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Research Article

Participatory Integrated Watershed Management Research for Sustainable Resource Use and Livelihood Improvement in Site Selection and Interventions in Southern Zone of Tigray, Ethiopia

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ABSTRACT

In Ethiopia, a significant number of studies have been done on land degradation and determinants of land management practices in different parts of the country. Several attempts have been made in the agriculture, forestry and other development sectors to improve land productivity, food availability and cash income of the poor farmers. However, it has not been still possible to curb up the situation since all the efforts have lacked proper planning and implementation of the research and development endeavors particularly in the field of natural resources. In recent days the idea of area development using an integrated watershed management (IWM) approach has received recognition in the national development strategy. The objective of the study to establish common understanding in integrated watershed management among different stakeholders, to select representative watersheds in areas with different agro ecologies, farming system and levels of land degradation, and to characterize biophysical, socioeconomic and institutional issues, and prepare intervention in the selected watershed, A multidisciplinary team was formed for site selection, characterization, planning and implementation of the watershed research. by the team members the site was selected on the Raya Azobo wereda it is known as Guguf water shed and formal survey was carried out using structured questionnaire to quantify and verify the informal survey findings. The site selection was depending on different agro ecologies, farming system and levels of land degradation low altitude-low rainfall-mixed farming). The preliminarily delineated boundary was verified in the field using GPS and establishes reference benchmarks for future operations. Finally, map of the watershed was produced, and other information such as elevation ranges, area, slope and other aspect was extracted. The delineated watershed was geo-referenced and digitized for its contour, roads, rivers and other features. The selected watershed does vary in biophysical, land use, soil type conditions, irrigation coverage, means of water use and the type and number of livestock they support, including agro-ecological zoning, elevation, rainfall pattern and amount, temperature, land use and soil types. The analysis was done by SPSS v20.as a result the soil type 45.2% red soil, 22.6% black soil, 29.0% clay and 3.2% other type this is in the cultivated land. Similarly, the slope of the study area is also58.1% flat, 29.0% slightly sloppy and 12.9% sloppy. The application of fertilizer for the common crops in the study area 77.4% of the farmers apply fertilizer for maize and 22.4% without fertilizer, in line with this for teff 61.3% apply fertilizer and 38.7% without fertilizer. For sorghum 87.1% apply fertilizer and 12.9% also without fertilizer, similarly for barley 80.6% apply fertilizer and 19.4% without fertilizer. In general, the primary research interventions in the lowland agro-ecology would focus on the identified soil and water management, Crop Production Practices, Livestock Production Practices, Forestry and Agro-forestry Practices constraints involving integrated multidisciplinary approaches and focus on conservation based, integrated watershed management research.

Key words: Site selection, Awareness creation, Delineation, action plan, Interventions, Ethiopia

INTRODUCTION

In Ethiopia, a significant number of studies have been done on land degradation and determinants of land management practices in different parts of the country. These works mainly focus on nature of land degradation, traditional farmers' land management practices, soil and water conservation by government and other actors,

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farmers' perception on soil fertility change and on causes of land degradation (Aklilu, 2006; Habtamu, 2006; Eyasu, 2002; Yohannes, 1999; Pender & Berhanu, 2008). Land degradation, comprising degradation of the natural vegetation cover, soil erosion, loss of soil fertility and moisture stress is a well known problem in Ethiopia /Hedwig and Still hardt, 1999. Erosion causes a decline in land productivity per year in particular experience, severe soil erosion is formed mainly due to sleep terrain, poor surface cover, and intensive cultivation of sloppy areas and degradation of grazing lands due to population and livestock pressures.

Several attempts have been made in the agriculture, forestry and other development sectors to improve land productivity, food availability and cash income of the poor farmers. However, it has not been still possible to curb up the situation since all the efforts have lacked proper planning and implementation of the research and development endeavors particularly in the field of natural resources As a result, the Ethiopian Institute of Agricultural Research has also given emphasis to research in watersheds as a priority agenda. Integrated watershed management research is expected to improve the interaction between the physical, social, technological, economic and policy dimensions; interdisciplinary approach to solve problems; and the full participation of all stakeholders during problem identification, planning, implementation, monitoring and evaluation.

