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Farmers' Perception on Integrated Watershed Management and Household Annual Income Evaluation at Maego Watershed, North Ethiopia

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Authors' contributions

This work was carried out in collaboration between the both authors. Author GYD designed the study, wrote the protocol, managed the analyses of the study, managed the literature searches, read and approved the final manuscript. Author DEY performed the statistical analysis and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to assess integrated watershed management (IWSM) measures and determinant factors for household annual income at Maego watershed. Fifty one respondents were randomly selected from the upper and lower watershed beneficiaries and interviewed. Participatory Rural Appraisal was employed during the data collection. Simple descriptive statistical analysis and general linear regression model were used to analyze the data using SPSS and STATA softwares. Most of the farmers explained that even though the number of livestock owned by each household was decreased, the number of households which owned livestock had increased after IWSM. Exotic and cross breeds of livestock has been introduced with IWSM. The most commonly used soil and water (SWC) practices on farmlands were normal trench, stone bund and cut-off drain. Whereas, deep trench has been used on uncultivated land. Hillside and bench terraces have been used on both cultivated and uncultivated lands. Most of the respondents rated SWC measures as very intensive to protect soil erosion in flat and steep slopes; whereas in gentle slope they rated as intensive. According to most of the respondents, IWSM had a positive impact on soil fertility, soil

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moisture, irrigation expansion, grass biomass and water level in wells. Furthermore, household annual income was significantly increased after IWSM. This increased income was recorded from rain fed and irrigated crop production, cattle, poultry and off-farm income. The determinant factors of household annual income after the watershed management were livestock size, labor equivalent, access to market, distance to input supply, farming experience, age and education of household head. Therefore, in designing to improve household income with watershed management, it is recommended to focus on adjusting to these factors. The farmers said that using of fuel wood from the exclosure was prohibited. There should be well managed fuel wood consumption from the closed areas.

Keywords: Income; integrated watershed management; Maego watershed.

1. INTRODUCTION

The backbone of the Ethiopian economy is Agriculture. However, its productivity has been decreased due to degradation of agricultural land induced by soil erosion [1]. Deforestation and high rate of soil erosion are also serious environmental problems. They have been severely reducing the capacity of natural resource to contribute for food security, and other benefits, such as fodder and fuel wood in Ethiopia [2,3]. Measurements from experimental plots estimated that annual soil loss from cropland was about 42 t ha^{-1} $year^{-1}$ [4]. Land degradation not only decreases land productivity but also accelerated ecological degradation and increased social problems [5,6]. Soil erosion and consequent degradation of agricultural land is particularly severe in the highlands of Ethiopia. Tamene et al. [7] indicated that some 50% of the highlands of Ethiopia were already significantly eroded, and that erosion was causing an annual decline in land productivity by 2.2%. Sustainable, effective and efficient methods against erosion and degradation is an integral component of natural resource management to achieve productive agriculture, food security and restoration of ecology [7,8].

In coping with land degradation, soil and water conservation (SWC) measures through watershed approach and exclosures of degraded hillsides have been extensively carried out in Ethiopia, especially in the Tigray region under various packages by governmental and non-governmental organizations [9]. The impacts of these measures can be classified into short- and long-term effects based on the time needed to become effective against soil erosion [10]. The short-term effects of the structures are the reduction in slope length and the creation of small retention basins for run-off and sediment immediately after construction and reduce soil loss [11]. The medium- and long-term effects include the reduction in slope angle by formed bench terraces, development of vegetation cover on the bunds and gullies, and change in land management [11].

