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Identification, Prioritization and Mapping of Major Constraints and Potentials in the Medo Watershed the Case of West Arsi District in Central Rift Valley Area of Ethiopia

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ABSTRACT

The concentration to characterize the biophysical and socio-economic features in the integrated watersheds is to identify and prioritize production constraints for designing appropriate research and development interventions. The objective of this study was to assess the current biophysical of characteristics of Medo watershed, West Arsi Zone of Oromia, Ethiopia. To do so relevant data and tools were used; ArcGIS, Microsoft Excel sheet and fundamental formulae were applied for the analysis are some. The results of the study indicated that the major land use types in the watershed are agricultural land covering 50%, vegetation (shrubs, forests and, plantations) covering 24% and settlement covering 16% out of the total land use. Slope gradient of Medo watershed ranges from zero to more than 20 and the slope gradient of 2-5 and 5-10 cover the greatest in area coverage representing 201 ha and 170 ha respectively. We can also observe that about 8% out of the total area is subjected to severe erosion. Sandy clay loam was the dominant soil textural classes in the surface soils and Phaeozems, Retinols and Andosols are the dominant soil types, which cover 57%, 36% and 7% of the sub-watershed area for lower, middle, and upper slope positions, respectively. Mean annual rainfall of the area ranges from 960.09 mm at lower part of the watershed to the 1304.93 mm at upper part of the watershed. Accordingly, Medo sub-watershed is laid in majority of at sub humid agro ecological zone. An assessment of the trees within the landscape of watershed showed some remnant natural forests and a wide variety of shrubby vegetation is encountered at all landscapes. About 40 percent of the watershed, is under high to extremely severe soil loss values (>45 ton per hectare per year). The baseline study also identified that those natural resources degradation such as land, and or/ soil fertility, reduction, and recent changes in the areas' weather condition in line of climate change prevailing in current years are few of the many factors that are contributing to the land and crop productivity reductions in the area. Therefore, prioritizing the identified problem and preparing intervention of different technologies and development plans to solve the problems by taking into consideration the existing opportunities of the watershed.

INTRODUCTION

Land degradation reduces the production potential of land and the overall utility of land resources, thus making it unsustainable to produce enough food, feed, and fiber crops for the growing population in the country. In a nutshell natural resource degradation, in any form, in Ethiopia has direct impact on water resources, livestock and crop production and productivity, unemployment and rural-urban migration, incidence of drought and ultimately on food security (Desta *et al.*, 2005). To address the problem of natural resource degradation in the country, government and non-governmental organizations have introduced different conservation measures since the 1970's famine. However, due to the poor consultation and participation of local people in the planning and implementation of the practices, shortage of skilled human power and lack of state-of- the- art scientific approach, the natural resource management efforts were not as effective as desired to bring fundamental change. (Bewket, W., 2003; Lemenih, M.; 2004; Gebremedhin, *et al.*, 2003).

Learning Watershed as a framework approach consists different harmonizing approaches and a series of procedures at different stages of implementation (Carol M, 1996). Baseline characterization helps understand the initial livelihood condition of the people in the watershed before intervention. It builds necessary foundation for the plan and obtains proper information for effective planning, implementation, and monitoring (Bonsa *et al.*, 2020). The watershed's general biophysical characteristics are groups of features that distinguishes one watershed from others. These groups of features or biophysical characteristics are very important inputs or elements whenever one needs to study about watershed's resources availability, utilization and management (Amanuel *et al.*, 2011).

Some impact studies have showed that investments in watershed management in the developing world do pay off in economic terms. However, such impact studies do not typically include detailed biophysical and socio-economical components (Sisay *et al.*, 2019). Similarly, watersheds management in West Arsi including Medo watershed has got attention for more physical interventions to restore degraded lands and improve livelihood benefits, and biophysical characteristics of the watershed was not assessed. Because of this, a detail biophysical and socio-economic characteristics of the watershed must be known for accurate planning to solve problems. Therefore, the

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analysis from biophysical and socioeconomic information in the watershed helps prioritize the problems with their appropriate management options and technologies which in turn leading to the implementation phase to make all the community in the watershed benefited from watershed management. Therefore, the study was aimed to assessment biophysical characteristics to identify constraints, opportunities, and document the baseline information for appropriate watershed management which is also used as benchmark for impact monitoring.