Watershed development planning in Ethiopia was started in the 1980's. Since then the government, nongovernmental organizations and local community efforts on rural development have been based on watershed development program. Few complete studies however, examined the extent to which Community Based Watershed management interventions have resulted in the desired effects (e.g. P Pathak and others, 2007, Assefa,2011). impact studies do not typically include detailed socio-economical components. Similarly, watershed management in Eastern Tigray has grown in recent years from more technical interventions to restore degraded lands. Monitoring of such interventions is critical since existing evaluation techniques do not represent realistic and local specific scenario

Although a watershed management research approach has become one of the focal points of agricultural and rural development, lack of investment in development of infrastructures, lengthy loan procedures, poor linkages and cooperation among the stakeholders and difficulty in timely supply of inputs are among the major challenges associated with the implementation of watershed management interventions. Thus, the proposed model watershed sites will be expected to have either of the following characteristics: high altitude-high rainfall-mixed farming systems; high altitude-low rainfall-mixed farming systems; mid altitude-low rainfall-mixed farming; mid altitude-high rainfall-coffee based; mid altitude, intermediate rainfall and enset/False banana tree/ based farming; low altitude-low rainfall-mixed farming; and low altitude-high rainfall mixed farming.

Guguf Watershed covers a cultivated area, some vegetation cover/bushes different fruits such as chat, coffee, banana, papaya, e.t.c. and somewhat surrounded with mountains that recharges small amount of water and contains a long-distance river stream starting from maichew woreda of *kebelle E/ teklehaimanot* district area. The water that recharges a little bit from the mountains and flows through the river stream uses for irrigation system of the farmers living in two Keble's of *Tsige-a /chluke/* and *Genete /combolsha/* of the *woreda Raya Azebo.* If properly managed and rehabilitated this can play a significant role in balancing the global issue of the climate change. But, due to the lack of awareness of the communities, this watershed is highly deteriorated and decreased its productivity by soil erosion, low water management and potential, land sliding; low input nutrient depletion and sedimentation resulted from the steep sloped areas of the watershed.

Objectives

- To establish common understanding in integrated watershed management among different stakeholders.
- To select representative watersheds in areas with different agroecologies, farming system and levels of land degradation.
- To characterize biophysical, socioeconomic and institutional issues, and prepare intervention and action plans for the priority issues in the selected watershed.

MATERIALS AND METHODS

Description of the study area

The study was carried out at South Tigray Zone situated in Tigray Region. South Tigray Zone is one of the six zones of Tigray Region. The capital town of South Tigray zone, Maychew, is located at a distance of 660 kms north of Addis Ababa and 120 kms south of Mekele, the capital town of the region. The zone is geographically located at 12º 41'north latitude and 38º59'and 39º 54' east longitudes, at an altitudinal range of 930 – 3925 masl. Long term meteorological data indicate that the area receives 400 to 912 mm of mean annual rainfall with mean daily temperature ranges between 9 to 32 ºC. It shares common border with Eastern Tigray zone in the north, Amhara regional state from the south and west, Afar Regional state from the east. the study mainly focused in the two major agro-ecologies (lowlands and highlands) covering a large area of the zone. The zone is mainly characterized by both irrigation based and rain fed based mixed crop-livestock farming systems. Out of the five rural woredas of South Tigray zone, the study was conducted in two of them Raya Azebo and Enda Mehoni woredas. Raya Azebo represents rain-fed based farming systems of lowlands. Enda Mehoni was selected to represent mainly the highlands and partly mid-altitude areas of the zone According to traditional classification systems, Southern Tigray zone is characterized by three distinct agro-ecologies, including lowlands (locally named as Kolla), midland (Weinadega) and highland (Dega). However, according to the department of Natural Resources Management and Regulatory Department (1998) of Ministry of Agriculture, the zone is classified under the dry land Agro - ecology of tepid to cool sub-moist plains and mountains and plateau (SM2-5).

