Journal of Science and Sustainable Development (JSSD), 2015, 3(1), 99-115

ISSN: 2304-2702 (print); 2414-4479 (online)
DOI: https://doi.org/10.20372/au.jssd.3.1.2015.041

Assessment of Watershed Management Practices for Sustainable Rural Livelihood Improvement in Meja, Jeldu District, Ethiopia

Birhanu Ayana[1], P Natarajan[2] and Tesfaye Balemi[3]

[1] *Monitoring and Evaluation expert of Peace Centers for Climate and Social Resilience (PCCSR) Project, College of Law, Haramaya University, Ethiopia* E-mail: brihanuayana@yahoo.com
[2]*Department of Biology, College of natural and Computational Science, Ambo University* E-mail: drpnatarajan123@gmail.com
[3]*Department of Plant Science and Horticulture, College of Agriculture and Veterinary Science, Ambo University P.O.Box 19, Ambo, Ethiopia,* E-mail: *tesfayeb2005@yahoo.co.uk*

Abstract

Poor watershed management practices and resultant problems of land degradation, low agricultural productivity, food insecurity and poverty are particularly severe in the rural highlands of Ethiopia. The current study was undertaken at Meja watershed, located in the Jeldu district of Oromia region to assess potentials and constraints for sustainable participatory integrated watershed management practices for the improvement of rural livelihoods. The study investigated socio-economic and biophysical conditions, along with their management practices. The results indicated that there was inefficient implementation of participatory integrated watershed management practices in terms of rainwater, soil and forest managements; as a result water scarcity and accelerated soil erosion, sedimentation, soil fertility loss were prominent, with a resultant reduction in both crop and livestock production in the watershed. Therefore, strategies to avert food insecurity situation are necessary. This could be achieved through a sustainable solution that better addresses integrated watershed management efforts.

Key words*:* Integrated Watershed Management, Rural livelihood, Soil Degradation and Watershed

Introduction

Watershed is the land and water area, which contributes runoff to a common point. It is considered as a biological, physical, economic and social system. Watershed management has emerged as a new paradigm for planning, development and management of land, water and biomass resources with a focus on social and environmental aspects following a participatory approach (Kerala Calling, 2004). Along with water, other natural resources such as soil, vegetation, and biota can also be managed efficiently by adopting integrated watershed management (IWM) approach. In the integrated watershed approach, the emphasis is on *in-situ* conservation of rainwater at farm level; where by excess water is taken out from the fields safely through community drainage channels and stored in suitable low-cost structures. The stored water can be used for surface irrigation or for recharging groundwater. Conservation of rainwater and its efficient use is achieved through appropriate crops, improved varieties, cropping systems, nutrient and pest management options for increasing the productivity and conserving the natural resources (Wani *et al.*, 2003). The major advantages of adopting IWM approaches are the involvement of those most affected by the decisions (the stakeholders) in all phases of the development of their watershed and holistic planning that addresses issues which extend across subject matter disciplines (biophysical, social and economic) and administrative boundaries (village, woreda etc.) (UNEP, 2002). Watershed development seeks to manage hydrological relationships to optimize the use of natural resources for conservation, productivity, and poverty alleviation. This requires coordinated management of multiple resources within watershed; including forests, pastures, agricultural land, surface and groundwater, all linked through hydrology (World Bank, 2007). Soil becomes more productive for agriculture, water for irrigation, and pastures and forests for more biomass. All livelihood activities that depend on these resources may be enhanced, and employment may increase as agriculture becomes more productive and additional labor is needed for harvesting and other operations (Kerr, 2002).

In Ethiopia, where agriculture is the backbone of the economy, severe food insecurity and natural resource degradation has become a serious challenge to the livelihood sources of the rural community. It has been estimated that 2 million ha of Ethiopia's highlands have been degraded beyond rehabilitation, and an additional 14 million hectare are severely degraded (UNEP, 2002). Removal of vegetation covers (through overgrazing and charcoal production) exposes the soil to wind and water erosion. Soil compaction occurs in areas where there is excessive trampling by animals. In cultivated areas; soil fertility is declining, as a result of the exhaustion of soils by mono-specific cropping and reduction of fallow periods. Soil degradation contributes to increasing rural poverty and food insecurity, because productivity is reduced, and subsistence farmers are less and less able to accumulate reserves of grain (UNEP, 2002).

