other production improvement technologies are highly dependent on the availability of sound agricultural extension services. Agricultural extension service played a vital role in assisting pastoralists to identify and analyze their production problems and make them aware of opportunities for improvement. Table 16 presents the service pastoralists have received from agricultural development agents. About 50%, 24%, 11% and 5% of the sampled households got good, very poor, poor and very good services from the agricultural extension respectively.

Table 16 presented the quality of the health services in study watershed. The result of study indicated the presence of poor health services to the human and their livestock and the level of satisfaction of the HHs about the availability of health service is poor. Generally, there is a need to improve these services. Access to roads and transport is an important service for the economic development of rural areas. It helps for distribution and dissemination of technology, selling and purchasing of farm inputs and products. On the other hand, poor

access to road and transport networks impede the efforts of individuals, governmental and non-governmental organization to participate in the development process. The road network has not yet well developed in the watershed. There is only one main roads running from Dalomana to Maddawalabu, and the result from FGD and KIIs indicated that the average distance to the main road is about 1.2 hours with the maximum distance up to 1.6 hours.

Table 16. Access to infrastructure

Access to infrastructure	Frequency	Percent
How do you evaluate access to infrastructure?		
Very poor	50	21
Poor	38	16
Good	101	42
Very good	39	16
Excellent	12	5
How do you evaluate the access to agricultural extension services?		
Very poor	58	24
Poor	26	11
Good	120	50
Very good	25	10
Excellent	12	5
How do you evaluate the access to livestock health service?		
Very poor	48	20
Poor	77	32
Good	67	28
Very good	31	13
Excellent	17	7
How do you rate the service from human health centers?		
Very poor	67	28
Poor	98	41
Good	46	19
Very good	24	10
Excellent	5	2

Source: Survey data (2018)

Food security and Shocks

In terms of access to rural credit services, about 87% of the HHs received loans in the past years and out of the credit beneficiaries, 70.4% of the total HHs received loan from neighbors. About 8.5% of the HHs d received loan from relatives/friends and local money lenders (Table 17). The type of credit the communities often receive is in the form of cash, without any collateral obligation. High interest rate and group members' failure to pay their credit are among the stated problems related to access to loan. Traditional saving has key roles among the community and only about 5% of the HHs receives a loan from government (Table 17).

The study watershed are located in one of the food insecure kebeles of the woreda and about 62% the sampled HHs experienced food shortage (Table 17). Livelihood status of the interviewed HHs classified as worst (22.5%) and somewhat bad (48.3%), and only 1.2% of the HHs livelihood status were fine (Table 17). Drought, unreliable income,

and poor harvest are the major reason the food problem. The major coping strategies used by families include borrowed money, relied on neighbors, relied on family to send money, government support and selling livestock.

Table 167. Livelihood status of households across study watersheds

Categories	Frequency	Percentage
Have you taken loan in the past?		
Yes	209	87
No	31	13
Access to credit		
Neighbor farmers	169	70.4
NGO	36	15
Government	5	2
Relatives	18	7.5
Cooperatives	12	5
Food shortage and shocks		
No	91	38
Yes	149	62
Livelihood status		
Worst	54	22.5
Somewhat bad	116	48.3
Average	67	28
Fine	3	1.2

Source: Survey data (2018)

Conclusions and Recommendations

Characterization of rangeland watersheds in semi-arid rangelands of southeast Ethiopia were conducted in 2018 and 2019. Both the crop and livestock production and livestock production ware the main activities to earn a living. Respondents ranked sale of livestock and livestock products, sale of honey and sale of crops as the main source of income. The pastoral and agro-pastoral in the watershed mainly depends on the production of livestock as their main livelihood because of the suitability of the area for the production of livestock. Drought, the existence of pests, diseases and weeds, land degradation, high price of input, shortage of improved seeds and shortage of land were a major constraint for crop production. Livestock feed shortage, disease, marketing, lack of improved genotype and low animal by product are the major constraint for livestock productions. Drought, bush encroachment, crop encroachment, overgrazing, overutilization, population increase, disease and inappropriate government policies were the main factors for degradation of rangelands. To overcome such problem awareness creation on rangeland restoration, conservation of feed resource, introduction of drought tolerant improved forage technology, introduce improved forages, feed system and management like feed trumping techniques and multiplication improved forage from small to large scale farming for the community is important. Land degradation together with poverty is the most serious problem. Since the well-being of the population is highly interrelated to natural resources it has to be managed properly in a sustainable way. Hence, watershed based interventions should be conducted to improve the management and restoration of degraded landscapes through harmonized