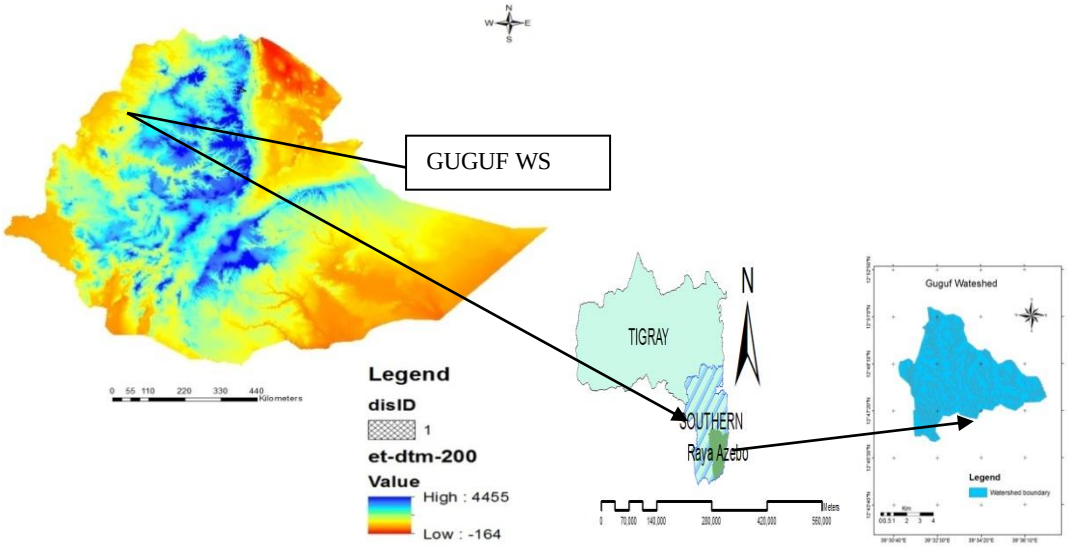

Fig. 1: Location map of the study areas.

Sampling procedure

systematic sampling design was followed for the watershed selection, all village inhabitants of watershed was obtained from *kebele* administrative offices, watershed committee and developmental centers from the selected watershed100 households were randomly selected and interviewed.

Data source and method of data collection

The study was used both qualitative and quantitative data based on both primary and secondary data sources collected from different households, government offices and publications through survey, interview, Focus group discussion and reviewed documents. Besides, GIS tools were used to delineate the watershed. Identify different stakeholders, organize discussion forum, identify the roles and responsibilities of each stakeholder, identify team members for IWM and arrive at a common understanding. The awareness creation workshop was gender sensitive and organized at the respective one location of the potential watershed sites. A multidisciplinary team was formed for site selection, characterization, planning and implementation of the watershed research. The following disciplines was considered for team formation: gender specialist, soil survey and land-use, hydrology, soil and water conservation, socioeconomics, extension, sociology, agro-climatology, forestry, agronomy, livestock. Moreover, representatives of the local government (BoA, livestock, health, education, water resource offices, etc) and the community was part of the multidisciplinary team. An informal survey was conducted to gather qualitative information about the watershed biophysical, socioeconomic and institutional issues. Informal survey was involved direct observation of the watershed issues, informal discussions with individual and group of farmers, and key-informant interviews, Mid and final workshop was organized to validate the constraints identified in the watersheds and review the intervention plans, respectively, A formal survey was carried out using structured questionnaire to quantify and verify the informal survey findings. The analysis of this was done by the Statistical Package for Social Scientists (SPSS v20).

