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Socio economic impact of integrated watershed management practices, Case study at Korocho Watershed, Gibe District, Hadiya zone, Southern Ethiopia

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Abstract

Integrated watershed management is becoming increasingly important concept in all over the world and attention is shifting to overall socio-economic welfare along with better water and soil conservation. It is socio- political and ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people. Therefore, this study assessed the socio economic impact of integrated watershed management practices in Korocho watershed, southern Ethiopia. Crop grain yield measurements and questionnaire survey data collection methods were employed to collect the essential data from 82 households, randomly selected from two sub-watersheds of the upper and downstream beneficiaries proportionally. Descriptive statistics and a binary logistic model were used to analyze the impacts of independent variables on farmers' adoption. Descriptive statistics and linear regression model were used to analyze the impacts of independent variables on farmers' income generation. A total of 8 independent variables were identified and used, out of which six were found to be significantly affecting farmers' income generation. These were access to irrigation, non-farm income, education, livestock owned, age and land size of respondents. The study showed that integrated watershed management has a positive impact on socio-economic welfare and it has high contribution in household annual income. Hence, better consideration of socio economic impact of integrated watershed management is critical to increase household annual income and high focus should be given to the upper beneficiaries of the watershed to minimize the income difference between the upper and lower beneficiaries.

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Introduction

Watershed degradation is a serious problem in Ethiopian threatening agricultural development and rural livelihood (Bewket, 2003).Watershed degradation not only decreased land productivity but also increased social problems (Sertse, 2007 and Darghouth *et al.*, 2008). Integrated watershed management involves the management of the socio-economic, human-institutional, and biophysical interrelationships between soil, water, and land-use (Wang *et al*, 2005). Watershed is not simply the hydrological unit but also sociopolitical and ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people (Wani *et al.*, 2008). In watershed degradation in the form of soil erosion and declining fertility is serious challenge to agricultural productivity and economic growth (Lemenih, 2004). Soil erosion is one of the features of watershed degradation. For sustainable use of these degraded resources, watershed management is imperative. Watershed management is the integrated use of land, vegetation and water in a geographically discrete drainage area (Darghouth *et al.*, 2008). Likewise, Walie (2015) indicates that watershed management deals with issues such as soil, water, forest, human resource and integrated knowledge in management of the resources. Adane (2010) reveals that participatory watershed management is considered as a management strategy aiming at reducing poverty, conserving natural resources and promoting good institutions, social linkage and economic returns.

Ethiopia is one of the poorest countries in the world (World Bank, 2003). Its economy is based mainly on agriculture providing employment for over 80% of the labor force which accounts for a little over 50% of the GDP. The watershed degradation directly affects economic development, food security, poverty alleviation and social welfare. However, fluctuations in production and volatility of markets have affected development of the sector (Kassie *et al.*, 2012). The importance of the agricultural sector is more conspicuous, especially in rural areas, where families depend heavily on agriculture to make a living (Kansiime, 2018). Watershed management is also considered as the basis for development (Mucavele, 2013). The livelihood of the vast majority of the population depends on this sector. Vulnerability of the economy to problems related to watershed degradation (Ayalneh, 2003). Several governmental & non-governmental organizations have launched integrated watershed development projects to tackle some of these generic problems (Yoganand and Tesfa, 2006). Most watershed projects in developing nations are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor (Swami *et al.*, 2012). As a result, attention to participatory watershed management is increasing across the developing world as soil erosion continues to degrade agricultural land; reservoirs and irrigation infrastructure are clogged with sediment (Kenge, 2009). Even though participatory watershed approach has now become necessary in any developmental activity especially with regards to natural resource management, there are still major challenges that militate against its successful implementation in developing countries (Mireku *et al.*, 2015).

Korocho watershed is one of the integrated watershed management practical areas developed in Gibe District. Before integrated watershed management, the watershed was known for its high erosion and nutrient depletion resulting in gully formation, silted up of cultivated and grazing lands of its downstream part. Consequently, the production and productivity of the land decreased to the extent of disabling the farming community to cover their daily food throughout declining socio economic impact of integrated watershed management. Therefore, this research is aimed to identify the socio economic impact of integrated watershed management practices in Gibe District, Southern Ethiopia.

