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Socio-Economic Impact Assessment of Integrated Watershed Management in Sheka Watershed, Ethiopia.

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Abstract
Integrated watershed management (IWSM) was taken as the basic operational unit to rehabilitate degraded watershed and improve agricultural productivity in Ethiopia. However, its effectiveness was rarely evaluated. Therefore, this study assessed the contribution of IWSM in selected socio-economic benefits in Sheka watershed, Ethiopia. Crop grain yield measurements and questionnaire survey data collection methods were employed. Statistical methods were used to analyze the data. The results revealed that there were significantly higher teff and sorghum grain yields in the treated sub-watershed than the untreated one. Milk yield of local dairy cow and honey bee yield was increased by 12.3% and 24.24%, respectively, after IWSM. Annual household income of downstream beneficiaries of the watershed was significantly higher than upstream beneficiaries. The highest annual income was recorded from the users of both improved livestock and irrigation. The most determinant factors for household annual income were irrigation access, livestock number, cultivated land and off-farm income. The average contribution of income generating activities of IWSM in household annual income was 31.3%. Therefore, IWSM is not only effective in increasing crop and livestock production but also it has high contribution in household annual income. But high focus should be given to the upper beneficiaries of the watershed so as to minimize the income difference between the upper and lower beneficiaries. Thus, it is better to introduce IWSM in to the untreated watershed.
Key words: Integrated watershed management, upstream, downstream, Sheka watershed.

1. Introduction

Watershed degradation in Ethiopia is one of the main constraints for agricultural productivity, resulting from the interaction of natural and anthropogenic factors, including erratic rainfall, rugged topography and unsustainable land management practices, both in areas of food crops and in grazing lands. Watershed degradation not only decreased land productivity but also increased social problems (Sertse, 2007, Darghouth *et al.*, 2008). Soil erosion is one of the features of watershed degradation. In Ethiopia, soil erosion by water constitutes the most widespread and damaging process of soil degradation (Woldeamlak, 2003). It is estimated that fertile topsoil is lost at a rate of one billion cubic meters per year from all over the country, resulting in massive environmental degradation and constituting a serious threat to sustainable agriculture and forestry (Bishaw and Abdu, 2003).

Several governmental and non-governmental organizations have launched integrated watershed development projects to tackle some of these generic problems (Yoganand and Tesfa, 2006). They emphasize the need to go beyond soil and water conservation (SWC) technologies to include multiple crop-livestock interventions that support and diversify livelihood opportunities for the poor and create synergies between targeted technologies, policies and institutions to improve productivity, resource use sustainability and market access (Kerr, 2001).

In Ethiopia, watershed development planning has been started in 1980's with large watersheds (MoARD, 2005). However, large efforts remained mostly unsatisfactory due to lack of effective community participation, limited sense of responsibility on assets created and unmanageable planning units (MoARD, 2005). After some years experience, the ministry of agriculture and WFP technical staff developed simple participatory and community-based watershed planning guidelines which includes integrated natural resource management interventions, productivity intervention measures and small scale community infrastructures (MoARD, 2005).

The study area is one of the integrated watershed management (IWSM) projects developed in Ethiopia. Before IWSM, 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 the year (District Agricultural Office, unpublished). Therefore, since 1995, IWSM approach which includes physical and biological SWC measures together with enclosures and income generating technologies was launched by the integration of Relief Society of Tigray (REST) and Kolla Tembien Agricultural and Rural Development Office to overcome this problem. However, empirical data on the contribution of these measures in socio-economic benefits are lacking because no scientific research has been done in the study area. Hence, applying scientific assessment and measuring of the actual benefits gained so far by the community will create opportunity to improve and/or continue the existing IWSM interventions in the study area and other parts of the country with similar agro-ecological and socioeconomic conditions. Therefore, this study was carried out to assess the impact of IWSM technologies on crop and livestock production and evaluate its contribution to household annual income in the upper and lower beneficiaries of the watershed.

2. Materials and methods

2.1. Description of the Study Area

This study was conducted at Sheka watershed in kolla Tembien district, Tigray, Ethiopia as shown in figure 1. The watershed is located 130 km far away from Mekelle to the North-West direction with $13^{0}41^{'}42.1^{''}$-$13^{0}43^{'}26.3^{''}$ latitude and $38^{0}49^{'}20.6$''- $38^{0}49$'21.5'' longitude. According to unpublished secondary data of the agricultural and rural development office, total annual rainfall of the area ranges from 500 mm to 800 mm, which is uni-modal pattern and occurs in the months of June up to half of September. The mean annual temperature of the area is $24^{0}{}_{c}$, with a minimum of $17^{0}{}_{c}$ and a maximum of $30^{0}{}_{c}$. Its altitude ranges from 1763 up to 2032 m.a.s.l. According to agro climatic zonation of Ethiopia, it is categorized as Dry Weina-Dega zone. The soil types are mostly leptosols and cambisols (BoFED, 2003).