Even though a lot of efforts has been made by the government of Ethiopia to reduce land degradation, the results are not as such the country demands and most of the implemented SWC measures are not sustainable [12]. In developing countries most of the time farmers are enforced to participate in the conservation activity without any clear identification and priority of their needs [8,13]. Without identifying how local peoples are deciding to use their land and integrated SWC practices cannot be understood [14,15]. Considering farmers' perception on integrated watershed management is effective mechanism for the sustainable implementation of watershed management activities [16]. The benefits and constraint of integrated watershed management have not been scientifically studied. Therefore, the specific objectives of this study were: 1) To assess perception of farmers on the benefits of integrated watershed management; 2) To assess the perception of farmers about soil erosion and SWC practices; 3) To identify determinant factors of household annual income.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study area of the watershed is situated in Kilte Awulaelo district, Tigray, Ethiopia; and located between 13°33' and 13°58' latitude north and 39°18' to 39°41' longitude east. The watershed is located 55 km North of Mekelle which is the capital city of Tigray region. Its elevation ranges from 2220 to 2561 m.a.s.l. According to the simplified traditional agro-climatic classification system, which considers only altitude, the study area is characterized by *Weina-Dega*. The temperature range of the area is between 16°C and 34°C and the annual rainfall is within the range of 300 to 1200 mm with an average of 583.9 mmy^{-1} The rainfall is unimodal but erratic in variability and amount within and among seasons. The main rainy season is very short and extends from June to the first week of September (Ethiopia Meteorological Service Agency, 2016). Agriculture is the main source of income in the area, where the farming system is characterized by small-scale production of mixed crops and livestock (Wukro office of Agriculture, 2016, unpublished). Vegetation types and the agriculture production are influenced by the marked seasonality in rainfall distribution. The major crops grown in the area are wheat and Barley and the major livestock production are composition of cattle, sheep, goat, chickens and bee colony (Wukro office of Agriculture, 2016, unpublished). The most dominant tree which is naturally grown on the uncultivated part of the watershed is *Acacia etibaica*. The dominant exotic tree species in the watershed is *Eucalyptus camaldulensis.* The land holding size of most farmers in the study area was less than 1 hectare. The major soil types of the study site were Lithic Leptosol, Eutric Leptosol, Chromic Luvisol and Calcaric Cambisol [17].

2.2 Sampling Technique and Data Collection

A total of 51 representative sample households were randomly selected from the upper and lower beneficiaries of the watershed (Table 1). A formal survey was conducted after developing structured and semi-structured questionnaires to assess the gender, age, education, land tenure status, effects of institutional settings and social networks. Moreover, the impact of integrated SWC measures on annual household income and perception of farmers about soil erosion status, income generating activities, major crops production and productivity and irrigation activities was assessed. Secondary data such as climate, demographic and other related data was collected from the Bureau of Agriculture and Rural Development.

2.3 Data Analysis

The quantitative and qualitative data were analyzed using simple descriptive statistics such as frequency, percentage, range, minimum, maximum, standard deviation and t-test. Furthermore, in analyzing the determinant factors for household annual income, a general linear regression model was used. Several determinant factors were selected based on the household's characteristics, institutional arrangement and based on literature reviewed. For this reason, twelve households' attributes were included in the regression analysis. In addressing the general linear regression model, all the original least square (OLS) assumptions were followed and the data were found suited to the model due to the linear behavior of income and the regresses were also found with no endogenity problem. Using Breusch-Pagan / Cook-Weisberg test for heteroscedasticity, the data were also with no homoscedasticity problem and using on the Ramsey RESET test using powers of the fitted values of total income of household, it was found with no omitted variable. In managing and analyzing the data, STATA and SPSS softwares were used. Mathematically, the final model was expressed as follows:

$$Y= ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5X_5 + ß_6X_6 + ß_7X_7 + ß_8X_8 + ß_9X_9 + ß_{10}X_{10} + ß_{11}X_{11} + ß_{12}X_{12} +E$$

In this model $ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5X_5 + ß_6X_6 + ß_7X_7 + ß_8X_8 + ß_9X_9 + ß_{10}X_{10}+ ß_{11}X_{11} + ß_{12}X_{12}$ is the systematic (or explanatory) part of the model and E is the random (unexplained) part of the model. The residual term E is again assumed to be normally distributed with expectation 0 and variance $δ^2$. The unknown parameters $ß_1$, $ß_2$…, $ß_{12}$ are called the regression coefficients and $ß_0$ is constant. Y is household annual income; X_1, X_2, …,X_{12} are explanatory variables.