In Meja watershed, there is high rainfall and large area of land use for cultivation. The cultivated land is highly prone to sheet and rill erosion due to lack of soil and rainwater management practices. The reduction of forest cover in the uplands and the lack of conservation measures on hillsides had resulted in the formation of big and active gullies. The increase in human population has also contributed to reduced land holding and created pressure on the limited land for agricultural and livestock production. As a result, the community is exposed to seasonal food shortage and health problems. The adoption of sustainable participatory integrated watershed management as a platform for integrated land and water management and improving the livelihood of community in Jeldu district become crucial. Therefore the objective of this study was to assess the major potentials and constraints to sustainable watershed management through participatory integrated watershed management approach.

Materials and Methods

Description of the study area

The study was conducted in the Meja watershed which is located in Jeldu district, West Shewa Zone of Oromiya Regional State, Central Ethiopia (9° 02' 47" to 9° 15' 00" N and 38° 05' 00" to 38° 12' 16" E). The district has an undulating terrain with an altitude ranging from 2900-3200 meters above sea level. Rainfall pattern is bimodal with the main rainy season from June to September and the short rainy season from February to March. The mean annual rainfall of the area ranges from 1800 to 2200 mm. The maximum and minimum temperature of the area is 17^{0}C and 22^{O}C respectively. Agriculture is mainly rain-fed. The soil type is characteristics of clay and clay-loam type, but the riverbed has a loam and sandy-loam type of soil (Hurst *et al.*, 1959 cited in Dereje, 2010). *Eucalyptus globules* is the main tree planted in the area.

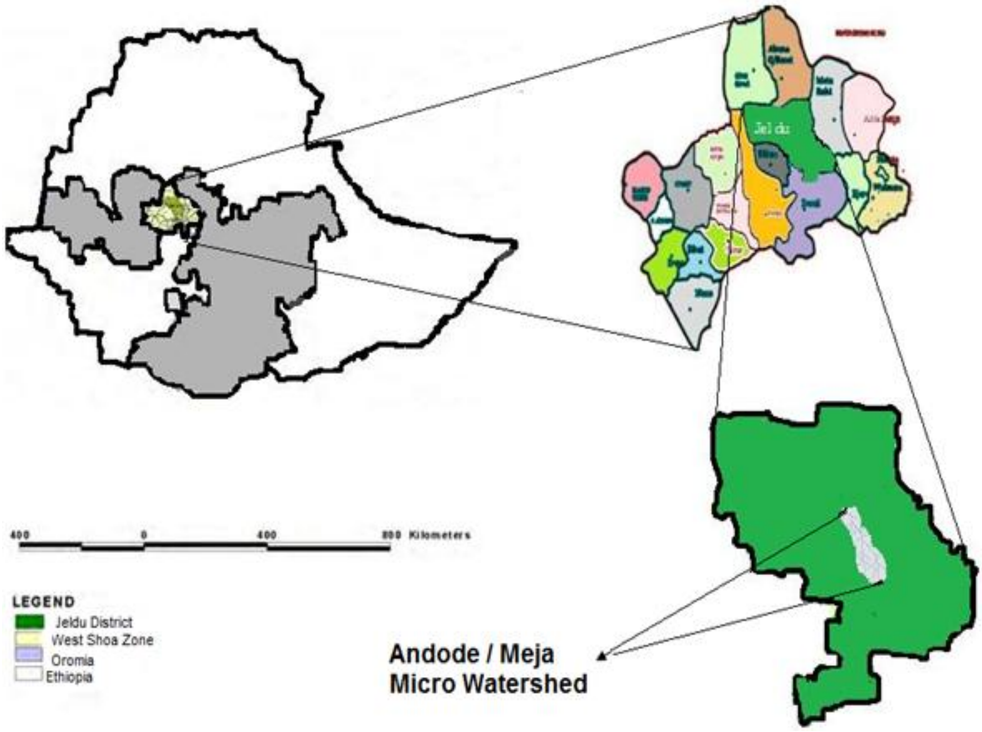

Figure 1: Location of Map of study area

Socio-economic survey

Socio economic study was conducted to assess biophysical and socio-economic constraints in the watershed under study. Structured and semi-structured questionnaires, group discussions with men and women representatives along with key informant interview were employed to collect relevant information. Moreover, discussion was held with, government administrators at various levels and natural resource management officers to get the necessary information on the history of the area, population dynamics, socioeconomic activities, and participation of the local people in conservation efforts. The number of sample household farmers selected for the interviews was determined by using the formula developed by Kothari (2004).

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq}$$

Where: n= sample size

Z = 95% confidence limit (interval) under normal curve that is 1.96

P = 0.1 (proportion of the population to be included in the sample that is 10%)

q = None occurrence of event =1-0.1 that is (0.9)

N = Size of population.

e = Margin of error or degree of accuracy (acceptable error term) (0.05)

In the catchment, sample households were selected using simple random sampling techniques from the list of households.