RESULTS AND DISCUSSION

Site selection and awareness creation was done by identify team members for IWM at center level and arrive at common understanding .by the team members the site was selected on the *Raya Azobo wereda* it is known as *Guguf* water shed. The site selection was depending on Agro-ecological representation, different farming system, different land use types (forest/agro-forest, crop) and levels of land degradation low altitude-low rainfall-mixed farming). Accordingly, the watershed sites within the different agro ecologies, farming system and levels of land degradation was selected. Presence of adequate number of inhabitants within the watershed, Preferably, there shouldn't be intensive interventions by other government and NGOs. The size should be manageable, It should not be far from the implementing institutions and all-weather roads for intensive follow-up and minimizing cost and Willingness of the stakeholders around the site. On the selected watershed it was formed team members and organized discussion forum and arrive at common understanding both teams (center level and in the watershed) and also identify the role and responsibilities of each stakeholder on the selected watershed. The training for awareness creation was given to the stakeholders by all the team members of the centre at *Mehoni* town which is nearest to the stakeholders. Generally, the common understanding about integrated watershed management was created. Delineation of the representative model watershed was done.

Land use/land cover: Most of the study area is intensively cultivated with cereal crops, such as sorghum, Teff and maize. Vegetables like onion, tomato, pepper and cabbages are grown close to streams and few areas are covered with bushes, shrubs and cactus trees especially in the south, east and southwest parts of the Raya valley area. In general, the hilly areas of Southern Tigray zone have forest reserve and protected with area enclosure along with physical soil and water conservation practices. The Land use /land cover in the highland area is predominantly cultivable land covered with different crops. Hilly areas are protected, enclosed and reserved