Table 1. Location of sample respondents

Location of respondents	Number of respondents	Percent
Downstream	25	49.02
Upstream	26	50.98
Total	51	100.00

3. RESULTS AND DISCUSSION

3.1 Household Characteristics

The age of the respondents ranged between 30 to 75 years, with averagely 49.75 years and 98% of them were male. Of the total respondents, 94.1% were married and 33.3% of them were illiterate, whereas 66.7% were able to read and write. The majority of households in the study watershed have more than 3 members-positively contributed to accomplish their farming activities and watershed management. The households also hold an average of 0.87 ha farmland (Table 2).

3.2 Livestock Holding Before and After Integrated Watershed Management

Livestock production has been used as an option strategy for sustaining livelihood in the study area. Before the introduction of integrated watershed management, 72.55% of the respondents had owned livestock, but after the introduction of integrated watershed management, the number of respondents who owned livestock has increased to 90.2% (Table 3).

To the contrary, the size of livestock in Tropical Livestock Unit (TLU) reduced from a total of 285.85 to 185.38 TLU. The average household's livestock holding size was 5.60 TLU before IWSM within the range of 0 - 34.98 TLU. But, after the IWSM it was reduced to an average of 3.63 TLU within the range of 0 - 9.98 TLU (Table 4). The reduction of the livestock could also be related with the preference of the households on introducing improved livestock management practices, introduction of improved breeds of livestock than keeping unmanageable size and change of land use management policies such as avoiding of free grazing.

3.3 Institutional Characteristics

The respondents received an average annual extension contact of 28.82 days per annum with minimum no extension contact and maximum 48 days extension contact per year (Table 5). Some of the respondents can travel one hour and twenty minutes on foot from their home to get extension services and market access.

Thirty three percent of the respondents said that they did not have market access for their forest products. However, they perceived that the price of forest products has been increasing from time to time.

3.4 Adoption of Soil and Water Conservation Practices

Stone bunds, trenches, hillside terraces, bench terraces and cut-off drains are the most dominant soil and water conservation techniques in the watershed. The survey showed that normal trench, stone bunds and cut-off drains were the most dominant ones on cultivated lands; whereas, deep trench was mostly constructed on uncultivated lands. Bench and hillside terraces have been constructed on both the cultivated and uncultivated lands (Table 6). Deep trench and bench terraces are the newly introduced

Table 2. Demographic characteristics of the respondents

Household characteristics		N = 51	Proportion of the total (%)	Mean	Std. Dev.	Min.	Max.
Sex	Male	50	98				
	Female	1	2				
Age (year)				49.75	11.26	30	75
Marital status	Single	1	2				
	Married	48	94.1				
	Widowed	2	3.9				
Farming experience (years)				27.63	13.98	6	50
Experience of IWSM (year)				10.02	3.80	0	20
Land holding (ha)				0.87	0.63	0	2.75
Education	Illiteracy	17	33.3				
	Read and write	34	66.7				
Family size in man equivalent				3.21	1.55	1.3	7.5

Source data: Survey data 2016

Table 3. Livestock holding summery

Response	Ownership of livestock before IWSM		Ownership of livestock after IWSM	
	Respondents	Percent	Respondents	Percent
Yes	37	72.55	46	90.20
No	14	27.45	5	9.80
Total	51	100.00	51	100.00

Source data: Survey data 2016

Table 4. Livestock holding in type

Type of livestock	No of animals owned Before IWSM				No of animals owned after IWSM				Difference (After-before)
	Local breeds	Cross breeds	Exotic breeds	Total in TLU	Local breeds	Cross breeds	Exotic breeds	Total in TLU	
Sheep	395	0	0	51.25	248	1	0	32.37	-18.98
Goats	325	0	0	42.25	99	3	0	13.26	-28.99
Cows	84	0	0	84	56	7	0	63	-21
Bulls/Oxen	50	0	0	50	45	0	1	32.2	-17.8
Calves	25	0	0	6.25	25	2	0	6.75	0.5
Donkey	48	0	0	48	54	0	0	37.8	-10.2
Mule	2	0	0	2	0	0	0	0	-2
Poultry	139	0	0	1.807	130	18	205	4.589	2.782
Bee Hive	65				4	10			
Total	928	0	0	285.56				189.97	-95.59
Mean				5.60				3.63	-1.88
Sta. dev.				6.20				2.15	
Minimum				0				0	0
Maximum				34.98				9.98	-24.99