Data analysis

Data obtained from the household questionnaire survey was analyzed using statistical package for social sciences (SPSS) version 15.0 and the results are presented using descriptive statistics; tables, graphs and percentages. The qualitative information generated by the informal discussions was used to substantiate results from the questionnaires.

Results and Discussion

Water availability and management issues

In the study area there were about 16 springs of which 14 are seasonal and 2 perennial. Out of 88 streams, 55 were seasonal and 33 perennial. There was only one perennial river in the watershed (DARDO, 2009). The water sources were not sufficient to meet the needs (i.e. for drinking and cooking, washing clothes, watering livestock and growing of crops by irrigation) of the community members in the watershed as reported by all respondents.

Out of the sampled household heads interviewed in the delineated watershed for the study, 32% reported that they had no access to water every day for household purposes (Figure 2). The result also showed that the main reason for the water scarcity was due to poor and inefficient application of rainwater management (RWM) to empower the water sources (66.9%) in the watershed. Even though the area has high rainwater potential, there was poor rainwater management practices to increase the time for infiltration of water into the soil profile by *in-situ* water conservation methods, practices that could have raised ground water table, and the poor water storage structures used in the watershed. It was observed that farmers destroyed natural trees on the course of streams and rivers for the sake of cultivation and grazing purposes due to shortage of land. Furthermore, the existing RWM interventions in the area are poorly practiced and farmers give less attention as well as no protection to them.