Materials and methods

Description of the study area

This study was conducted at Korocho watershed, which is found in Gibe district, southern Ethiopia (Fig. 1). The watershed is located at distance of 272 km from the capital, Addis Ababa. It is geographically located from 37°30' 30'' to 37°45' 30'' North latitudes and from 7° 45' 0'' to 7°45' 0'' East longitudes (Fig.1). It is bordered on the South by Gombora district, on the West by Yem special district and on North and East by Misha district. The topography ranges from 1250m-2350meters above sea level with an average altitude of 1800 meters and the area is characterized by highly topography intersected by valley bottoms, mountains and flat plains. The soils at the watershed are fertile and stable with favorable physical properties. The deep porous and stable soil structure permits deep rooting and make the soil quite resistant to erosion. In those parts of the watershed where the slope is steep, the soil is highly eroded due to high rainfall and absence of vegetation coverage. The mean annual rainfall ranges from 600 to 1200mm with mean annual temperature of 18°C -32°C.

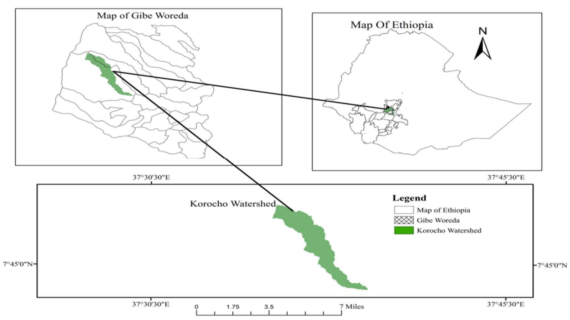

Fig. 1. Study area map.

Methods

Data sources and methods of collection

Data was gathered from both primary and secondary sources. Individual respondents were the primary source of information, which was obtained through interviews, focus groups, and key informant conversations. Whereas, the secondary data were collected from project documents district's reports and available literature. At the beginning stage of the survey, informal meetings were undertaken with a group of farmers in order to understand the general watershed and socio-economic situation of the population of the study area. Also, meetings with key informants was held to gain in-depth knowledge about the area and the focus group discussion was held with government and nongovernmental actors in watershed management, community leaders and extension workers. Field surveys were carried out to understand the socio economic condition of integrated watershed management and their impacts. As part of the process, the team did a transect walk in the selected watershed to observe the activities which included detailing the types of SWC interventions and their socio-economic impacts. Consequently, on the basis of the results obtained from the pre-test, necessary modifications were made to the questionnaire, which was ultimately translated from English into the local language, Hadiyisa. The interviews were conducted in Hadiyisa. Three enumerators were selected based on their understanding of the socio-economic condition of integrated watershed management practices. Training on how to conduct interviews and record information in the questionnaire was given researcher. At the end of the survey in each sub-watershed, discussions were held by the researcher and enumerators with key informants.

Sampling techniques and sample size

Multi-stage sampling procedures and a combination of both purposive and random sampling techniques were applied in the sampling process for the study. A multi-stage sampling procedure was used to select the study district, watershed, sub-watersheds, and sample households. In the first stage, Gibe district was selected purposively based on its accessibility for transportation and communication. In the second stage, Korocho watershed were selected purposively based on the extent of soil erosion and observable evidence related to the performance of the watershed management activities. In the third stage, two sub-watersheds were selected randomly from main watershed based on their close similarity to the selected program in their social, infrastructural, environmental settings and economic characteristics. In the fourth stage, a list of the name of the beneficiaries of the watershed was obtained in the farmers' training center of the study area and was serially numbered because the name of all the beneficiaries was registered by climate action through landscape management project. A total of 237 households benefited from the watershed, with 117 (49%) being upper-side beneficiaries and female-headed households accounting for 12% of upstream and 10% of downstream beneficiaries. The simplified formula provided by (Yilma, 2005) was used to determine the sample size of respondents at 95% confidence level, degree of variability=0.5 and level of precision= 9% (0.09):