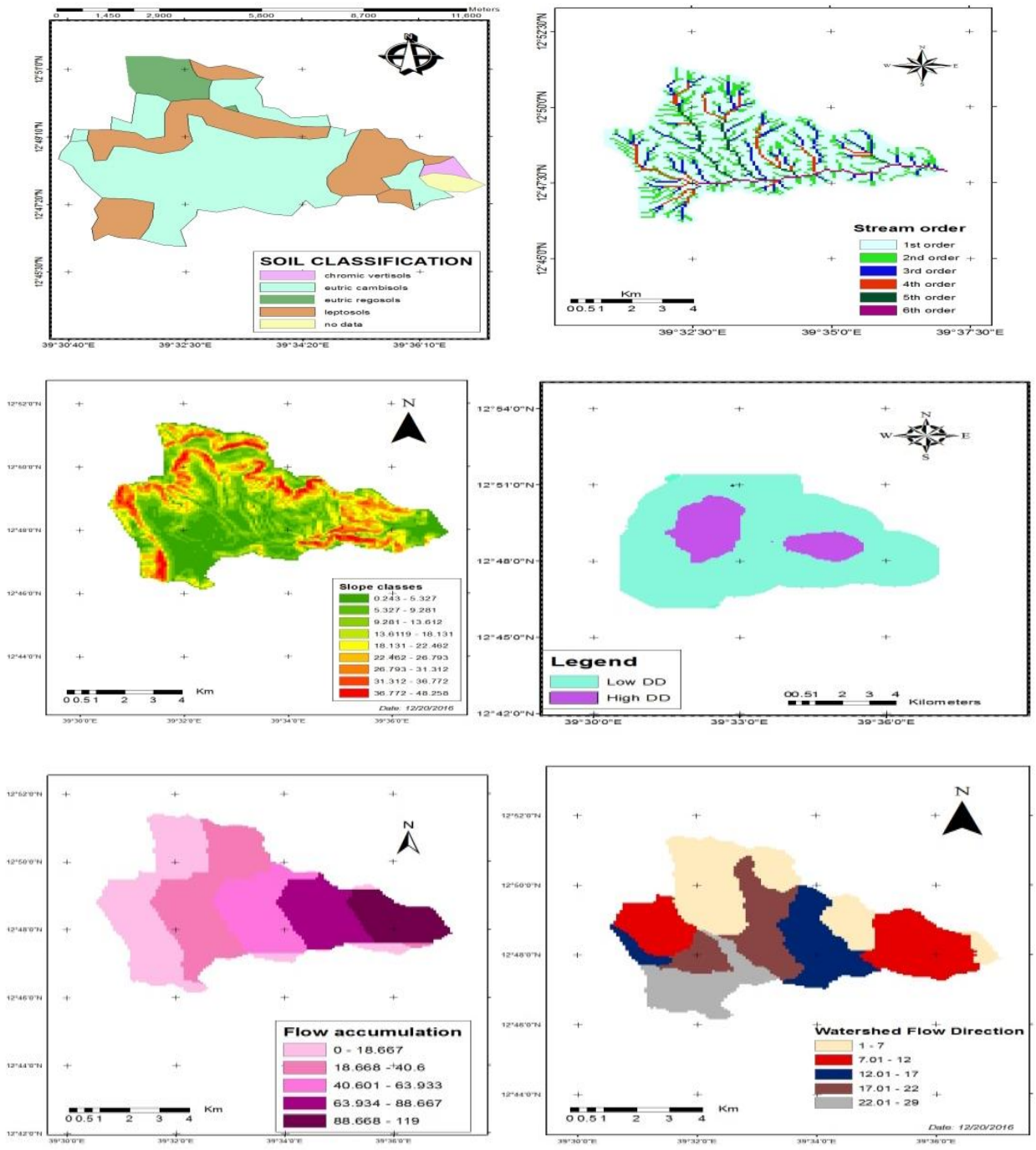

Fig. 2: Map showing the biophysical conditions of the selected watershed (Raya _*Azobo* and *Endamehoni*) in southern zone of Tigray.

forest land for Ox and cow grazing together (cited in characterization of farming *systems* and research directions in south tgray zone, tigray region November 2011).

Crop production

In the water shed the soil fertility status from the reconnaissance survey it is appeared to be suitable for agriculture. Farmer's offered practices with respect to crop and soil fertility management, agricultural water management and soil and water conservation aspects and the major production constraints were identified. mixed farming is widely practiced in this watershed, the main crops grown are sorghum, teff, barley, wheat and maize. *Chickpea, Dekoko,* linseed, grass pea and fenugreek are cultivated. The land area for rain-fed grown cereal crops, sorghum, maize and teff barley and wheat and the Land preparation is carry out by oxen. According to the respondents, they have different average plouhing /farming system for example maize 4 times teff 3 times and sorghum more than 5 times is common farming system in the community the main objective of ploughing is controlling weeds and incorporating the residual crop stubbles. In the community most of the crops sown after rain and somewhat there is sowing before rainfall but it depends on the crop type. When we see in percent 61.3% sowing after 37.8% before rain. Land preparation for tef, and barley begin in June and end in July and planting time from mid July to end of July. In contrary Land preparation for sorghum and maize is beginning during February (1st),

March (2ndand 3rd) and in April (3rd and 4th). Planting takes place in April to May. Weed taken as averagely it is more than 75% as critical problem. To solve this 61.3% of the community is caring out both by family and lobour and 22.6% also use labor and 16.1% of the community also caring out by their family. During the peak period almost of the farmers went to hire people, more than 50% for ploughing, weeding and harvesting and threshing. But there is 80.6% a labor constant in this community. With this the payment also different between man and woman, the maximum payment t is 150brr per day the minimum also 40 brr per day.

When we see the Crop productivity in average yield quintal per hectare in good and bad year with the most common crops, for maize in good year they get the maximum 50 quintal and the Minimum 10 quintal and the average yield quintal per hectare is 26.3quintal, in the bad year the maximum value 22 quintal and to the minimum 5 and averagely 9.8 quintal. According to the respondent the maximum yield *teff* in good year 34 quintal and the minimum 5 quintal and averagely 14 quintal for bad year the maximum yield is 16 quintal and the minimum yield 3 quintal and averagely 5.6 quintal, similarly, for sorghum in good year the maximum yield 52 quintal and the minimum yield 10 and averagely 31.9 quintal, in bad year the maximum yield is that 25 quintal and the minimum yield is also 7 quintal and averagely 15.9. in line with this barley production in good year the maximum yield 40 quintal and the minimum yield 5 quintal and for the bad year the maximum yield 18 quintal and the minimum yield 4 quintal and averagely 2 quintal per hectare. The slope of the study area is also58.1% flat, 29.0% slightly sloppy and 12.9% sloppy and the soil class from the farmers' perception and from the reconnaissance survey it is dominated by walka(clay)soil ede(alluvial)soil and hutsa(sandy)soil which are best for grown sorghum, teff, wheat, chickpea, maize barley and lentil and they are have good fertility rating.