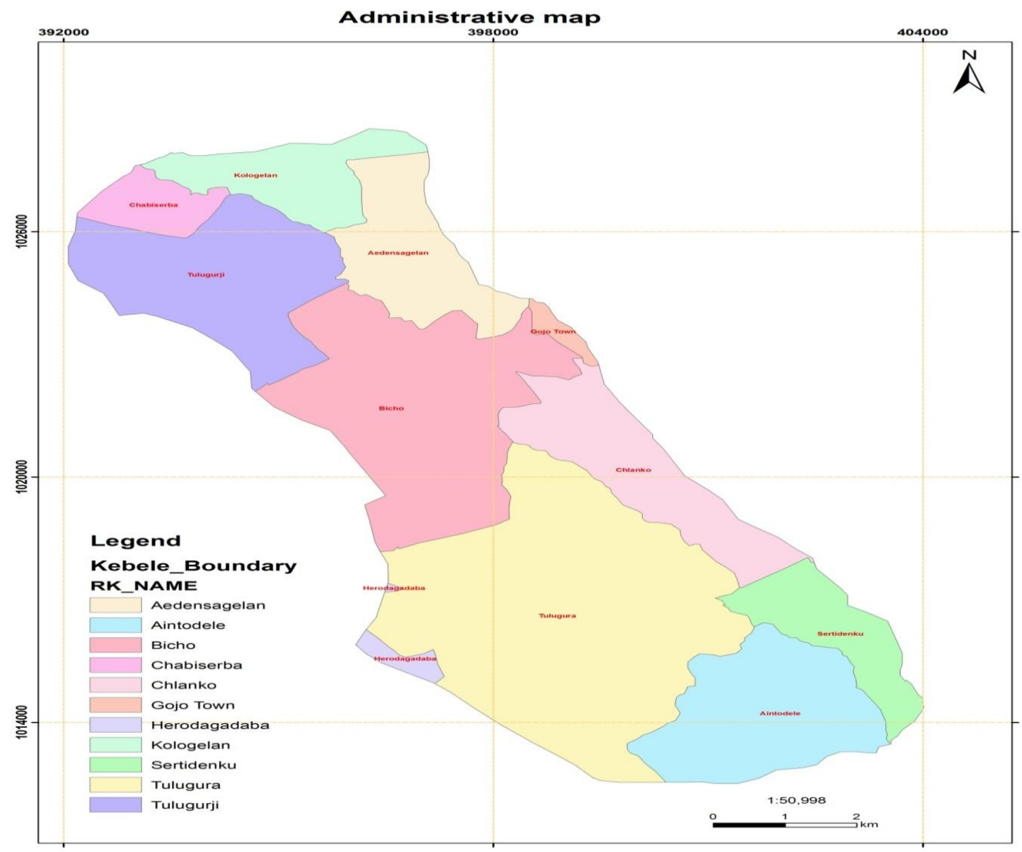

Figure 2: Administrative Map of the watershed under study

Forty two percent (42%) of respondents indicated that insufficient amount of water in water sources was the reason why they could not access sufficient water in the watershed. According to the focused group discussion with women, there were very thin stream discharges (locally called “Chororsa”) at every stream for fetching (Figure 3). Some of these streams even dry up during dry season (27.4%) and hence they had to walk long distance for water. Therefore, the availability of water sources at distant (33%) was also another reason raised by respondents in the survey for describing water scarcity issues. On average it takes 45 munities for a one way trip and another 45 munities waiting the turn and in total about 2hrs and 15 minutes was needed in the dry seasons. This affects production and productivity. Similarly, Degefa and Tesfaye (2008) reported that the problem of time and labor spent for fetching water affected not only household productivity but also the physical wellbeing of women fetching water from such a distant.

Figure 3: People waiting to fetch water in the watershed under study

Generally, the lack of access to sufficient water had brought illness to family members and livestock, time wastage and labor spent in fetching water, decreased livestock production and also problems in the case of irrigating farms and intensifying agriculture (Table 1).

Table 1: Water scarcity problems faced by households in the watershed under study

	Health problems of household members and food utilization	Decreased livestock production	Taking too much time and energy in fetching water	Inability to intensify agricultural production via small scale irrigation systems	Induced conflict over water use
% of total HHs with specified water problem	42.5	99.2	87.9	67.7	56.3

Soil degradation and management status

The survey on soil degradation and management issues was designed to include most soil problems and management issues in the watershed, i.e. soil erosion, sedimentation, fertility problems, and regarding soil management; type of protection measures, method of implementation, year of construction and any improvement seen after measures taken were assessed.

Soil erosion/sedimentation problems

Results from the socio-economic survey revealed that all (100%) of the respondents had reported soil erosion/sedimentation problems on their farm lands. The existence of sheet erosion (97.6%), sediments in ditches and furrows (94.4%), rills in the farm (94.4%) and gullies (25.8%) helped the respondents to understand whether there was soil erosion/sedimentation problems or not on their farmlands. According to most respondents the problems of soil erosion/sedimentation were seen on their farm land 10 years ago.

Almost all the respondents (96.7%) had said the problem of top soil erosion was very serious and if protection measures are not taken, productivity could be decreased and as a result a large portion of their farm land would be lost. The major causes of soil erosion/sedimentation and indicators of the problem as perceived by the respondents is shown in Table 2.

Table 2: Causes of soil erosion/sedimentation problems and its indicators as perceived by the respondents

Causes of soil erosion/sedimentation problems	* Percentage (%)	Indicators of soil erosion/sedimentation problems	* Percentage (%)
Deforestation	99.2	Sediments in ditches and furrows	94.4
Improper tillage	90.3	Existence of Sheet erosion	97.6
Slope/terrain	100	Rills in the farm	94.4
High rainfall and absence of its management measures	91.9	Gullies in the farm	25.8

*The percentages do not add up to 100 due to the multi response of the respondents

Soil fertility problems

All the farmers (100%) pointed out soil fertility as a problem on the farm land. They were able to know the existence of such problems through different indicators such as reduction of crop yield (100%) from year to year and increased input demand (92%) by the farm to keep production. According to one respondent in the watershed, a plot of land (about half hectare) which previously produce 15 quintal of wheat with only 50kg inorganic fertilizer, the same plot however, required supplemental manure in addition to the inorganic fertilizer, currently (up to the time of this study) and continually showed a decreased yield from year to year. According to the perception of some respondents, soil structure and color change (91%) was another indicator for soil fertility decline, where red colored and rough soil (commonly called "borki") was reported as an indication of low soil fertility. Similarly, 85 % of the respondents reported stunted crop growth indicates poor soil fertility. The other causes of soil fertility problem in the studied watershed include high rainfall followed by leaching and erosion (97.6%), continuous cultivation and removal of crop residues (96.8%), absence of the addition of manure (73.3 %) especially to a distant farm land and the absence or inappropriate application of inorganic fertilizer (63.4%). The sloppy nature and cultivation on steep slope in the study watershed were also contributory to the accelerated erosion. Furthermore, the degree and length of the slope was another important factor influencing soil erosion.

Soil problem management practices

According to the result of the surveyed HH, none of the respondents had any discussion on soil erosion problems with the local authorities, extension agents or any other community member. Additionally, none participated in soil conservation work initiated by the local authorities. About 67.7% of the respondents said the existing soil erosion/sedimentation protection, soil fertility management and other land improvement interventions are practiced privately on their farm land. While 80% said without consultation with government agents, they had adopted/learned soil conservation work from their neighbors and parents.