$$n = \frac{N}{1+N(e^2)}$$

Where n is the sample size, N is the population size of the watersheds, and e is the level of precision. Depending on the formula, 82 households (41 households from each of the upper & downstream beneficiaries) were taken by stratified random sampling methods for individual interviewing; and 32 households, which included the watershed team, were purposely selected for group discussion because they were the representatives of all the community groups and had responsibility for all integrated watershed management activities. Generally, 32 male and 9 of female from the upstream, and 32 male and 9 female from the downstream beneficiaries, were selected for individual interviewing using structured and semi-structured questionnaires.

Methods of data analysis

Simple descriptive analysis was used to compute the percentages and frequencies for some socioeconomic variables. Qualitative data was analyzed by using appropriate words and content analysis. Chi-square test was used to compare the perceptions of downstream and upstream households about crop grain yields and livestock product yields after watershed management. Mean comparisons of each source of household annual income and gross annual income between the upper and lower parts of the watershed were tested using the independent sample t-test. Linear regression model allows predicting outcome from a set of variables that may be continuous and discrete or a combination.

Result and discussion

Socio-economic Characteristics Households

Farmers' socio-economic settings in different situations that affect the role of community based watershed management for community livelihood improvement in their landholdings. In this study, the demographic and socio-economic features of the sampled households were assessed and presented (Table 1). The households are characterized as 78% males and 22% females and With regard to educational level, 50% households were illiterate while 49% were literate among which 21% can read and write, 20% was primary 1st cycle (1-4) and 9% was primary 2nd cycle (5-8). About 6%, 43%, 47%, and 4% of the households' family size was in the range of 3–5 and 5-8, 8-10 an >10% members, respectively.

Table1. Socio-economic characteristics households.

Socio-economic characteristics		Frequency percent
Sex		
	Male	64 78
	Female	18 22
Age		
	25 – 40	9 11
	41 – 55	39 48
	56 – 70	29 35
	> 70	5 6
Education		
	Illiterate	41 50
	Read and write	17 21
	Primary 1st cycle (1-4)	16 20
	Primary 2nd cycle (5-8)	8 9
Family size		
	3 –5	5 6
	5– 8	35 43
	8 –10	39 47
	> 10	3 4
Marital status		
	Married	72 88
	Widowed	3 4
	Unmarried	7 8
Occupation		
	Agriculture	61 75
	Agriculture and other	21 25

Agriculture was the principal occupation for all of the households and only 25% of them are involved in other income generating activities (petty-trading, laboring, guarding, etc). The age of the sample households varies from 25 year to 70 year, with the average age being 48 years. From this, 9(11%), 39 (48%), 29 (38%), and 5(6%) were in age between 25-40, 41-55, 56-70 and greater than70 year, respectively. The majority of the households' age is between 41 and 50. This indicates that the mature households provide well contemplated response concerning the role of community based watershed management for community livelihood improvement.

Respondents' perception on crop grain yields

Most of the respondents had benefited from the increasing of barley, maize wheat and teff yields after the intervention of IWSM. From the interviewed 48%, 35%, 48 and 42% of respondents had plots of cultivated land both in the treated and untreated sub-watersheds which were planted with barley, maize, wheat and tiff, respectively. There is no significant difference in grain yields between the upstream and downstream sub-watersheds. This reflects there is no variation in contribution of integrated watershed management in soil fertility status between the two sub-watersheds. This indicates that integrated watershed management has similar contribution in increasing the yield of crops in both streams. Even though wheat and teff grain yield was higher in the upstream sub-watershed than the downstream one, no significant difference was observed. This might be due to the fact that farmers have used animal manure mostly for their plots found near their home, and most of maize crops were sown near homesteads in upstream sub-watersheds. Maize grain yields increase a little bit in downstream sub-watershed with different types of conservation structures. This in line with finding of Kassie *et al.*, (2007), which shows that farm land with stone bunds are more productive than those without such technologies in semi-arid areas but not in higher rainfall areas, apparently because the moisture conserving benefits of this technology are more beneficial in drier areas.