MATERIALS AND METHODS

Description of the Medo Watershed

Medo learning watershed is in Wendo district of the West Arsi Zone of Oromia Regional State, Ethiopia. It covers an area of 504 hectare and the Medo sub watershed is one of the main streams draining into Rift valley basins. The area is located around 12 kilometers northeast of Shashemane town and 250 km south of Addis Ababa. Geographically, located between 38°35'E - 38°38'E longitude and 7°05'N - 7°06'N, latitude (Fig. 1). Medo watershed, which belongs to the sub watershed, is a main tributary to Lake Hawassa catchment at the low-lying areas outlet that is partially found in the central rift valley of Ethiopia

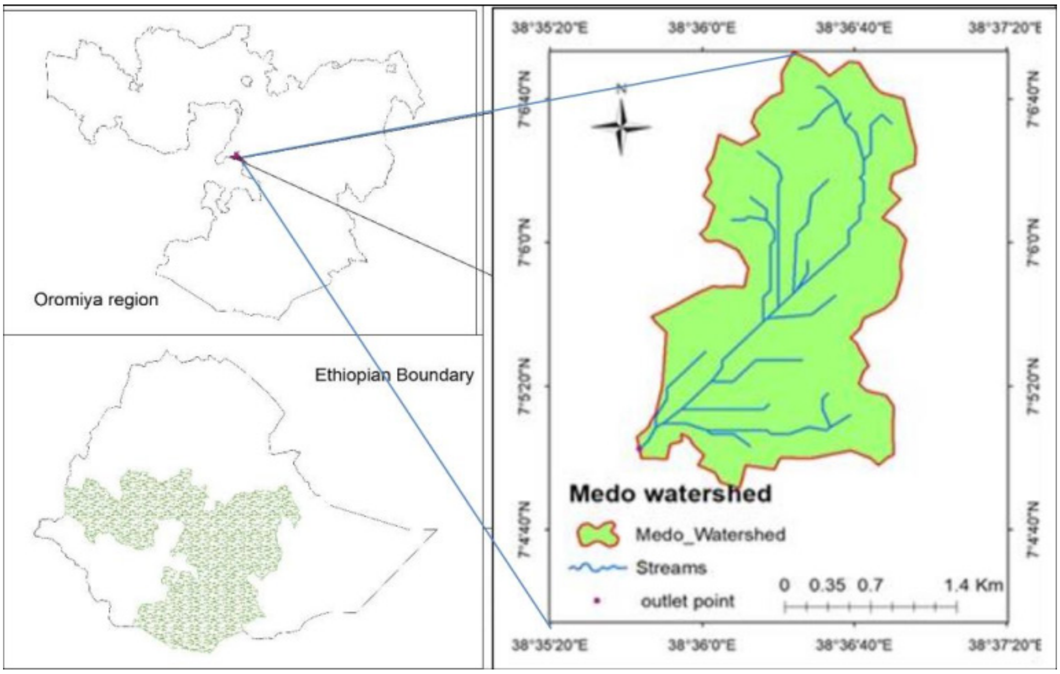

Figure 1: Location map of Medo watershed

Data Collection and Analysis

Watershed Delineation and Topographic Mapping

Reconnaissance survey was conducted to select a learning watershed in collaboration with different stakeholders. Based on the preliminary outlet identified during the site selection process, the watershed boundary was delineated using ArcGIS environment. The topographical map of delineated watershed was geo-referenced and digitized for its contour, roads, rivers, and other features. The preliminary delineated boundaries were verified in the field using GPS and establish reference benchmarks for future operations. Finally, elevation ranges, area, slopes, and aspect related information of the watershed were extracted using the Digital Elevation Model of 30 meters resolutions at htt ps://earthexplorer.usgs.gov/ website. The spatial input data were projected into the same projection's unit (UTM Zone 37N) before analysis. ArcGIS program was used to analyze the watershed characteristics.