The common protection measures that most farmers had exercised were ditches/trenches (99%) commonly called deep furrows, soil/earthen bunds (52.4%) and check dams (43.5%). Contour planting (40.3%) and stone bunds (9.7%) were also among the protection measures that fewer people in the watershed are using. While only 34% of the respondents taking protection measures had seen improvement, the rest (66%) did not. This was because of the fact that, as seen during field observation and according to the perception of most respondents, the farmers didn't apply and maintain the protection measures correctly. For instance ditches/ trenches were dug vertically which were even more responsible for gully formation and land form damages. Similarly, soil/earthen bunds were not protected, and livestock's constantly break them down for grazing purposes.

In the case of land use, any land type available was used for all purposes regardless of its natural suitability. Land use classification was done according to the distance of the respective plot from the residential location of the owner. Whatever the proper utility of the land may be, homestead area was reserved for enset, maize, potato and other vegetables and relatively distant plots are meant for other cereal crops; mainly for wheat and barley. Differences in farming systems and land uses can alter nutrient input and output fluxes in soil and vegetation. This can change soil fertility, which in turn affects biomass production and human decisions on land management (Priess *et al.,* 2001). In addition to inherent soil fertility gradients, diverse and long-term anthropogenic interventions are important sources of soil fertility which create zones of fertility within and between different farming systems (Brady and Weil, 2002). The major soil fertility management practices of the farmers are shown in Figure 4. For most of the farmers, there was no one single method or approach to soil nutrient management. They used a combination of two or more of the different methods.

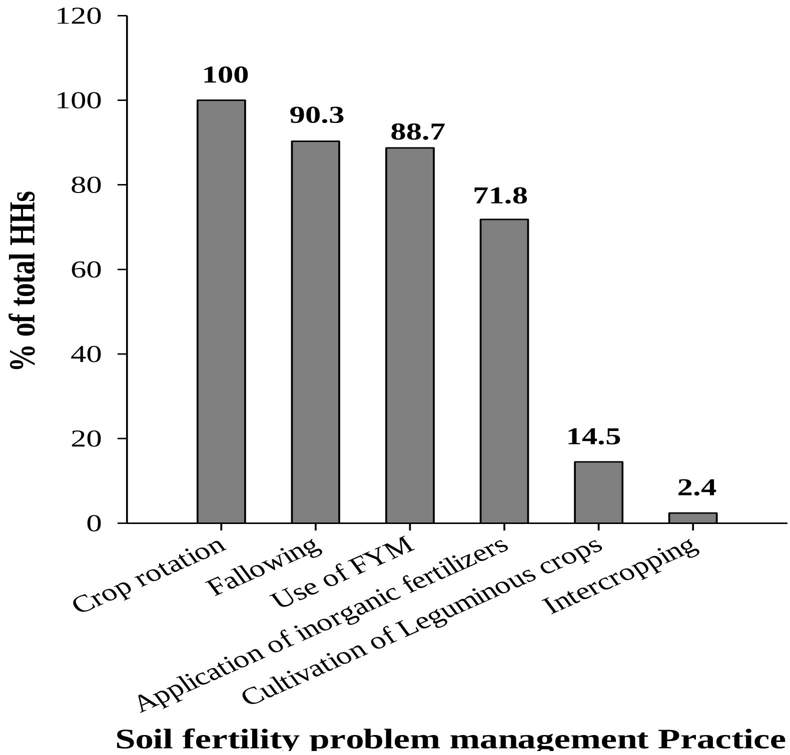

Figure 4: Major soil fertility management practices adopted in the study watershed

The study result indicated that, most of the respondents put their land under rotation with barley and wheat especially at the upper part of the watershed. At the lower part of the watershed, there was the rotation of potato and onion with cereal crops after small scale irrigation. According to the perception of 14.5% of the respondents, the farmers apply rotation of cereal crops with leguminous crops only when the farm land is considered poor in soil fertility, Half of the total farmland of a household was under annual crops, and the rest half was left fallow being rotated after every year for the purpose of fertility restoration. But, it seems that this type of cultivation would not be continued because of the rapid population growth and the resultant shortage of land. The result also showed that 90.3%of the respondents used fallow method for soil nutrient management. Application of farm yard manure was another means of soil fertility management practiced by the farmers'. But this was restricted to around homestead areas only and as a result farm plots at a distance from the home had less chance of being treated with manure. 88.7% of the respondents used manure. The remaining do not use because of lack of livestock and distance of farmland from the residential areas.