Source data: Survey data 2016

Table 5. Distance from homestead to institutions

Variables	Obs.	Measurement	Mean	Std. Dev.	Min	Max
Extension contact	51	No of days/year	28.82	17.46	0	48
Distance to extension	51	In walking minutes	38.43	29.09	2	120
Distance to input supply	51	In walking minutes	37.67	27.37	1	90
Distance to district	51	In walking minutes	26.94	30.31	1	120
Distance to nearest market	51	In walking minutes	36.67	28.82	0	120

Source data: Survey data 2016

techniques to the watershed. From the interviewed farmers, 78.6, 66.7 and 51.6% of them ranked 1st for integration of physical and biological SWC measures, check dam and bench terrace, respectively in protection of soil erosion. However, most of the farmers (68.6%) had not used integration of physical and biological SWC measures. According to the respondents, free grazing and scarcity of land were the main problems for plantation of trees/grasses as biological measures. Some of the surveyed farmers described their adoption and participation in the construction of various conservation structures on communal lands were undertaken against their will, development agents was taken the lead to enforce and impose punishment for not being participate in conservation activities. The primary reason for this was feeling of ownership insecurity. Majority (90%) of the farmers had made maintenance for the collapsed SWC structures on their farmlands. Whereas, 10% of them had no maintained SWC structures due to the shortage of labor.

3.5 Perception of Farmers on Soil and Water Conservation Measures

Majority of the respondents rated soil erosion as severe before the implementation of SWC measures in all slope categories of the watershed. The reason was that even though run-off was not created on the flat land, it was damaged by sediment deposition coming from the upper catchment and gully was created on the flat and gentle slopes. They observed frequently how the loss of soil from cultivated fields has been reducing the depth of the topsoil through time and the number of stones in their farmlands has been increasing over time. Assefa [18] reported the most important top soil for crop production activity was deteriorating over time due to erosion processes. Whereas, after the construction of SWC measures, most of the respondents mentioned that soil erosion was slight in flat and gentle slopes; and medium in moderate and steep slopes (Table 7).

Farmers have good perception on SWC measures to protect soil erosion on their farmlands. Most of the respondents (36.73 and 48% of them) rated SWC measures as very intensive on the flat and steep slopes, respectively. On the gentle slope, most of the respondents (60.42%) rated its effect as intensive to protect soil erosion (Table 8). Similar results have been reported by Awdenegest and Holden [19] that farmers believed soil erosion and soil fertility loss can be controlled by SWC measures. However, Tesfay et al. [20] found that majority of the surveyed farmers observed an increasing trend in the severity of soil erosion over the past 8 years (80%).

3.6 Opinions on the Benefits of SWC Structures

The majority of the farmers (92%) reported that soil erosion, soil moisture and soil fertility were the main problems for crop productivity before integrated watershed management. However, after the introduction of integrated SWC measures the effect of soil erosion on crop productivity was decreased. From the interviewed farmers, 29.4% of them said that there was no soil erosion, soil fertility and soil moisture problems on their crop productivity after SWC measures. As indicated in table 9, majority of the farmers explained that soil fertility, soil moisture, availability of grasses, irrigation area, water level in wells and spring development have been increased due to the reduction of soil erosion by SWC practices. Similar observation was recorded by Worku and Tripathi [21]. Wolka et al. [22] also reported that farmers had a positive opinion about the role of SWC in improving soil fertility and crop productivity in southern Ethiopia. However, some respondents (5.88 and 7.84%) mentioned that water level in wells and spring development decreased, respectively after integrated watershed management; and 21.57% of the respondents reported that there was no change in water level in wells and spring development (Table 9). Farmers of the study area appreciate soil fertility impacts due to integrated SWC indirectly in