Biophysical Resource Survey

Biophysical characterization was conducted to identify detail information about topography and landforms, present land use, soils erosion status, vegetation, climate, and water resources. It was supported by remote sensing technology, especially with the availability of high spatial and temporal resolution satellite data and aided with Geographic Information System (GIS) tools and hydrological modeling. Using these biophysical information and feedback obtained from farmers and other stakeholders' constraints and opportunities were identified and prioritized for intervention planning.

Land Use/Land Cover and Topography

Many spatial data were produced using a global positioning system (GPS) with a positional error of ±3 m from DEM and satellite images. These Landsat images of the study area were freely downloaded from htt ps:// earthexplorer.usgs.gov/. Landsat imagery was used to generate LULC datasets. A maximum likelihood classifier was used in a supervised classification procedure to classify the images independently in ERDAS Imagine 15 software. To assess the accuracy of image classification, reference data points were used to ensure that all four LULC classes were adequately represented based on their proportional area. The land use land cover map generated with ArcGIS environment was cross-checked and verified by field observation and knowledge of the elderly as well as Google Earth. Digital Elevation Model (DEM) was used to analyze topographic characteristics (elevation, slope class) of the watershed using ArcGIS.

Soil Sample Collection

The soil of the watershed was characterized in two stages. First, reconnaissance survey was conducted with the participation of the local community, in which local soil classes was identified. Soil samples were taken from every systematically selected georeferenced sampling points across the slope. Profile was opened for each locally identified soil class and pre-identified sampling points. The newly opened representative soil profiles and horizons were described and designated according to guidelines of soil description (FAO, 2006). On standard soil site and soil profile description sheets, all key morphological and physical parameters, as well as other pertinent information, were documented at field.

Climatic Data Collection

30 years seasonal climate (mean annual rainfall, minimum and maximum temperatures) were obtained from the National Meteorological Agency (NMA). For the nearest weather stations located around the watershed.

Methods of Data Analysis

Soil Classification

The soils of the study area were finally classified into different units based on morphological, physical, and chemical properties, according to the (FAO, 2006) classification system.

Table 1: Data sources and analysis tools

S/N	Input data types	Sources	Analysis tools for
1	Climate data (RF data of stations)	NMAE	ArcGIS, Ms.xls
2	Soil Data (Field soil sample collection)	Survey	ArcGIS
3	DEM-30	SRTM, MoWIE	ArcGIS
4	Satellite Images (Landsat LDCM 2020)	USGS webpage	ERDAS (RS) & ArcGIS
5	Field data	Observations, discussion, survey by GPS	ArcGIS, Google- earth, ERDAS(RS), Mussel color chart, camera
6	Demographic, physiographic, soil, hydrologic and farming system related secondary data)	CSA, MoWIE, Woreda offices, Review Lt.	Tabular & narrative descriptions using Ms Excel, Word

RESULTS AND DISCUSSION

Biophysical Resources Assessment of Medo Watershed

Classification of the Soils According to WRB

The soils of the study area were finally classified into different units based on morphological, physical, and chemical properties, according to the studied soils were classified; according to World Reference Base Legend IUSS Working Group (WRB, 2014) classification system. According to the WRB soil classification system, three soil types are identified in the Medo watershed. Therefore, the

Table 2: Medo watershed soil type based up on (FAO/WRB, 2014) classification system

Profile	Soil unit	Soil types	Local names	(%) of watershed
Upper	Vitric Andosol	Andosols	Dima	7
Middle	Leptic Retisols	Retisols	Guaracha	36
Lower	Cambic Phaeozems	Phaeozems	Guaracha	57
Total				**100**

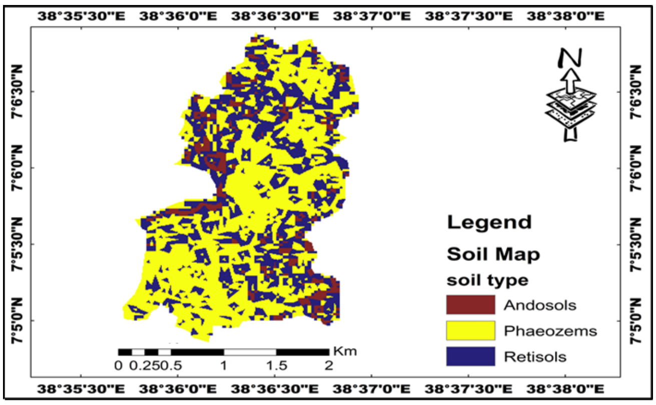

Figure 2: Soil map of the Medo watershed

studied soils were classified as Vitric Andosols (Arenic), Leptic Retisols (Arenic) and Cambic Phaeozems (Aric) for upper, middle, and lower slope positions, respectively. Phaeozems, Retisols and Andosols are the dominant soil types which cover 57%, 36% and 7% of, respectively.