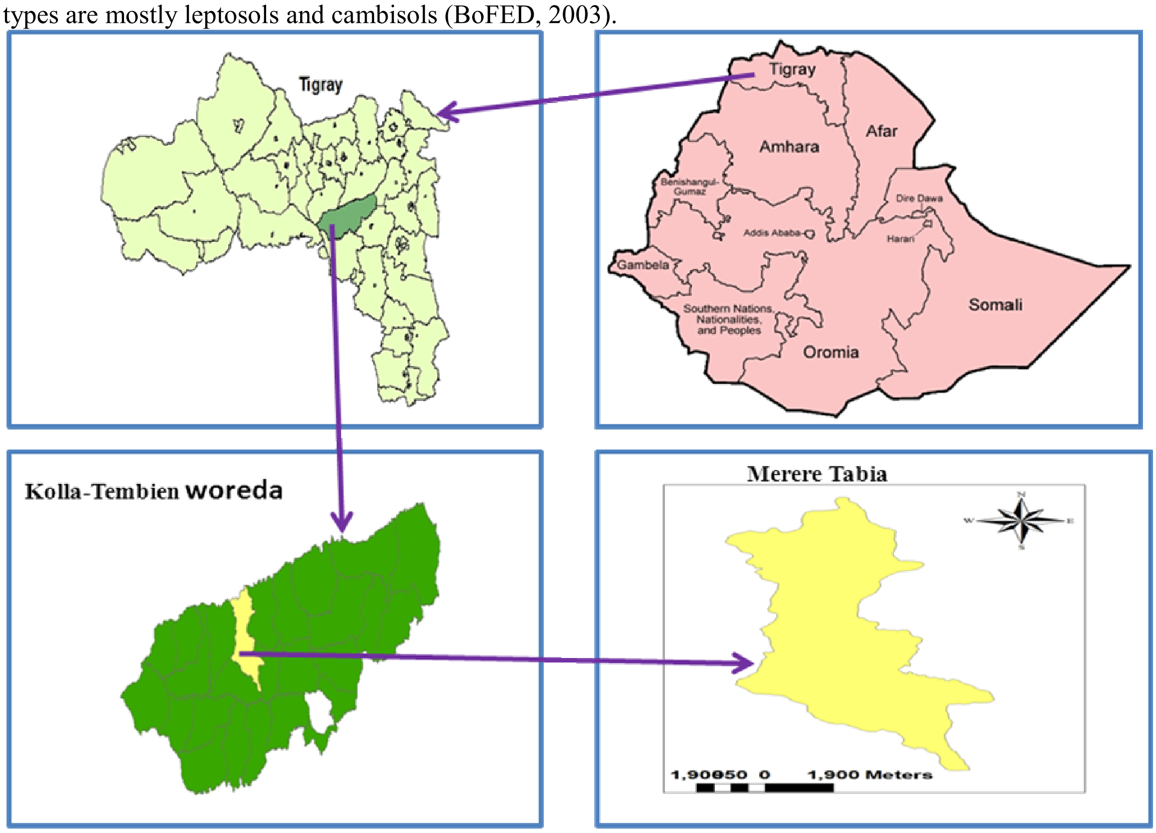

Figure 1: Location of the study area

Total population of the study site was 6553, out of which, 50.5% were female. There were about 1150 households, with 226 female headed. Accordingly, the average size of the households was 5.7 persons. From the total population of the site, 32.26% were beneficiaries of the watershed (District Agricultural Office, Unpublished). Crop-livestock integrated farming system is common in the study area where crop husbandry is the most important component of the livelihood of the farmers. The area was known for livestock production.

2.2. Measurement of Major Crops Grain Yield

So as to know the impact of IWSM on crop grain yield, the grain yield of three types of crops (maize, teff and sorghum) from each of treated and untreated sub-watersheds with four replications in each sub-watershed was weighted during harvesting time of the farmers. The sample of each crop was taken from a plot of 5m by 10m ($50m^2$) formed by systematic random sampling on transect walk of the two sub-watersheds. It was systematic because similar slope and varieties of crop (local varieties) were considered for each type of crop in order to minimize the effect of varieties and slope on crop productivity.