Farmers of the study area appreciate soil fertility impacts due to integrated watershed management indirectly in terms of the colour of plants. The quality and amount of harvest is another important measure of soil fertility. However, even in climatically good years, low crop yields are not perfect indicators of declining soil fertility, since yields may be significantly affected by a range of other factors, such as weeds or pests.

As the study of Azene, & Kimaru, (2006), farmers associate soil fertility with resistance of the crops against diseases. This is mostly a qualitative measure, pointing to the need to help farmers regulate and quantify such indirect measurements.

The high increased grain yields after the introduction of integrated watershed management might be related not only to conservation measures, but also to application of chemical fertilizer, animal manure and compost. As the farmers mentioned, even though they have used similar amount of chemical fertilizer, they were unable to get similar results in the two sub-watersheds. This might be due to the reason that chemical fertilizers could be washed away by run-off in the untreated sub watershed. However, the study conducted by Wani *et al.*, (2008) indicated that low moisture in the soil reduced nitrogen fertilizer by 38% and increased maize yield by 18%.

Table 2. Respondents' perception on main crop yields after integrated water shed anagement.

Crop type	Location of the respondent	Perception of the respondent on crop yield after IWSM			
		Increased	Decreased	No change	χ^2
Barley	Upstream	23	4	14	
	Downstream	24	3	14	0.921
Maize	Upstream	27	3	11	
	Downstream	23	4	14	0.663
Wheat	Upstream	28	3	10	
	Downstream	27	5	9	0.752
Teff	Upstream	19	6	16	
	Downstream	17	9	15	0.690

after integrated water shed management

As shown in the table 2, no significant variation was observed between the upper and lower beneficiaries of the watershed in their perception of the increase of grain yields after the introduction of integrated watershed management. In the study area, 94% of upstream and 92% of downstream respondents said that soil erosion was the main problem for their crop production before integrated watershed management. Even though there is no significant difference was observed according to χ^2 test, there is a little variation in perception among the respondents concerning the increment of major crops grain yields after integrated watershed management in the study area could be explained through the difference in exposure, position of their agricultural land, understanding of their environment or in realizing the impact of the ongoing integrated watershed management measures in their surroundings.

Perception of respondent on livestock production

Thirty three percent of the respondents have increased their number of livestock after integrated watershed management due to increasing of forage availability and income creation. Even though the total number of livestock in the watershed had been increased, 37% of the respondents explained that their livestock number was decreased after integrated watershed management practices due to reduction of free grazing and focused on improved breeds.

From the sampled households, 19% and 13% of the lower and upper stream beneficiaries had introduced modern beehives, respectively. Whereas, 24% and 15% of the lower and upper beneficiaries introduced improved dairy cows, respectively. Fifty-four percent of the respondents said.

That in addition to the introduction of modern beehives, average local honey bee yield had been increased from 12.2kg to 14.4kg per year. The average honey production from modern beehive was 21.70kg per year per hive and it ranged from 9 to 35kg per hive per year. Milk yield of local dairy cows was increased from 0.79 to 1 liter per day after integrated watershed management; and milk yield of the improved dairy cows' ranges from 1.5 to 5 liters per day. Egg production from the improved poultry ranges from 226 to 322 eggs per hen per year.

However, most of the respondents said that local poultry egg yields had no change after the introduction of integrated watershed management. Table 3 shows that there was no significant difference between the upper and lower beneficiaries of the watershed in their perception in the increase of milk, egg and honey yields after intervention.

Table 3. Perception of respondents' on livestock productivity after intervention.