Application of inorganic fertilizer in the form of DAP and Urea was another alternative means of soil fertility management system in the watershed. However, the amount of fertilizer applied per hectare by most of the farmers (60.6%) was significantly less than the officially recommended dose of DAP and Urea (100kg DAP/ha and 50kg Urea/ha) (Eyasu, 2002). The major constraint on the use of fertilizer was the high price, which make unaffordable by many of the poor households in the study area. As a result, some farmers have stopped using it. From the surveyed respondents, only 71.8% were found to use fertilizers.

According to surveyed HHs, only 2.4% of respondents pointed out that they were using intercropping methods as treatment to the soil fertility of their farm land. Through field survey such types of management practices were observed in the irrigable lands of study watershed.

Forest/plantation status

According to the perception of the surveyed HHs and visual observation carried out, there was almost no more natural forests (0.8%) existing in the watershed, but rather, remnants of very few scattered natural trees left on the cropland (Figure 5). There are also some scattered vegetation around the steep slope and gorge of Meja River. However, all the respondents (100%), agreed and reported that there was natural forest some 20 to 30 years before in the watershed.

Figure 5: Remnants of natural forest in the cropland in the watershed under study

The plantation of eucalyptus tree (66.7%) for market was found to be very common in the watershed. Most of the farmers plant eucalyptus tree on steepy land and around the streams and rivers. But few others were converting their cropland to eucalyptus plantation. According to the surveyed HHs, there was great change in the status of both natural forest and plantation forest at present. According to the respondents, plantation forest has increased (100%) while the natural forest covers only about 25.8%. this showed how much the natural forest has disappeared (75.8%) in the watershed. Farmers reasons for the causes of disappearance or reduction of the natural forests among others includes; the conversion of forest to farmland (98.4%), fuel wood and charcoal production (91.9%), deforestation for construction purposes (82.3%) and 54% for timber production. The study observed that all the respondents at one time or another had remove trees for any of the above mentioned reasons, culminating into multiple responses from the farmers in the watershed.

Effects of forest cover change

The presence of forest provides many ecosystem services and has many functions. It protects the soil from erosion problems by reducing surface runoff and increasing infiltration, serves as sources of food and home for different kinds of animals including birds. Despite these facts, almost all area of natural forest has disappeared in the study watershed, leading to heavy flow of rainwater carrying soil particles and significant amount of minerals and nutrients away from the farmlands. This has resulted in yield decline and more rills and gullies formations followed by land fragmentation. The other effect of forest cover change observed was the reduction of the water flowing in the form of springs and streams from the area, leading to the reduction of drinking water for human and livestock. Stream flow reduction (99.2%) and drying was observed as the main impact of the reduction or absence of natural forest in the study area (Fig 6).

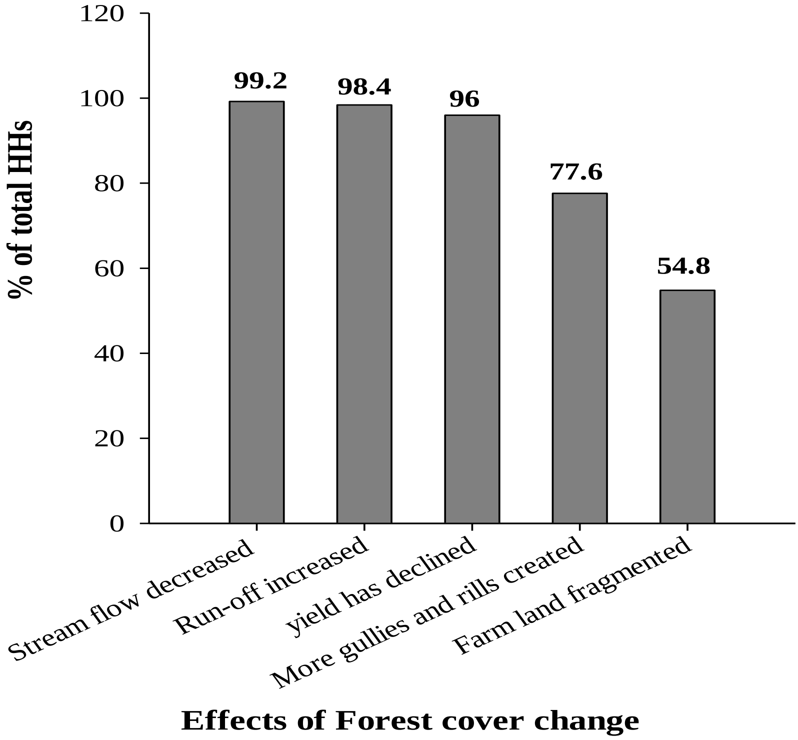

Figure 6: Effects of forest cover change as perceived by respondents in the watershed

Forest protection measures practiced in the watershed

Natural resource management is an essential issue for the development of an area. The results indicated that there were no practical activities carried out by the government, local as well as international nongovernmental organizations (NGOs), and by default, the communities to conserve and rehabilitate the forest.. Rather farmers plant eucalyptus (66.7%) mainly for income generation and not for the sake of protecting the effects of forest cover change..