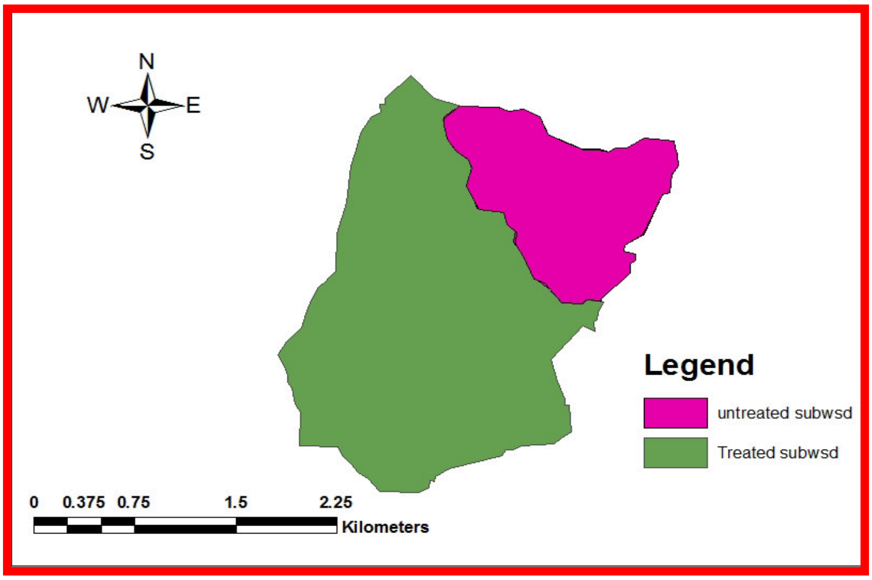

Figure 2: Map of treated and untreated sub-watersheds

2.3. Survey Data Collection

Data were collected from primary and secondary sources. The major sources of the primary data were individual farmers through interviews, focus group and key informant discussions. For the secondary data project documents, reports of office of agriculture and rural development were reviewed.

Sample selection: List of the name of the beneficiaries of the watershed was obtained in the Farmers' Training Center (FTC) of the study area and was serially numbered because the name of all the beneficiaries was registered by SLM project in 2010. There were a total of 344 households benefited from the watershed, out of which, 179 (52%) were upper side beneficiaries, and 17% of the upstream and 16% of the downstream beneficiaries were female headed households. The total sample size was taken based on the following formula (Cochran, 1977).

$n_o = Z^2pq/d^2$ ---------------------- (I) $n = n_o/(1+(n_o-1)/N)$----------------------(II)

n_o - is the desired sample size when the population is greater than 10000
n - is number of sample size when population is less than 10000
Z - is 95% confidence limit i.e. 1.96
p - is 0.1 (proportion of the population to be included in the sample i.e.10%)
q - is 1-0.1 i.e. (0.9) (proportion of the population not to be included in the sample i.e.90%)
N - is total number of population
d - is margin of error or degree of accuracy desired (0.05)

Depending on the formula (II), 70 households (35 households from each of the upper and downstream beneficiaries) were taken by stratified random sampling methods for individual interviewing; and 28 households which included watershed team were purposely selected for group discussion because they were the representative of all the community groups and have responsibility for all IWSM activities. Generally, 19% of male and 23% of female from the upstream, and 21% of male and 22% of female from the downstream beneficiaries, were selected for individual interviewing using structured and semi-structured questionnaires.

2.4. Data Analysis

The impact of IWSM on major crops grain yields was tested using Matched pairs test in JMP 5 software at $P < 0.05$ level of significance. Livestock productivity was expressed in terms of milk, egg and honey yields. Chie-square (X^2) was used to compare the perception of downstream and upstream farmers about crop grain yields and livestock product yields after intervention of IWSM. Livestock number was measured in terms of Tropical livestock unit (TLU) with average of 250 kg live weight which was calculated by conversion factor for TLU.

To evaluate household annual income, all sources of income such as crop and livestock sales and value of crops and livestock products retained for household consumption using annual average local prices were considered. The off-farm/non-farm income was also computed as part of gross household income. The income data were collected from September, 2010 to August, 2011. Test for equality of income among households who used different types of income generating activities such as improved breeds of livestock including modern beehives, cash for work program and irrigation in household gross income was computed using one way ANOVA. Least Significance Difference (LSD) was used to compare the household annual income (Morgan *et al.*

2004). Mean comparisons of each source of household annual income and gross annual income between the upper and downstream of the watershed were tested using Independent Sample T Test.

Determinants of total income at household level: In this analysis, the dependent variable was the household annual income. To identify the factors that influence household annual income, multiple linear regression model was used. Based on literature and the nature of the study, the most preferred factors expected to affect household annual income were: sex of household head, age of household head, labour equivalent of the household, size of cultivated area, irrigation access, size of livestock in terms of Tropical Livestock Unit (TLU), off-farm income and education of household head.