Livestock type	Location of the respondent	Perception after intervention			
		Increased	Decreased	No change	χ^2
Local dairy cow	Upstream	25	3	13	
	Downstream	21	4	16	0.670
Local poultry	Upstream	25	5	11	
	Downstream	23	7	11	0.812
Local honey bee	Upstream	24	4	13	
	Downstream	20	7	14	0.544

productivity after intervention

The positive contribution of integrated watershed management in increasing of milk yield from local and cross breed dairy cows and honey production from local and modern beehives could be attributed to the improvement of forage availability by planting different exotic (sesbania) and local forage seedlings and closing of the area from animal and human interventions. The farmers have started to use the sesbania for their livestock as a supplementary feeding. Integrated watershed management has also improved the availability of local forage grasses in the communal closed areas. Demelash & Stahr, (2010) reported that enclosures combined with conservation had a positive impact on livestock productivity by increasing forage availability.

Water availability for livestock drinking was also increased after integrated watershed management measures. Decreasing of livestock grazing land had led to stay livestock around homesteads. According to the respondents and direct observation, major grazing areas available were small near to homesteads and crop aftermath together with farm boundaries.

The flat land was totally devoted to crop production. Introduction of modern beehives through formation of user groups and individuals has started in the treated hillside. Beekeeping is strategically relevant as it complements natural resource management activities and provides a means to address landless and poor households, who might not have access to other income earning activities. It has been effective in establishing start-up with new hives for individuals and cooperatives and efficient in that significant income is being produced with small investments. Meaza (2010) reported that modern beekeeping have created improved livelihood in terms of better income so as enhancing capability to buy household demands; productive investment like buying animals, saving and expenditure in different needs of the households.

The difference in introduction of improved livestock production technologies among the HHs might be due to the fact that geographical positioning of the households in the watershed and most of the farmers could not take two or more types of improved livestock technologies at the same time for fear of loan burden. Furthermore, the lower beneficiaries had access to crop residue due to more water access for livestock drinking. Even though improved forages like Leucaena leucocephala and Sesbania sesban have been expanded in the communal uncultivated lands, expansion of these improved forages in individual farmers' fields was very limited because more attention was given to crop production rather than forage production due to shortage of land. Similar results have been confirmed by Yayneshet (2010). In other cases, as Teklu *et al.* (2011) studied in Benishangul-Gumuz, expansion of improved forage among households was limited due to weak extension services and limited involvement and devotion of research institutions.

The difference in farmers' perception about the contribution of integrated watershed management to livestock productivity could be related to livestock management system, livestock number before and after integrated watershed management, different in adoption of the technologies and geographical positions among the households of the watershed. Some of the respondents had grazing land access outside the watershed and had owned more livestock before integrated watershed management. As it was pointed out in the group discussion, poor farmers were able to buy livestock after integrated watershed management and started to share grasses from the communal area. Therefore, those who keep a high number of livestock and those who used to take the share of the poor were the ones resisting expansion of zero grazing and said that their milk yield was decreased after integrated watershed management. Similar observation was confirmed by Gebreyohannes & Hailemariam (2011 (2011) in Atsbi-Wemberta district.

The contribution of integrated watershed management practices

More than 61% of the respondents perceived that watershed management is a source of income generating activities. It also allowed for a better utilization of natural resources, created employment opportunity and increased productivity. In this regard, KIs stated that majority of households in the community recognize that watershed management activities can create income, conserve natural resources from uncontrolled soil degradation, and serve as sources of animal fodder and fire wood. Hailu (2015) reports that about 92% of the respondents had perceived watershed management technologies increase land productivity. Nyssen *et al.* (2007), on the other hand, state that about 75% of the farmers in their study area were in favor of stone-bund building on their land, which can imply that the local community recognizes the benefits of conservation efforts. Various studies Bewket (2007) and Simeneh (2015), evidence that the physical soil & water conservation measures have the potential to improve cropland productivity, rehabilitate degraded land, and lead to increased crop production per hectare.

Table 4. Mean annual income sources of beneficiaries in Ethiopian birr.