Crop production status

Crop production was found to be the main farmers' activity primarily for subsistence and source of income. The cropping pattern is monocropping, especially at the upper part of the watershed where cultivation of barley (100%) followed by wheat (97.6%) was dominant. Beans (21.8%) and peas

(16.9%) are among the legume crops that are rotated with cereals. Teff (9.7%) and maize (24.2%) were also cultivated around the outlet of the watershed. Enset (10.4%), potato (81.5%), onion (31.5%) and other vegetables were also cultivated at the homesteads especially by using irrigation water in the lower part of the watershed. In this lower part of the watershed; crop production through the use of irrigation was wide spread after the harvest of rainy season crop, which allow for double cropping.

In the case of fertilizer utilization, farmers use both Urea and DAP (71.8%) was found to be common among farmers to solve the soil fertility problems being encountered. The amount of these commercial fertilizers applied appropriately by the farmers varies from person to person based on their economic status. Farmers with high economic level use the recommended dose of 100 kg DAP/ha and 50 kg Urea/ha (Eyasu, 2002). But 60.6% of respondents reported that they use less than the recommended dose per hectare because of their low economic status. As supplementary to the commercial fertilizers, farmers use improved seed (51.6%), pesticides and herbicides (90.3%), compost (25.8%) and FYM (88.7%) on their farm to improve soil quality. Almost all (100%) surveyed HHs had pointed out, despite having applied all these treatments to their farm land, the yield was found declining from year to year. Significant percentages of surveyed households (99.2%) believed that, the decline in the fertility of their cropland was one of the most important reasons for the reduction of yield. As management measures, farmers directly or indirectly adopt RWM to reduce erosion problems and also increasing farm inputs (84.7%). The addition of large amount of farm inputs, as practiced in the area, was meaningless with less RWM technology and maintenance practiced, nutrients together with farm inputs may be washed out from the field, thereby making it uneconomical.

Livestock production status

Among livestock kept in the study watershed are cattle, sheep, equines and chicks. Cattles are kept for meat, milk and milk products and as wealth status. Equines play beneficial roles for households as they are used to transport humans, farm products, farm inputs and other services. Similarly, sheep and chickens are reared for the sake of their meat and as a source of income.

From the total surveyed households, 94.4% had livestock. In responding to the trend of livestock in the past 10 years for those keeping livestock, all the farmers (100%) reported that the number and the productivity of the livestock had decreased from year to year. The average number of livestock possessed per HH in the watershed was cattle (4), sheep (2), Equines (2) and chicken (2) with no household having goat.

The shortage of lands for grazing had forced farmers to collect crop residues, which could have impacted on the soil properties and the long term productivity of the area. Since crop residues as source of fodder for livestock (63.7%) was also not enough, the livestock wandered the whole day along the course of streams and rivers searching for green leaves. The scarcity of water for drinking (98.4%) and the long distance to be traveled in the area plus the problems associated with water borne diseases (93.5%) called "dullandula" by the local people were among other reasons for the reduction of the number and productivity of livestock.

Food security status

Quantitative measurement of food security indicators at household level was not carried out under this study. Rather, the study relied on a self-reporting method for examining household food security. Household heads were asked whether they could meet food and other basic needs all year round from their own production and could afford to purchase from the market by deploying their own assets.

According to the results of the surveyed HHs, 35.5% of respondents felt that they are food insecure. This situation was more prevalent at the upper part of the watershed where low level of small scale irrigation system was practiced. About 24.2 % of the total HHs interviewed reported that they are food secure while 13.7% and 26.6% claimed that food supply situation varies from one year to another and from season to season respectively. According to a respondent in the upper part, it is possible to attain food security situation when the weather system especially rainfall distribution in the year is very good. But during frost (locally called "wagy") years it is impossible. Farmers also relate food insecurity situation with shortages of land for crop production and livestock rearing, the reduction of water, and soil fertility.