Multicolleaniarity was examined using Variance inflation factor (VIF), collinearity diagnostics which includes eigenvalues, condition indices (CIs) and variance proportions. Finally, a total of 8 explanatory variables were entered in to the linear regression analysis. The analysis indicates which determinants are more important for the improvement of total household income. Normality of the income variable was tested using histogram of the residuals. Mathematically, the final model was expressed as:

$$Y = ß_0 + ß_1 (Sex) + ß_2 (Cultivated\ land) + ß_3 (TLU) + ß_4 (Off\text{-}farm) + ß_5 (Labor) + ß_6 (Age) + ß_7 (Irrigation) + ß_8 (Education) + E$$

The residual term E is assumed to be normally distributed with expectation 0 and variance δ^2. The unknown parameters $ß_1$, $ß_2$…, $ß_8$ are called the regression coefficients and $ß_0$ is constant. The explanatory variables were expressed as:

Access to irrigation: Irrigation supplements moisture, which enables farmers to maximize agricultural production. It is assumed to have a direct relation with the total income of a household. Access to irrigation for household is a dummy variable, 0 if a household has access to irrigation and 1 otherwise.

Cultivated land size: Total cultivated land is the total sum of the household's own and/or rented in/out from/to other households and measured in hectares. This did not include the grazing and fallowing lands. Farmland is the major input for agricultural production in rural households.

Education level of a household head: In the study area, the head of the household is responsible for the co-ordination of the household activities. It is likely that educated farmers would more readily adopt IWSM technologies and may be easier to train through extension support. The variable entered in the model as dummy variable with zero if a household head can read and write, and otherwise one.

The number of livestock owned: This is a continuous variable measured in terms of TLU. Households with higher livestock holding would lead to higher probability of getting excess livestock for selling and hence generating additional income, particularly the owner of improved varieties of livestock including modern beekeeping could earn higher income.

Gender of the household head: This is a dummy variable with 0 for male and 1 otherwise. Male household heads are expected to have higher income compared to female household heads because of better labor inputs used in male-headed households.

Age of a household head: Age is a continuous variable and measured in years. It influences whether the household benefits from the experience of an older person, or has to base its decisions on the risk-taking attitude of a younger farmer. Advanced aged household heads are more reluctant to accept new IWSM technology and agricultural production styles than younger household heads. Thus, age of household head is hypothesized to have negative contribution to household income.

Labour equivalent: This is a continuous variable measured in terms of adult labour force. It is expected that households with more labour equivalent could have more income.

Off-farm/Non-farm income: This is a continuous variable measured in ETB. It is expected that households with more off-farm/non-farm income could earn more gross income because they might introduce improved technologies.

3. Results

3.1. Analysis of Major Crops Grain Yields

Teff (Eragrostis tef) and sorghum grain yields were significantly differed between treated and untreated sub-watersheds, with that teff and sorghum yields were increased by 62 and 61%, respectively, in the treated sub-watershed compared to the untreated sub-watershed (Table 1). Moreover, maize grain yield was increased by 27% in the treated sub-watershed over the base yield of the untreated sub-watershed (Table 1).

Table 1: The effect of IWSM on major crops grain yield (Mean ± S.E)

Type of crops	Treated sub-watershed (kg/ha)	Untreated sub-watershed (kg/ha)	P
Teff	*1037 ± 128*	640 ± 47	0.049
Maize	*3037 ± 336*	2400 ± 264	0.179
Sorghum	*2825 ± 298*	1750 ± 193	0.047

S.E__ Standard error of the mean; Mean value calculated from n = 4, kg_killogram, ha_hactare

Farmers' perception about crop grain yields: Table 2 shows that most of the respondents had benefited from the increasing of sorghum, maize and teff yields after the intervention of IWSM. From the interviewed 70 respondents, 24 (34.3%) farmers had plots of cultivated land both in the treated and untreated sub-watersheds which were planted with sorghum. As shown in the table 2, no significant difference was observed between the upper and lower beneficiaries of the watershed in their perception of the increase of sorghum, maize and teff grain yields after the introduction of IWSM.

Table 2: Farmers' perception about major crops grain yields after IWSM

Type of crop	Location of the respondent	Perception of the respondent on grain yield after IWSM			
		Increased (%)	Decreased (%)	No change (%)	X^2
Sorghum	Upstream(N=35)	80	0	20	0.777
	Downstream(N=35)	74	0	26	
	Total(N=70)	77	0	23	
Maize	Upstream(N=35)	80	0	20	0.513
	Downstream(N=35)	88	0	12	
	Total(N=70)	84	0	16	
Teff	Upstream(N=35)	77	0	23	0.083
	Downstream(N=35)	94	0	6	
	Total(N=70)	86	0	14	

After the intervention of IWSM measures, the irrigation area was increased from zero to 14.04 ha inside the watershed and 10 ha outside the watershed by using a canal from the watershed (District Agricultural Office, Unpublished). Forty percent of the respondents had cultivated maize in rainfed and irrigated areas with integration of tomato, onion, carrot, pepper, orange, papaya and banana in the irrigation area. In the study area, 90% of the respondents said that soil erosion was the main problem for their crop production before IWSM.