Table 6. Adoption of soil and water conservation measures

Types of SWC measures	Users on cultivated land	Users on uncultivated land	Users on both land use types	Non -users
Hillside terrace	2 (3.92%)	20 (39.2%)	17 (33.33%)	12 (23.53%)
Bench terrace	2 (3.92%)	20 (39.2%)	17 (33.33%)	12 (23.53%)
Stone bund	7 (13.73%)	11(21.57%)	16 (31.37%)	17 (33.33%)
Deep trench	3 (5.88%)	21 (41.18%)	5 (9.8%)	22 (43.14%)
Normal trench	14 (27.5%)	8 (15.7%)	7 (13.73%)	22 (43.14%)
Half moons	1(2%)	17 (33.33%)	5 (9.8%)	28 (54.9%)
Check dams	6 (11.76%)	11(21.57%)	8 (15.7%)	26 (50.98%)
Integration of physical and biological SWC	3 (5.88%)	5 (9.8%)	8 (15.7%)	35 (68.63%)
Plantation of trees and grasses on contours	5 (9.8%)	7 (13.73%)	5 (9.8%)	34 (66.67%)
Cut-off drain	12 (23.53%)	10 (19.61%)	3 (5.88%)	26 (50.98%)

Source data: Survey data 2016

Table 7. Rating of soil erosion before and after implementation of SWC measures

Slope category	Rating of soil erosion (From 51 respondents)					
	Slight		Medium		Severe	
	Before SWC(%)	After SWC(%)	Before SWC(%)	After SWC(%)	Before SWC(%)	After SWC(%)
Flat	11.36	58.8	40.9	29.4	47.7	11.76
Gentle	14.28	57.57	38.77	36.36	46.94	6
Moderate	27.94	43.24	22	51.35	50	5.4
Sloppy	0	33.33	28.57	63.33	71.43	3.33

Table 8. Rating of SWC measures to protect soil erosion

Rating of SWC measures	Flat Slope		Gentle Slope		Moderate Slope		Steep Slope	
	Number of respondents	%	Number of respondents	%	Number of respondents	%	Number of respondents	%
Low	7	14.29	1	2.08	1	2.04	13	26.00
Moderate	9	18.37	10	20.83	18	36.73	6	12.00
Intensive	15	30.61	29	60.42	15	30.61	7	14.00
Very intensive	18	36.73	8	16.67	15	30.61	24	48.00
Total	49	100	48	100	49	99.99	50	100

Source data: Survey data 2016

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 [23] 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. Demissie and Fisseha [24] reported that farmer perception of erosion severity also explained yield loss perceptions with the same direction of effect, suggesting that farmer perceptions of yield loss depend on their perceptions of soil loss.

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 [25].

3.7 Income Status of Households Before and After IWSM

Household annual income was significantly increased after integrated watershed management (Table 10).

The determinant factors that significantly and positively affecting the annual household income after IWSM were farming experience of the household head, livestock number in tropical livestock unit (TLU), family size in labor equivalent, access to market and distance to input supply from the homestead. To the contrary, age and education of the household head were significantly and negatively affecting the income level of the household (Table 11). This means the more aged and educated of the household head, the less income of the household. This may be due to the fact that the more educated persons are the young ones in their age and have less involved in agricultural activities. However, Getaneh [26] concluded that education had a positive impact on household annual income in Lake Tana basin of Ethiopia. Household family size in labor equivalent means a larger amount of labor available to the household. Labor increases productivity per ha of land, and in turn, household total income increases for a given land base. The positive association between labor and household total income seems reasonable. Households which are near to input supply had more income than far away households because they can get easily an access for agricultural inputs like chemical fertilizers, new seeds, pesticides and the like. Similar results have been recorded by Getaneh [26] in Lake Tana basin of Ethiopia. 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 and increasing forage availability. 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. Pender et al. [27]) found that improved livestock production significantly increased household income, both directly through income earned from livestock, and by contributing to increased crop production.