Topographic Assessment of Medo Watershed

The altitude of Medo watershed ranges from 1700 to 2100 meters above sea level and therefore itis characterized by undulating topography (valleys) and plateaus (flat highlands) respectively.

Based on steepness of slope and slope length. Slope gradient of Medo watershed ranges from 0 to more than 20 percent and the slope gradient of 2-5 and 5-10 cover the greatest in area coverage of 201 ha and 170 ha, respectively (table 6). We can also observe that about 8% out of the total area is subjected to severe erosion, which are not suitable for agriculture (FAO, 2006). This indicate that more of the watershed landscape might be exposed to extreme flooding at time of high rain fall occurrences which implies that the need of soil and water conservation structures for sound and sustainable natural resources use in the area. This is agreed with the findings of stating (Betteridge, *et al.*, 1999) that the slope configuration provides few depositional sites within the hill slope.

Table 3: Medo watershed slope class based up on FAO classification system (FAO, 2006)

No	**Slope class**	**Description**	**Area (ha)**	**Area (%)**
1	0-5	Flat	201	39.49
2	5-10	Gentle	170	33.40
3	10-15	Moderate	96	18.86
4	15-20	Steep	37	7.27
5	>20	Extremely steep	5	0.98
Total			**509**	**100**

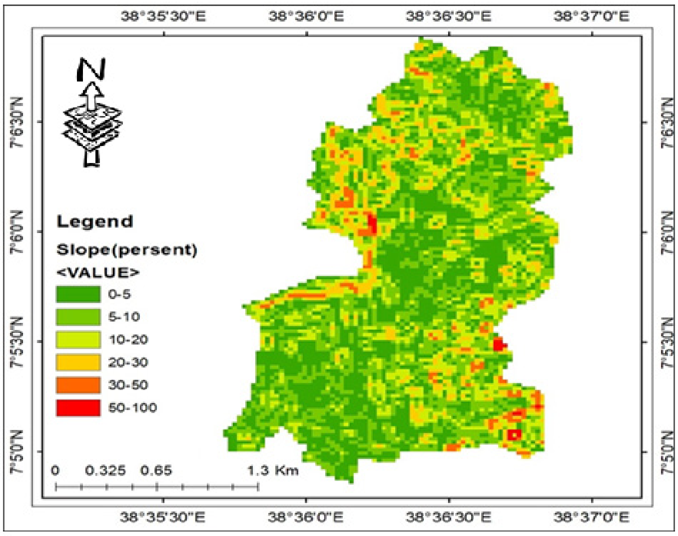

Figure 3: Slope map of the Medo watershed

Climate and Agroecology Characteristics Medo Watershed

Mean annual rainfall of the area ranges from 960.09 mm at lower part of the watershed to the 1304.93 mm at upper part of the watershed, with the average annual rainfall of 1126.67 mm. Rainfall pattern of the area is bimodal type. The short rainy season occurs from February to May, and the long rains extend from June to September. The mean

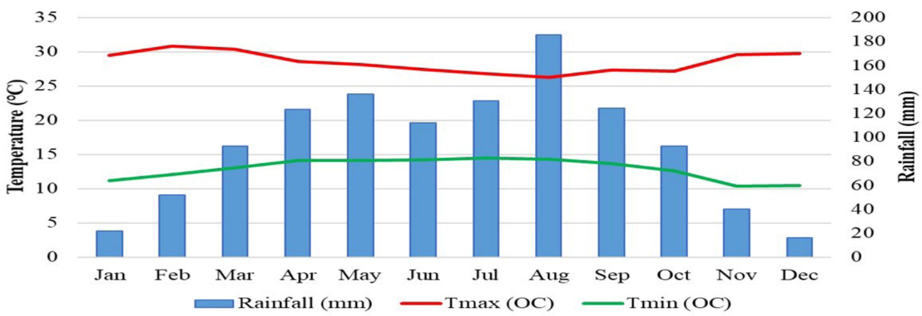

Figure 4: Observed monthly mean rainfall, maximum and minimum temperatures of medo watershed (1985-2015)