3.2. Perception of Farmers about Livestock Production

Thirty two percent of the respondents have increased their number of livestock after IWSM due to increasing of forage availability and income creation. Even though the total number of livestock in the watershed had been increased, 57% of the respondents explained that their livestock number was decreased after IWSM due to reduction of free grazing and focused on improved breeds. REST and sustainable land management projects provided improved livestock types like dairy cows (Barka/Begait breeds), poultry (Bovine brown and Rhod Island Red) and modern beehives through loan. From the sampled households, 20% and 29% of the lower and upper stream beneficiaries had introduced modern beehives, respectively. Whereas, 23% and 14.3% of the lower and upper beneficiaries introduced improved dairy cows, respectively. Sixty-seven percent of the respondents (Table 3) said that in addition to the introduction of modern beehives, average local honey bee yield had been increased from 13.2 kg to 16.4 kg per year. The average honey production from modern beehive was 23.75 kg per year per hive and it ranged from 10 to 45 kg per hive per year. Milk yield of local dairy cows was increased from 0.89 to 1 litre per day (12.3% increment) after IWSM; and milk yield of the improved dairy cows' ranges from 1.5 to 3 liters per day. Egg production from the improved poultry ranges from 216 to 312 eggs per hen per year. However, most of the respondents said that local poultry egg yields had no change after the introduction of IWSM (Table 3). 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 of IWSM.

Table 33: Farmers' perception about livestock productivity after IWSM

Type of livestock	Location of the respondent	Farmers' perception on livestock products after IWSM			
		Increased (%)	Decreased (%)	No change %)	X^2
Local dairy cow	Upstream (N=35)	51.4	17.1	31.4	0.57
	Downstream (N=35)	45.7	11.4	42.9	
	Total (N=70)	48.6	14.3	37.1	
Local poultry	Upstream (N=35)	2.9	0	97.1	0.32
	Downstream (N=35)	0	0	100	
	Total (N=70)	1.4	0	98.6	
Local honey bee	Upstream (N=35)	72.2	0	27.8	0.73
	Downstream (N=35)	61.9	0	38.1	
	Total (N=70)	66.7	0	33.3	

3.3. The Contribution of IWSM in Household Annual Income

Household income sources: Rain fed crop income was the major source of household annual income in both the downstream and upstream beneficiaries. The lower beneficiaries had more and significantly different cropping income compared to the upper beneficiaries; moreover, they had also more and significantly different total income than the upstream beneficiaries (Table 4). The contribution of IWSM in terms of irrigation access to the cropping income of the lower and upper beneficiaries was 35% and 2%, respectively.

Table 4: Income sources of upstream and downstream beneficiaries in ETB

Parameters	Downstream hhs (N=35)	Upstream hhs (N=35)	Total hhs (N=70) (ETB)	P
Cropping income				
Rainfed income	6865	6079	6472	0.265
Irrigated income	3710	83	1896.5	0.001
Sub-total	10575	6162	8368.5	0.001
Livestock income				
Local livestock income	3148	3053	3100.5	0.861
Improved livestock income	993	1337	1165	0.542
Sub-total	4141	4390	4265.5	0.804
Off-farm/non-farm income	2448	2426	2437	0.749
Total	**17164**	**12978**	**15071**	**0.011**

Hhs_ households

The total crop income contribution to annual household income of the upper and lower beneficiaries was 47.5% and 61.6%, respectively. Livestock production and off/non-farm activities had a contribution of 29% and 14% to the average annual income of the sampled households, respectively. Even though improved breeds of livestock including modern beehives had high contribution (21%) in household annual income of the farmers who introduced them; overall impact to the watershed was minimal (8%).

Household annual Income vs. access to irrigation and improved livestock: It was found that the users of both irrigation and improved livestock had the highest average annual income; but the smallest household annual income was observed with the non-users of irrigation and improved livestock technologies (Table 5). The average annual income for only improved livestock users was almost similar to that of only irrigation users. Mean annual income of the users of both improved livestock and irrigation technologies was significantly higher than the users of only improved livestock and irrigation; furthermore, non-users of both improved livestock and irrigation had mean annual income significantly lower than the users of improved livestock and irrigation access (Table 5). The contribution of IWSM to overall household annual income of the sampled households in terms of irrigation, improved livestock production and cash for work programs was 31.3%, with 37% to the lower beneficiaries and 24% to the upper beneficiaries.