It is not common practice to use chemical fertilizers. Most of the farmers believe that their farms have fertile soils, and therefore, do not need to be fertilized. When we see in percent for the common crops in the study area 22.4% of the farmers apply fertilizer for maize and 77.4% without fertilizer, in line with this for teff 38.7% apply fertilizer and 61.3% without fertilizer. For sorghum 12.9% apply fertilizer and also 87.1% without fertilizer, similarly for barley 19.4% apply fertilizer and 80.6% without fertilizer. From The farmer's suggestion on their land soil fertility 64.5% of land soil is slightly fertile and 22.6% also very fertile 9.7% also degraded and 3.2% also highly degraded. In addition to this, farmers said that they use less chemical fertilizers in study areas believe that because of the frequent soil moisture stress, application of fertilizers has a burning effect on crops and the fertilizer itself needs more moisture, so there is reduction on our productivity. In this case it should be developed the appropriate soil fertility management practices and integrating organic and inorganic sources of fertilizers improves the fertility status of soils by improving the nitrogen, phosphorus, organic matter and other mineral content of the soil and improve the moisture retention capacity of the soil and also improves the soil structure and get sustainability.

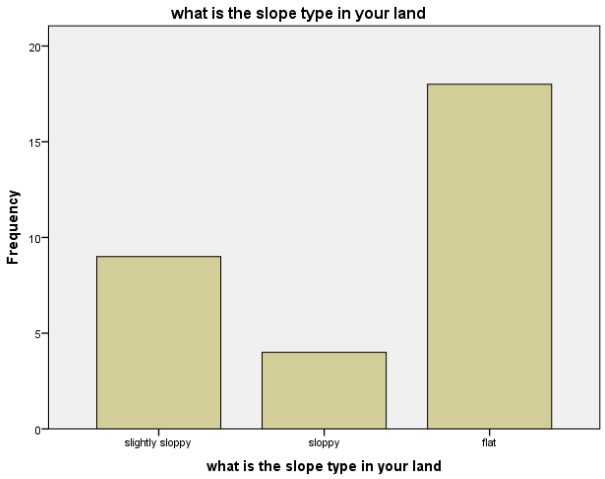

Fig. 3: of slope classification by users

Table 1: Summary description.

Characteristics	Description/statistics
Major Agro- geologies (simple classification)	Cool sub_moist mid highlands Tepid sub-moist mid highlands
Rainfall (mm), average of recent 10 years and its CV)	400-912
Soil type (coverage and distribution)	Vertisol, Fluvisols, Luvisols, cambisols, (FAO, 1990).
Altitude range (masl)	930-3925
Temperature (°C)	9 - 32
Land use (ha)	
Rain fed crops (450 ha)	Sorghum (75ha), maize (158.25ha) and teff (196ha), barley (21 ha)
Irrigated crops (41 ha)	Vegetables (6.25 ha) and fruit (10.5 ha) perennial plants (24.25 ha)
Grazing land	Bush (61ha)
Forest land	d/t trees (50 ha)
Other	----
Livestock	No
oxen	325
cows	429
poultry	800
calf	189
sheep	200
goat	322
Horses(mules)	15
donkey	152
camel	52

In the study area there is drought and crop failure occurrence, the return period of the drought and crop failure occurrence in three years in the past 10 years .. When we see the last three drought events, it was faced in both *main rain season(kremt)* and short rain season (*belg)* season. In the recurrent of drought there must be detailed understanding of the causes and effects of climate variability and increasing the adaptive capacity of a system represents a way of coping with changes and uncertainties in climate and the enhancement of adaptive capacity is a way of reducing vulnerabilities and promoting sustainable development. In general, from group discussion and the questioner, the main factors contributing to the occurrence of recurrent drought in the study area are Climate change induced drought, increased population pressure and land use changes those are the

major production constraints identified with respect to crop and soil fertility management. Under extreme conditions, total crop failure and famine followed by migration and death of farming communities is the crucial result of drought stress. To strengthen the economic capacity of households and encourage them for enhanced utilization of agricultural inputs, during the drought/ burden time it is necessary to crate access of the community to different types of income generating enterprises, such as, improved crop varieties poultry, fruits and vegetables, cash crops, bee keeping and others should also be promoted through introduction of improved technologies and other associated packages.