maximum temperature varies from 26.30°C to 30.82°C while the mean minimum temperature varies from 10.4°C to 14.5°C, with the average temperature of 21.2°C (Table 6). Sub humid is region with an optimum temperature from 1500-2500 m above sea level altitude. Accordingly, Medo sub-watershed is la id in majority of at sub humid agro ecological zone.

Survey result revealed that about 58% of the households have responded that there is a decreasing and irregularity in rainfall and about 20% of the households reacted that there is the emergence of animal and plant disease. Additionally, the increase in temperature and decrease in river flow and springs during the last 10 years were perceived by informal survey in the watershed (Figure 5).

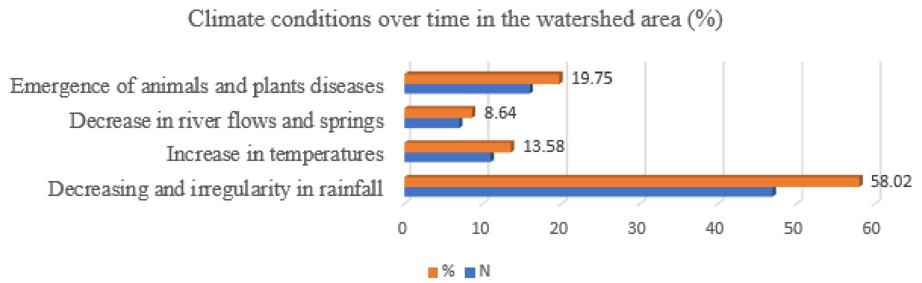

Figure 5: Climate conditions over time in the watershed area

Land Use/Land Cover of Medo Watershed

From the analysis of LULC in ArcGIS, there are five major types of land uses identified and reclassified in the watershed. As shown in Figures 4 and 5, the major land use types in the watershed are agricultural land covering 50%, vegetation (shrubs, plantation, and natural forest) covering 24% and settlement covering 16% out of the total land use. The remaining land use types grazing land