Table 5: Household annual income Vs access to irrigation and improved livestock production

Description	Observation	Mean income + S.E (ETB)	Minimum (ETB)	Maximum (ETB)	P
Improved livestock users	10	15241 ± 1992^a	8662	27712	0.001
Irrigation users	19	14677 ± 1353^a	8074	29955	
Improved livestock and irrigation users	18	21302 ± 1601^b	10021	37836	
None of them-users	23	10425 ± 866^c	4435	19180	
Total	70	15070 ± 832	4435	37836	

S.E_ standard error of mean, mean calculated from n = 10, 19, 18 and 23

Determinants of total income at household level: According to table 6, the coefficient of irrigation access was negatively and significantly associated with the household total income as expected. From the sampled households, 81.4% of them revealed that in addition to increasing of annual income, there was an increase in the variety of foods in their diet due to the introduction of fruits and vegetables in the irrigation site. Land size was positively and significantly associated with household total income as expected. The magnitude of its coefficient was higher than the magnitude of the other coefficients. Livestock holding in TLU was positively and significantly associated with household total income. Off-farm/non-farm income influenced the household total income significantly with a positive sign (Table 6).

Table 6: Multiple Linear Regression estimates of the determinants for household income

Variable	Coefficients	Std.Error	t	P
Constant	7098.266	2782.902	2.551	0.013
Sex of household head	-2698.130	1685.700	-1.601	0.115
Cultivated area	5064.662	2125.334	2.383	0.020
TLU(Tropical Livestock Unit)	886.169	306.349	2.893	0.005
Off-farm income	0.849	0.314	2.702	0.009
Labour equivalent	790.363	537.293	1.471	0.146
Age of household head	-58.291	54.153	-1.076	0.286
Access to irrigation	-3030.480	1120.619	-2.704	0.009
Household head education	-961.374	1476.076	-.651	0.517

4. Discussion

4.1. Analysis of Major Crops Grain Yields

The significant difference in teff and sorghum grain yields between the treated and untreated sub-watersheds reflects the difference in soil fertility status between the two sub-watersheds. This indicates that IWSM has great contribution in increasing the yield of teff and sorghum grains. Even though maize grain yield was higher in the treated sub-watershed than the untreated 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. Plots 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 (Menale *et al.*, 2007). This implies that the performance of stone bunds varies by agro-ecological type, suggesting a need for the design and implementation of appropriate site-specific technologies. Wani *et al.* (2003) studied that the maximum and minimum sorghum grain yield in Adarsha IWSM were 3000 kg/ha and 470 kg/ha, respectively; and the maximum and minimum maize grain yields were 3700 kg/ha and 1400 kg/ha, respectively.

Farmers of the study area appreciate soil fertility impacts due to IWSM indirectly in terms of the colour or vigorousity 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 and Gathiru (2006) reported, farmers associate soil fertility with resistance of the crops against diseases. This is mostly a qualitative measure, pointing to the need to help farmers calibrate and quantify such indirect measurements. The high increased teff, sorghum and maize grain yields after the introduction of IWSM might be related not only to SWC measures of IWSM, 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 in the treated and untreated sub-watersheds, 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, if there is no enough moisture in the soil, reduction in nitrogen fertilizer by 38% in Veitnam, increased maize yield by 18% (Wani *et al.*, 2010).

Increasing of irrigation access forced the farmers to introduce different fruits and vegetables. This enables them to diversify their production cropping patterns. Intercropping of maize with vegetables was common in the irrigation area. The increase in irrigation access could be attributed to the increase of water availability and construction of small water harvesting structures by IWSM projects. The variation in perception among the respondents concerning the increment of major crops grain yields after IWSM 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 IWSM measures in their surrounding (Belaineh and Lars, 2005).

4.2. Livestock Production

The positive contribution of IWSM 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. IWSM has also improved the availability of local forage grasses in the communal closed areas. Mulugeta and Stahr (2010) and Tefera (2005) reported that enclosures combined with SWC had a positive impact on livestock productivity by increasing forage availability. Improved nutrition through adoption of improved forage and better crop residue management could substantially raise livestock productivity (Girma and Misra, 2007). Water availability for livestock drinking was also increased after the interventions of IWSM 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 grazing areas near homesteads and crop aftermath (stubble and weeds) 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 (Hebert, 2010). 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 households 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 twice a year by using irrigation and had 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 recorded by Yayneshet (2010) and Mekoya *et al.* (2008). In other cases, as Beyene *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 IWSM to livestock productivity could be related to livestock management system, livestock number before and after IWSM, 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 IWSM. As it was pointed out in the group discussion, poor farmers were able to buy livestock after IWSM 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 IWSM. Similar observation was recorded by Gebregziabher and Gebrehiwot (2011) in Atsbi-Wemberta district.