In the study area there are common crops for sell, which are teff, sorghum and maize from those 25.8% covers by teff, 22.6% covers by sorghum and 19.3% cover by both maize and sorghum and they have sufficient perennial cash crops for sell and for home consumption, In the irrigated, they commonly use as source of income, which are papaya, *gesho*, chat, avocado, banana, mango and coffee. From this chat, gesho and coffee have satisfactory price, in contrary papaya have low price. In rain-fed, cereal after cereal is common practice for example; continuously sorghum after sorghum or maize/*teff* after sorghum year after year. This practice is simply because farmers give due emphasis to sorghum and *teff* as sources of their food and cash. but there is poor access to markets, prevailing high interest rates for credit, poor road network and the high cost of inputs. The price of agricultural products is not based on market demand and supply, but rather determined by individual merchants. As a result, farmers get low prices for their products, while at the same time having to contend with the high cost of agricultural inputs such as fertilizers and seeds

Livestock management

The main livestock being reared are cattle, sheep, goats, and chicken. Other types of livestock owned by a small number of farmers are camels, donkeys and mules and the most common management practice is stall feeding and the second is control grazing and collected grass. With this more than 80% of the animals in the community are local animals the rest are improved. In the watershed there are a number of animals, but there is a serious problem on feed. The contribution of animals on the economy it is more than 50%. The number of cattle kept is a declining trend because of recurrent draught, feed shortages, inadequate grazing land and disease. in study area the Major livestock feed resources are cut grass in order to feed animals and during the very dry season (period of drought), they let their animals graze freely in the closure areas for a short period of time and crop residue (sorghum and maize Stover wheat straw), green grass (weeds, area enclosure) cactus during the dry season .But in the last 10 years because of the drought the main source in both season was cactus ,with this also another problem is faced in the main source in dry and wet which is in cactus because of kucinia (cactus's disease) almost all becomes dry, so fodder is the is a serious problem.

The market condition for the livestock products they send directly to the market for sell their products their also sell to any user directly to consumer, the hole seller and to if any to the cooperatives. The main output for the cattle in the area mainly for milk, meat, skin, manure and source of income for home consumption and market values are the most common. In this community they get advice on livestock husbandry, grazing land and other activities but they are not satisfied by the advice stile they require training, in poultry, zero grazing animal production, feed conservation and total management on all activities on livestock. During this study and discussions three major researchable livestock production constraints were identified. These are: Poor Production and Productivity, Animal feed shortages, Animal health problem, and lack of water for cattle /no ponds and drought. The livestock research strategy will engage a mix of disciplines where the livestock production problems may consider crop / livestock integration across the areas.

Water resource (water supply and livestock use)

The surface water resources in the lowland area are mainly depend on natural streams and Perennial rivers, which originate from the highland areas and flow, basically West to East direction within the valley. Moreover, as per the information from the farmers, *teklehaymanot* River is a potential river which could currently for human supply and irrigation schemes. This originates from the high land which is *E/ndamehoni wereda*. It is the only source of supply and livestock use because of lack of another option for supply and livestock there is serious problem on water resource, this source also it has not any quality and quantity at all. As this time the river also diverted by the upper water shed community, so there is a shortage of domestic water use and livestock use both season's spring and summer.