and inclusive ways. Community in the watershed and natural resources management faces interlinked complex problems, implying the importance of integrating different approaches to address the problems in the watershed and improving the livelihood of the community. Thus, integrated watershed management program should be implemented to address different problems so that both natural resources and livelihood of the local community can be optimized.

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References

Amsalu, A. 2006. Best Practices in Soil and Water Conservation in Beressa Watershed, Highlands of Ethiopia. Ph.D. Thesis, Wageningen Agricultural University, Wageningen.

Anantha, K.H., Suhas, P.W., Sreedevi, T.K. 2010. Baseline Socio-economic Characterization of Watersheds. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Bagherian, R., Goodarzi, M., Shadfar, S. 2011. Relationship between attitude toward watershed management programs and level of participation. Middle-East Journal of Scientific Res., 9(3): 324-329.

FAO. 2011. The state of the world's land and water resources for food and agriculture – managing systems at risk. Rome & London, FAO & Earthscan.

FAO. 2017. Watershed management in action – lessons learned from FAO field projects. Rome.

Mohammed, M., Habtamu, T., Ahimed, A. 2018. Socio-economic and environmental impacts of invasive plant species in selected districts of Bale Zone, Southeastern Ethiopia. Afr. J. Agric. Res. 13(14): 673-681.

Mulugeta, E., Shure, S., Falmata, G. 2017. Assessment, Resources Characterization and Mapping of Ilasa Watershed in the Case of Goba Distinct in Highland of Bale Zone, Southeastern Ethiopia. American-Eurasian J. Agric. & Environ. Sci., 17 (6):499-513.

Teshome, A., Abule, E., Lisanework, N. 2010. Traditional rangeland resource utilisation practices and pastoralists' perceptions on land degradation in south-east Ethiopia. Tropical Grasslands, 44(2010):202–212.

Wani, S.P., Anantha, K.H., Sreedevi, T.K., Sudi, R., Singh, S.N., D'Souza, M. 2011. Assessing the environmental benefts of watershed development: Evidence from the Indian semi-arid tropics'. Journal of Sustainable Watershed Science & Management, 1(1):10–20.

Wani, S.P., Joshi, P.K., Raju, K.V., Sreedevi, T.K., Wilson, M.J., Shah, A., Diwakar, P.G., Palanisami, S., Marimuthu, A.K., Ramakrishna, Y.S., Sundaram, M.S., D'Souza, M. 2008. Community watershed as a growth engine for development of dryland areas. A comprehensive assessment of watershed programs in India, Andhra Pradesh, India. International Crops Research Institute for the Semi-Arid Tropics, Global Theme on Agro-ecosystems, Open File Report 47.

Wani, S. P., Maglinao, A.R., Ramakrishna, A., Rego, T.J. 2003. Integrated Watershed Management for Land and Water Conservation and Sustainable Agricultural Production in Asia. Proceedings of the ADB-ICRISAT-IWMI Annual Project Review and Planning Meeting, Hanoi, Vietnam, 10-14 December 2001. ICRISAT, Patancheru andhra Pradesh, pp: 268.

Water and Land Resource Centre (WLRC). 2016. BER Eco-Region Degradation Hotspots. Water and Land Resource Centre, Addis Ababa University, Addis Ababa.

Worku, T., Tripathi, S.K. 2015. Watershed Management in Highlands of Ethiopia: A Review. Open Access Library Journal, 2: e1481. http://dx.doi.org/10.4236/oalib.1101481.