4.3. Determinants of Total Income at Household Level

The significant association between household's annual income and irrigation access indicates that irrigation through IWSM is one among many factors that increase household annual income. The magnitude of the coefficient of access to irrigation reveals that irrigation has large impact to household annual income. Small-scale irrigation had an important impact on food security for populations directly involved in production of irrigated crops, also producing a greater variety of food, some of which was used for local consumption, but most of which was sold to produce income (Hebert, 2010). Getaneh (2011) and Wagnew (2004) also reported that households with irrigation access had more and significant total household annual income than non-users. The positive and significant associations of TLU with total household annual income indicates that large total livestock number have high contribution to household annual income. This could be related to the contribution of IWSM in terms of improved breeds of livestock, increasing forage availability and introduction of modern beehives. From the farmers' point of view, beekeeping enabled them to purchase additional livestock feed and livestock number like oxen and dairy cows. Livestock production contributes to 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. Even if the result of this study shows that TLU has a positive impact on household annual income, increasing the number of livestock may increase the cost of production and might have negative impacts to the watershed. Therefore, additional research is needed to study the cost and benefit analysis of livestock production and the carrying capacity of the watershed for livestock production. 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 result of Pandit *et al.* (2007) also indicated that household income of the watershed settlers have been improved by adopting watershed-friendly activities such as agro-forestry and improved agriculture farming.

The significant impact of cultivated land holding 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 (World Bank, 2008), land access is a critical issue in Ethiopia. This result is similar to Aikaeli (2010) in Tanzania and Getaneh (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 IWSM projects. The farmers were able to purchase improved poultry, goats and modern beehives from cash for work programs after the IWSM. 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 Kothapally watershed had increased household income through non-farm activities (Wani, 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.

5. Conclusions

IWSM has a positive and significant impact on major crops grain yield. This could be related to the increasing of soil fertility in the treated sub-watershed. Even though there was no significant difference in maize grain yield between the treated and untreated sub-watersheds, most of the respondents expressed that maize grain yield was increased more than by half after the intervention of IWSM because the farmers were aware of the problems of soil erosion on their crop productivity. Irrigation access was also created after IWSM in the downstream of the watershed, consequently, vegetables and fruits have been introduced. Furthermore, IWSM has high contribution to livestock productivity in terms of milk, egg and honey yields. Even though there was a difference in farmers' perception about the impact of IWSM on their livestock products, most of the farmers explained that honey and milk yields have been increased after the intervention of IWSM 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 sub-watershed. After the introductions of IWSM, farmers were able to own livestock, but free grazing was decreased (most of the farmers keep their livestock near their home).

Income generating activities like irrigation access, improved livestock and cash for work programs introduced by IWSM 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 IWSM have higher contribution to household annual income rather than introducing only one type of technology or not using at all. Multiple Linear Regression Model analysis also shows that having more livestock, irrigation access, off-farm income and large size of cultivated land have significant contribution in household annual income. Therefore, integrated watershed management is not only effective in increasing crop and livestock production but it has also high contribution in household annual income.

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References

Aikaeli, J., 2010. 'Determinants of Rural Income in Tanzania: An Emprical Research'. Research report 10/4, Dares Salaam, REPOA.

Azene Bekele and Gathiru Kimaru, 2006. Participatory watershed management: Lessons from RELMA's work with farmers in eastern Africa. ICRAF Working Paper no 22.

Belaineh, L. and Lars, D., 2005. Determinants of smallholder farmers' perceptions of risk in the Eastern

Highlands of Ethiopia. J. Risk Res. 8 (5): 383-416.

Beyene Teklu, Tegene Negesse and Ayana Angassa., 2011. Effect of farming systems on livestock feed resources and feeding systems in Benishangul-Gumuz region, western Ethiopia. Hawassa University, Wondo Genet College of Forestry and Natural Resource, Shashamene. *International Research Journal of Agricultural Science and Soil Science* Vol. 1(1) pp. 020-028.

Bishaw Badege and Abdu Abdelkadir, 2003. Agroforestry and Community Forestry for Rehabilitation of Degraded Watersheds on the Ethiopian Highlands. College of Forestry, Oregon State University, Corvallis, Oregon 97331, U.S.A. International Symposium on Contemporary Development Issues in Addis Ababa, Ethiopia.

BoFED (Bureau of Finance and Economic Development), 2003. Soil map of Tigray. Tigray regional states BoFED, physical planning development, GIS center, Tigray, Ethiopia.

Cochran, W., 1977. Sampling Techn`1iques. 3rd ed. John Wiley and sons. USA.

Darghouth, S., Ward, C., Gambarelli, G., Styger, E. and Roux, J., 2008. Watershed Management Approaches, Policies and Operations: Lessons for Scaling Up. Water Sector Board Discussion Paper Series Paper No 11. The World Bank, Washington, DC.

Gebregziabher Gebreyohannes and Gebrehiwot Hailemariam, 2011. Challenges, Opportunities and Available Good Practices related to Zero Grazing in Tigray and Hararghe, Ethiopia. DCG Report No. 66.

Getaneh Kebede, 2011. The Impact of Selected Small-Scale Irrigation schemes on Household income and the Likelihood of Poverty in the Lake Tana Basin of Ethiopia. M.Sc. Thesis, Presented to the Faculty of the Graguate School of Cornell University.