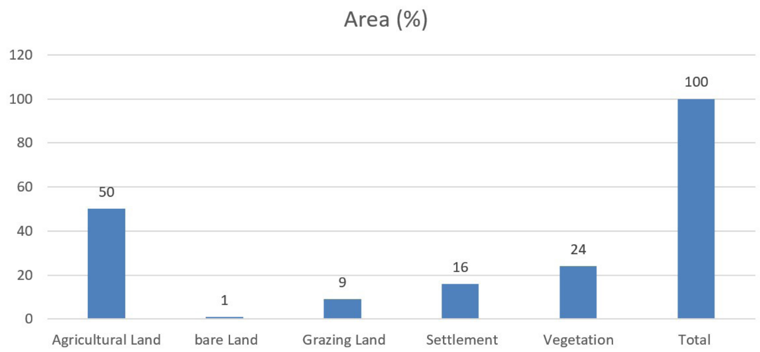

Figure 6: Land use types and percent coverage of Medo Watershed

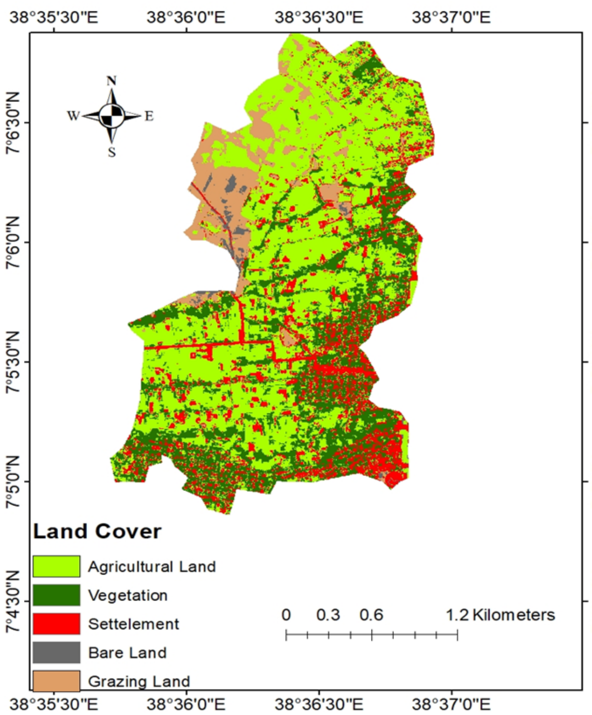

Figure 7: Land use/ cover Map of Medo Watershed

and bare land are covered at 9% and 1%, respectively. Maize, wheat, haricot bean, potato and teff, sugarcane, coffee, and khat are the dominant crops grown in the study area. Croplands are expanding at the expense of grazing and vegetation lands and the bordering lands between the farmlands are becoming very narrow. After the crop products are collected the ground will be left bare and then exposed to erosion, since there is no habit of integrating perennial cash crops with these cereal crops. Away from the outlet, the vegetation cover varies from closed dry thicket to open shrub land, and further to grassy plains. Small-scale eucalyptus stands near settlements and at agricultural field edges. Cropping schedules are twice annually in that it is between February – April and July – September. Moreover, different types of irrigated agriculture have been practiced in the lower part of the watershed. Potato and perennial crops are the dominant crops grown in the study area which dominantly use the supplementary irrigation water. Enset (Enset ventricosum) is a staple, perennial crop, which is dominantly grown at homestead.

Soil Erosion and Conservation Measures Status

Soil erosion in almost all the survey area showed visible signs of sheet erosion and active rill erosion. Many rills that have prominent role in the development of gullies were observed in the watershed. Accordingly, two big gullies and other small gullies were formed because of water erosion in the watershed. According to the rangeland health and pasture condition (2003) scoring models,

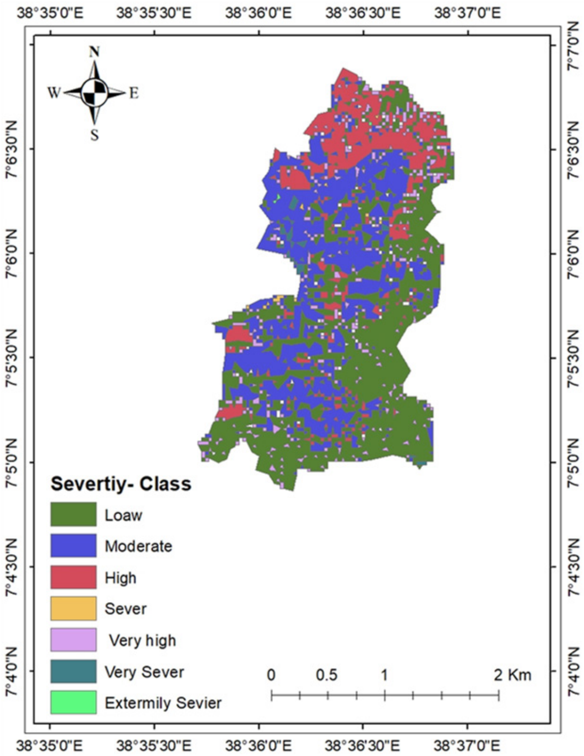

Figure 8: Soil erosion assessment of medo watershed and conservation priority class

Reduction of vegetative cover causes increased surface runoff and often leads to accelerated erosion. Rills and gullies develop, followed by larger flow concentrations. Runoff is closely linked to chemical and nutrient and contaminant transport. It can also be a sensitive indicator of ecosystem change. Plant community types and the character of vegetative cover are one of the factors that determine the rate and areal distribution of runoff from a watershed. For every watershed and site within the watershed, there exists a critical point of deterioration resulting from surface erosion. However, only very few farms have established structural soil and water conservation measures. The high presence of soil erosion and the low numbers of soil and water conservation measures should be one of the key-entry points in this

Table 4: Soil erosion severity and conservation priority class (Hurni,1985)

Soil loss ($t\ ha^{-1}\ yr^{-1}$)	Severity classes	Priority classes	Proportion by Area (%)
0-5	Low	VII	31.63
5-11	Moderate	VI	29.73
11-20	High	V	19.40
20-30	Very high	IV	11.19
30-45	Sever	III	5.36
45-60	Very Sever	II	1.64
>60	Extremely Sever	I	1.05
Total			**100**

watershed. Therefore, soil and water conservation in association with tree planting should be one of the first activities undertaken in this watershed.