Water harvesting and small scale irrigation

In an endeavor to address the occurrence of recurrent droughts and food insecurity, the government has been engaged in a variety of water harvesting programs to supplement the rain-fed agriculture. Even if, traditional flood water diversion and physical water pond structures and other water harvesting structure are common but they are not functional. The soils are fertile and the huge area is suitable for irrigation. During the different dry seasons, farmers use surface water irrigation and apply traditional flood diversion methods during the rainy seasons to irrigate lands used to grow mainly sorghum, maize and teff. Sustainable agricultural development cannot be achieved by depending on rainfall alone. But there are major problems on irrigation, technical managerial land tenure and shortage of water etc. consequently, an intensive assessment of irrigable land, crop-water requirement and possibility of small-scale irrigation in specific areas is essential. Moreover, systematic research on irrigation and drainage is vital for high potentials for irrigated agriculture. To solve the effect of insufficient agricultural water management research technologies and environmental degradation due to different hazard researches must be focused on the determination of crop water requirements based on climatic, soils and crop data of the locality and followed by the determination of irrigation regimes, that is how much to irrigate and when to irrigate.

Land/natural resource degradation and watershed integration

The main environmental constraints facing in the watershed are deforestation, soil erosion, free grazing and limited water resources. To protect this problem there are many traditional measures taken but the traditional measures, have limitations which standard/norm it is time taken, technical and it haven't long time, it protects only for the time being, so every year they have to woke. Although, the farmers taken their own solution to solve their problem, besides, there is need of Capacity Building: Awareness creation, training and experience sharing for farmers, development agents in best practices aimed at addressing these problems are the implementation of soil and water conservation measures, the planting of trees near homesteads and around farmlands (agro forestry), a reduction in the number of animals being kept, and creating area enclosures to provide feed for livestock and for beekeeping purposes practices in research, Introduction, adaptation, evaluation and pre-scaling up technologies of soil and conservation practices, which introducing Integrated conservation measures: Biological (*Vetiver* grass, pigeon pea), physical (soil bund, terraces etc.) By conserving the available water in the furrows, tied-ridge enables efficient utilization of moisture by crops and extends the growth period until grain filling and increased grain yield, evaluation of conservation measures for soil loss and runoff control on different land use systems, catchments will be treated in order to minimize the sediment load to the downstream, retain the soil water system and increase the base flow. Adaptation and pre-scaling up of new and locally available tree, grass species and Vegetative (aforestation, area enclosure etc...). The evaluation will be carried out from technical efficiency, socio economic benefit and impact and environmental protection aspect and others should be provided to strengthen the research capacity in soil erosion, soil and water conservation, participatory Integrated Watershed Management Research.

Because of low amount and poor distribution of rainfall, moisture stress is a frequent occurrence in the study areas, soil moisture conservation must be a main concern to do a research and it will be needed with respect to soil moisture conservation practices which is acceptable by the communities in terms of cost, accessibility and easy to use and In order to capture soil degradation and desertification, Research should call for in-depth studies to devise more quantitative information on the dynamic nature of soil and water in relation to crop growth and the livestock carrying capacity and enlarge optional cost effective in-situ water harvesting, retention and soil moisture conservation technologies (minimum tillage practice, mulching, rotation and green manure) by testing their effectiveness in-situ soil moisture conservation and also create information accessible on the moisture requirement of crops for optimum yield, which also requires intensification research on livestock-crop-soil-moisture relations.

Summary and conclusion

the study was mainly focused in the major agro-ecology which is lowland and it is mainly characterized by both irrigation based and rain fed based mixed crop-livestock farming systems. the soil fertility status from the reconnaissance survey it is appeared to be suitable for agriculture. Farmer's offered practices with respect to crop and soil fertility management, agricultural water management and soil and water conservation aspects and there is a huge potential for livestock and irrigated crops commodity value chain development. These potentials have been limited due to drought deforestation and shortage of fuel woods still and other related to drought. Recently, farmers are exposed to irrigated crops development without full understanding of the skill and science of irrigated agriculture.

Recommendation

- Research should be done on the early mature crops, moisture stress Soil and water conservation strictures a forestation, taking measures on moisture conservation structures supported by scientifically techniques, Accessibility of improved variants on animals Forage development
- Integration of different discipline on natural resource with crop production and moisture conservation

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