Girma Tadesse and Misra, A.K., 2007. Water and livestock for human development. Chapter 13. Livestock help the world's poor escape poverty, Nigeria. IWMI Part 4 Ch8-16 final.indd 485.

Hebert, P., 2010. An Evaluation of Catholic Relief Services (CRS) Integrated Watershed Management Programs in Ethiopia.

Kerr, J., 2001. Watershed project performance in India: conservation, productivity, and equity. American Journal of Agricultural Economics 83 (5), 1223-1230.

Meaza Gebreyohannes, 2010. Socio-Economic Analysis of Market Oriented Beekeeping in Atsbi Wemberta District of Eastern Zone, Tigray Region. A Thesis Submitted to Master of Arts Degree in Development Studies. Mekelle University, Mekelle, Ethiopia.

Mekoya, A., Oosting, S.J., Fernandez-Rivera, S., Van der Zijpp, A.J., 2008. Multipurpose fodder trees in the Ethiopian highlands: Farmers' preference and relationship of indigenous knowledge of feed value with laboratory indicators. Agricultural Systems 96, 184-194.

Menale Kassie, Pender, J., Mahmud Yesuf, Kohlin, G., Bluffstone, R. and Elias Mulugeta, 2007. Impact of Soil Conservation on Crop Production in the Northern Ethiopian Highlands. IFPRI Discussion Paper 00733.

MoARD (Ministry of Agriculture and Rural Development), 2005. Guide line for integrated watershed management, Addis Ababa, Ethiopia.

Morgan, A., Leech, L., Gloeckner, W. and Barrett, C., 2004. SPSS for introductory statistics use and interpretation. 2nd ed. Publishers: Lawrence Erlbaum Associates, Mahwah, New Jersey.

Mulugeta Demelash and Stahr, K., 2010. Assessment of integrated soil and water conservation measures on key soil properties in South Gonder, North-Western Highlands of Ethiopia. Orthodox Church Development and Interchurch Aid Commission (EOC-DICAC), Addis Ababa, Ethiopia.

Pandit, B.H., Wagley, M.P, Neupane, R.P. and Raj, B., 2007. Watershed Management and Livelihoods: Lessons from Nepal. Journal of Forest and Livelihood 6(2): 67-74 and 1-9.

Pender, J., Berhanu Gebremedhin and Mitiku Haile, 2002. Economic Returns And Impacts of Policies And Programs Affecting Land Management in Tigray Policies For Sustainable Land Management in The Highlands of Tigray, Northern Ethiopia. International Food Policy Research Institute (IFPRI), Mekelle, Ethiopia. EPTD Workshop Summary Paper No. 14.

Sertse Sebuh, 2007. Study and design guidelines on watershed management with reference to forestry.Unpublished. Bureau of Agriculture and Rural Development (BoARD), Mekelle, Tigray.

Tefera Mengistu, Demel Teketay, Hakan Hulten and Yonas Yemshaw, 2005. The role of communities in closed area management in Ethiopia. *Mountain Research and Development* Vol 25, No 1: 44–50.

Wagnew Ayalneh, 2004. Socio economic and environmental impact assessment of community based small-scale irrigation in the Upper Awash Basin. A case study of four community based irrigation schemes. M.Sc. Thesis Submitted to School of Graduate Studies, Environmental Science Program, Addis Ababa University.

Wani, S.P., Singh, H.P., Sreedevi, T.K., Pathak, P., Rego, T.J., Shiferaw, B. and Iyer, S.R., 2003. Farmer-Participatory Integrated Watershed Management: Adarsha Watershed, Kothapally India: An Innovative and Upscalable Approach. Case 7. Pages 123–147 in Research Towards Integrated Natural Resources Management.

Wani, S. P, Wangkahart, T., Dixin, Y., Li, Z. and Thang, N., 2010. Community watersheds for food security and coping with impacts of climate change in rain fed areas. Global Theme on Agro ecosystems, International Crops Research institute for the Semi Arid Tropics (ICRISAT), Patancheru.

Woldeamlak Bewket, 2003. Towards Integrated Watershed Management in high lands of Ethiopia: the Chemoga watershed case study. Tropical Resource Management Papers, No. 44 (2003); ISBN 90-6754-708-5.

World Bank, 2008. Environmental and Natural Resources Management. Federal Democratic Republic of Ethiopia for a Sustainable Land Management Project. Report No: 42927-ET.

Yayneshet Tesfay, 2010. Feed Resources Availability in Tigray Region, Northern Ethiopia for Production of Export Quality Meat and livestock. Ethiopia Sanitary and Phytosanitary Standards and Livestock and meat marketing Program (SPS-LMM) Texas A and M University System.

Yoganand, B. and Tesfa Gebremedhin, 2006. Participatory Watershed Management for Sustainable Rural Livelihoods in India Research Paper.