Parameters	Downstream	Upstream	Total	P
Rain fed crop income	8622	8573	8597	0.786
Irrigation income	4710	89	1886	0.002
Non-farm income	3550	3603	3577	0.706
Local livestock income	5957	5284	5622	0.000
Improved livestock income	3452	3355	3404	0.683

Rain fed crop income was the major source of household annual income in both the downstream and upstream beneficiaries. The contribution of watershed management in terms of cropping income of the lower and upper beneficiaries was 39.9% and 41.2%, respectively. The contributions of improved and local livestock income of the downstream and upstream beneficiaries were 43.6% and 41.4%, respectively. The downstream beneficiaries had more and significantly different local livestock income compared to the upstream beneficiaries. Moreover, they had also more total income than the upstream beneficiaries as shown in table 4 above.

Determinants of total income at household level

Based on Table 5, the age of respondents was associated with the possibility of participation in conservation practice to produce better household income (p= 0.005) level of significance. The probability of participating in integrated watershed management activities improves by increasing in age because farmer being aware of at least one of the available land, soil and water conservation technologies in the korocho watershed. This result is in line with Zegeye (2009), which says that most of the respondents aged were assumed to have a better understanding of the problems of soil erosion due to access to information and as a result usually more interested in watershed conservation practices. In the same way Amsalu and De Graaff (2007) found significant positive relation between age and the watershed conservation practice. This result was also match with other research findings, Abebe & Sewnet (2014); and Atnafe *et al.* (2015) reported, younger farmers do not expend more effort on conservation practice as compared to older farmers

Table 5. Linear regression model estimates of the determinants for household income.

Variable	Coefficients	Standard Error	t	p
Constant	7078.26	2682.90	2.551	0.013
Family size	770.36	547.29	1.471	0.146
Age of households	8.43	2.68	2.77	0.005
Sex of households	-2598.13	2685.70	-1.601	0.1 15
Education level	9.81	4.77	2.33	0.020
Livestock owned	786.16	206.34	2.893	0.005
Irrigation access	-2030.48	1121.61	-1.70	0.008
Cultivated land size	5054.66	1125.33	2.383	0.020
Non-farm income	0.94	0.31	2.702	0.009

The educational level of the respondents were significant (p =0.020) (Table 5), and it positively affected farmers' perception of integrated watershed conservation practices in the study area. A possible explanation is that the educated farmers tend to have a better understanding of soil erosion risks and hence tend to spend more resources (time, and money) on watershed conservation practices. This result simply explain the importance of education in increasing the awareness of the farmer and chances of accepting important watershed conservation measures for sustainable agricultural practices, which is consistent with the findings of Ersado *et al.*, (2004) who found that educated farmers are able to practice information and evaluate technologies. Educated farmers can understand, analyze, and interpret the advantages of integrated watershed conservation technologies easily than uneducated farmers. Similarly, Belachew *et al.*, (2020); Daniel and Mulugeta, (2017) found a positive relationship between education and the decision to use integrated watershed conservation measures. Therefore, farmers who were literate were expected to be more likely to use integrated watershed conserving technologies & has more total respondent's annual income than illiterates. This also in line with the findings of Asayehegn, 2012, who reported that irrigation users who completed nine years of education and above were two times higher than that of non-users

Respondent's annual income & irrigation access were significant association (p =0.008) (Table 5). Increasing of irrigation access forced the farmers to introduce different fruits and vegetables. This enables them to diversify their production cropping patterns. Legesse, & Drake, (2005) studied that the variation in perception among the respondents concerning the increment of major crops grain yields after integrated watershed management in the study area could be explained through the difference in exposure, position of their agricultural land, understanding of their environment and realizing the impact of the ongoing integrated watershed management measures in their surroundings. The magnitude of the coefficient of access to irrigation reveals that irrigation has large impact to household annual income. Irrigation has an important impact on food security for farmers directly involved in production of irrigated crops, also producing a greater variety of food, some of which was used for local consumption. Ayele (2011) and Wagnew (2003) also reported that households with irrigation access have more & significant total household annual income than non-users.