Soil Erosion Assessment of Medo Watershed and Conservation Priority Class

The soil loss amount, severity and extents varied for the different parts of the sub watershed. About 50 percent of the study area has a soil loss value of less than 10 t ha-1 yr-1 (Figure 7 and Table 4), mainly along the flat to gentle slopes of the downstream area. About 40 percent of the watershed, is under high to extremely severe soil loss values (>45 ton per hectare per year). This includes the mountain chain, and the valleys of the upstream part of the watershed (Figures 2 and 3). Most of the parts of this watershed have experienced intensive soil erosion behavior, which is beyond the tolerable soil loss level. This threatens the annual crop production and the productivity of the land influencing the local farmers' food security (Brevik, 2013; Pimentel and Burgess 2013).

Table 5: Perception on major causes of natural resources degradation in the area

Degradation of natural resources in the area	**N**	**%**
Inappropriate tillage	2	2.47
Over tillage	21	25.93
Deforestation	30	37.04
Water erosion	28	34.57
The status of soil capability in terms of soil fertility	**N**	**%**
High	2	2.60
Medium	54	70.13
Low	6	7.79
Deteriorating	15	19.48
Total	77	100.00
Steps did you take in soil conservation	**N**	**%**
Building biophysical conservation structures	54	88.52
Improving cover crops	5	8.20
Minimum tillage	2	3.28

Source: Baseline survey data, 2022

CONCLUSION

This baseline report presents the results of the data collected from the combination of field and on farm surveys of the Medo watershed. The assessment of biophysical characteristics of Medo watershed gives awareness one how to significantly describe the basic features and to use them as an input for different activities to be conducted inside the watershed. Therefore, the analysis from biophysical and information in the watershed helps prioritize the problems with their appropriate management options and technologies which in turn leading to the implementation phase so that all the community in the watershed will be benefited. Results exhibit that this watershed does have moderate climatic condition, which is suitable for massive agricultural production. The rainfall pattern is bimodal in that with little support of irrigation, crop production can be possible with rain fed system. The significant variations in the physicochemical properties of the studied soils indicate slope positions soil management needs of each soil type to maintain soil organic matter and essential plant nutrients. Despite the presence of soil erosion on farms and steep slopes on several farms, only few of the farms in the watershed had established contour lines, terraces, or other conservation measures to divert runoff and control soil erosion. The cause and impact of land degradation in Medo watershed had been explored using different methods explained in the study. Natural resources degradation such as Land, and or/ soil fertility, reduction, and recent changes in the areas' weather condition in line of climate change (rainfall in amount and duration, unusual length of dry season) prevailing in current years are few of the many factors that are contributing to the crop productivity reductions in the area. Factors that affect these natural resources depletion by hampering the production and productivities of the local community in the areas were the scarcity of land for farming family, soil infertility, and fluctuation of weather condition. These situations are happening at the expense of species diversity and bringing a reduction in food provision for poor rural households in addition to other resources depletion in the area. It can be concluded that planned watershed managements as interventions for Medo watershed improvements are impressive for the success of any development works carried out for the surrounding communities.

RECOMMENDATIONS

Based on the findings obtained from the study, the following recommendations are suggested:

• Since baseline characterization helps understand the initial livelihood condition of the people in the watershed, detail biophysical characteristics of the watershed must be known for accurate problem solving before intervention.

• Participatory implementation of degraded land rehabilitation in the watershed particularly construction of integrated physical and biological soil and water conservation measures should have to be encouraged.

• Generally, prioritizing the identified problem and preparing intervention of different technologies and development plans by participating communities and different potential stakeholders are crucial to solve the problems by taking into consideration the existing opportunities of the watershed.

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