Causes of food insecurity

Based on the study result, the major factors for food insecurity at the household level in the watershed are

Table 3. Reasons for households becoming food insecure in the watershed under study

Reason	% of total households
Inability to produce sufficient grain due to poor RWM on crop farm and Inability to intensify production via small scale irrigation	67.7
Inability to rear sufficient number of livestock due to insufficient amount of water	52.4
Land scarcity for more grain and livestock production	72.6
Meager income from non-farm activities	7.3

land scarcity due to high population growth, which was the main problem for expansion of crop production and livestock rearing (72.6%).There was no free land to be allocated for landless farmers especially younger individuals in the watershed. This hinders both crop and livestock production and clearly contribute to affecting food security situation at the household level.

Poor RWM to produce sufficient grain and inability to intensify production via small scale irrigation by stream and rivers diversion was another reason for food insecurity. Poor RWM also resulted in surface water scarcity for livestock production (52.4%). Undulating terrain of the watershed; which makes the land more susceptible to soil erosion and soil fertility loss, and the lack of insufficient water and soil conservation measures in the watershed ultimately decreased yield resulting to food insecurity. Furthermore, nature of the terrain in the upper part of watershed also hinders the farmers from using Meja river for small scale irrigation purposes. Similarly, insufficient income derived from non-farm activities (7.3%) was a causal factor for food insecurity among the households.

Conclusion

The study concludes that the inefficient conservation practices and management of rainwater in the watershed was the root cause for water scarcity, soil and forest degradation, the reduction in crop and livestock production and productivity as well as the resultant food insecurity situation. Problems of land and water management are also aggravated by the poor and lack of participatory integrated watershed management measures by all stakeholders. Therefore, strategies to secure food among the expanding population in the study areas will have to seek a sustainable solution that better addresses the integrated watershed management efforts.

Acknowledgement

The first author would like to thank Nile Basin Development Challenge (NBDC) of the CGIAR Challenge Program on Water and Food for financing this research work. My gratitude also goes to Dr. Matthew McCartney, Dr. Birhanu Zemedam, Dr. Bharat R. Sharma, and Gerba Leta for their thoughtful guidance and encouragement.

References

Brady, N. C and Weil, R. R 2002. The nature and properties of soils. *Prentice-Hall, New Jersey*.

Degefa Tolossa and Tesfaye Tafesse. 2008. Linkages between Water supply and food security. *http://www.rippleethiopia.org/documents/stream/20080908-wp6-water-and-food-security*. accessed Oct.19.2010.

Dereje Dargie. 2010. Impact of land use change on reservoir sedimentation (case study of karadobi).*http://etd.aau.edu.et/dspace/bitstream/123456789/2211/1/DEREJE_DARGIE%20.pdf* (*Accessed, on October 19, 2010*)

District's Agriculture and Rural Development Office. 2009. Annual Report (Unpublished)

Eyasu Elias. 2002. Farmers' Perceptions of soil fertility change and management. *SOS Sahel and Institute for Sustainable Development, Addis Ababa, Ethiopia.*

Hurst, H. E, Black, R. P and Simaika, Y. M.1959. The Nile Basin. Vol. IX. The hydrology of Blue Nile and Atbara and the Main Nile to Aswan, with reference of some Projects. *Ministry of Public Works, Physical Department, Cairo, Egypt*.

Keralacalling. 2004.WatershedManagement.*http://www.kerala.gov.in/keralcalljuly04/p1719.pdf*. Via the internet accessed Oct.19.2010.

Kerr, J. 2002. Sharing the benefits of Watershed management in Sukhomajri, India. In: Selling Forest Environmental Services: Market-based mechanisms for conservation and development Pagiola S, Bishop J and Landell N (eds)-Mills*, London: Earthscan*, pp.327-343.

Kothari, C. R 2004. Research Methodology. New age International (Pvt) Ltd, publishers. *Jaipur (India)*.

Priess JA, De Koning GHJ and Veldkamp A (2001). Assessment of interactions between land use changes and carbon and nutrient fluxes in Ecuador. *Agric. Ecosyst. Environ*., 85: pp.269-279.

United Nations Environmental Protection (UNEP) (2002). Africa Environment Outlook. Past, Present and Future Perspectives.

Wani SP, Pathak P, Sreedevi TK, Singh HP and Singh P (2003). Efficient Management of Rainwater for Increased Crop Productivity and Groundwater Recharge in Asia. CAB International 2003. Water Productivity in Agriculture: Limits and Opportunities for Improvement. (eds). W. Kijne, R. Barker and D. Molden), pp.199-215.

World Bank (2007). Watershed Management Approaches, Policies and Operations: Lessons for Scaling-Up (draft report). Washington, DC: Agriculture and Rural Development Department, World Bank.