The positive and significant associations of livestock with household annual income (p=0.005) (Table 5). This indicated that the large livestock number have high contribution to household annual income. This could be related to the contribution of integrated watershed management measures in terms of improved breeds of livestock, increasing forage availability and introduction of modern beehives. Mulugeta and Stahr (2010) stated that enclosures combined with SWC had a positive impact on livestock productivity by increasing forage availability. This result is also consistent with those of Herrero *et al*., (2013), who made conclusions in support of this finding. Improved nutrition through acceptance of improved forage and better crop residue management could substantially raise livestock productivity. From the farmers' point of view, beekeeping enabled them to purchase additional livestock feed and livestock number like oxen and dairy cows. Livestock production contributed to the total household income directly through the sale of livestock and their products, and indirectly through use as a source of draught power and manure for crop production activities. The highest relative advantage in household annual income contribution was recorded from the utilization of both irrigation and improved livestock technologies in integrated way. The implication of this is that introducing of integrated technologies through watershed management is better to improve household annual income rather than introducing only one type of technology or not using at all. The results of Pandit *et al.* (2007) also indicated that household income of the watershed settlers have been improved by accepting watershed-friendly activities such as agro-forestry and improved agriculture farming.

The significant impact of cultivated land to the household total income implies households with large land size can produce more and increase their total income. Thus, land holding size is an important input in rural poor households to increase their annual income (although it will typically be difficult for a household to markedly increase the size of its landholding). Because agriculture is the main source of income and livelihood for more than 85% of the country's population (Abi *et al*., 2008), land access is a critical issue in Ethiopia. This result is similar to Aikaeli (2010) in Tanzania and Ayele (2011) at Lake Tana basin of Ethiopia that land size had a positive and significant effect on household total income.

The positive and significant association of off-farm income with the household total income shows that off-farm/non-farm has high contribution in household total income. This could be related to participation in cash for work programs introduced by integrated watershed management projects. The farmers were able to purchase improved poultry, goats and modern beehives from cash for work programs after the watershed management. Furthermore, farmers who had more off-farm/non-farm income could able to use more chemical fertilizers. Other findings indicated that watershed management activities in Adarsha Watershed, Kothapally India had increased household income through non-farm activities (Wani *et al*., 2003). Pender *et al.* (2002) also reported that households with non-farm/off-farm income had higher total income than others in the Tigray region. The negative sign in the coefficients of irrigation, education, age and sex indicate that no access to irrigation, illiteracy, elder and female headed households have reduced household annual income at a rate of 961.4, 58.29 and 2698 ETB, respectively.

Conclusion

The integrated watershed management program at the Handosha watershed made significant positive impact on crops grain yield, water resources, rural livelihoods and environments. This could be related to the increasing of soil fertility after watershed treatment. Most of the respondents expressed that they had benefited from the increasing of grain yields after watershed intervention. Based on field survey, there is no significant difference in grain yields between the upstream and downstream watershed.

This reflects there is no variation in contribution of watershed management in soil fertility status between the two streams. Irrigation access was also created after watershed management practices in the downstream of the watershed, as a result, vegetables and fruits have been introduced. Furthermore, watershed management has high contribution to livestock productivity in terms of milk and honey yields. Even though there was a difference in farmers' perception about the impact of watershed management on their livestock products, most of the farmers explained that honey and milk yields have been increased after the intervention due to the increment of forage and water availability and introduction of improved breeds of livestock.

Especially, expansion of modern beekeeping is clearly observed in the rehabilitated hillside of the treated watershed. The socio-economic status of population notably enhanced due to the impact of watershed management. Income generating activities like irrigation access, improved livestock and cash for work programs introduced by watershed management program has their own contribution to household annual income.

The highest household annual income was reported in households who introduced both irrigation access and improved breeds of livestock. Furthermore, downstream households have significantly higher mean annual income than upstream households of the watershed because they were irrigation users. From this, we can conclude that introducing of two or more income generating technologies of watershed management have higher contribution to household annual income rather than introducing only one type of technology or not using *at al.* The econometric model analysis shows that having more livestock, irrigation access, off-farm income, educational level and cultivated land have a positive influence on in household annual income while our assessment reveals institutional and technical factors undermine coordination in watershed management activities. Technological options for better management must be identified to plan interventions targeting at clear and measurable outcomes.

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