Most of the respondents (92 and 86%) replied that income sources from rain fed and irrigation, respectively were increased after IWSM. Similarly, 67 and 80% of the respondents said that the income sources from cattle and poultry, respectively were increased after IWSM (Table 12). According to the respondents (78%), the income obtained from off-farm income like food for work programs was highly increased due to IWSM. To the contrary, the respondents (78

Table 9. Farmers' perception on the impact of SWC measures on biophysical factors

Rating Effect	Soil fertility		Soil moisture		Grass biomass		Irrigation area		water level in wells		spring development	
	Resp.	**%**	**Resp.**	**%**	**Resp.**	**%**	**Resp.**	**%**	**Resp.**	**%**	**Resp.**	**%**
Increased	45	88.24	49	96.08	50	98.04	41	80.39	37	72.55	36	70.59
Decreased	2	3.92	2	3.92	1	1.96	2	3.92	3	5.88	4	7.84
no change	4	7.84	0	0	0	0	8	15.69	11	21.57	11	21.57
Total	51	100	51	100	51	100	51	100	51	100	51	100

Source data: Survey data 2016
Resp. = Number of respondents

Table 10. Two-sample t test with unequal variances

Variable	Mean annual household income (EBR)	Std. Dev.	Min	Max	P value
Income before IWSM	5799.84	4581.81	900	20148	0.0001
Income after IWSM	14160.86	9400.62	3000	63000	

Source data: Survey data 2016

Table 11. Determinant factors for household annual income after IWSM

Income after IWSM	Coef.	Std. Err.	T	P>t	[95% Conf.	Interval]
Age	-413.7404***	128.4536	-3.22	0.003	-673.7811	-153.6998
Education	-780.5838*	444.3166	-1.76	0.087	-1680.056	118.8881
Farming experience	310.645**	150.583	2.06	0.046	5.805704	615.4843
Land size	-133.3139	2137.539	-0.06	0.951	-4460.536	4193.908
Livestock number	1315.528**	568.6111	2.31	0.026	164.4353	2466.621
Family size	1638.15*	854.3715	1.92	0.063	-91.43475	3367.735
Extension contact	-39.72339	72.24547	-0.55	0.586	-185.9767	106.5299
Access to market	5152.523*	2784.111	1.85	0.072	-483.6154	10788.66
Distance to input SS	86.41161*	49.94643	1.73	0.092	-14.69964	187.5229
Distance to Market	-43.11218	48.63459	-0.89	0.381	-141.5678	55.34341
Access to Credit	-2756.604	2918.688	-0.94	0.351	-8665.178	3151.971
Distance to road	78.64919	49.04558	1.60	0.117	-20.6384	177.9368
Constant	19263.07*	6814.263	2.83	0.007	5468.313	33057.82

Source data: Survey data 2016

, **, * = specifies the significant variables at 10, 5, 1 level of significance, respectively*

Table 12. Impact of IWSM on household income sources

Income sources	Amount of income after IWSM					
	Increased		Decreased		The same	
	Resp.	%	Resp.	%	Resp.	%
Crop production						
Rain fed	47	92.16	1	1.96	3	5.88
Irrigation	44	86.27	1	1.96	6	11.76
Animal production						
Cattle	34	66.67	11	21.57	6	11.76
Sheep and Goat	21	41.18	23	45.10	7	13.73
Donkey	11	21.57	18	35.29	22	43.14
Beekeeping	18	35.29	18	35.29	15	29.41
Poultry	41	80.39	9	17.65	1	1.96
Off-farm income	40	78.43	10	19.61	1	1.96
Selling wood/tree	12	23.53	39	76.47		

Source data: Survey data 2016

Resp. = Number of respondents

and 45%) responded that income sources from selling of wood and sheep and goat, respectively have been decreased after IWSM (Table 12). According to the farmers, using of fire wood from the exclosure was totally prohibited. This was managed by the kebelle administrative bodies. Furthermore, the number of sheep and goats owned by each household was decreased after IWSM due to the prohibition of free grazing. But there was limitation of distributing high productive breeds of sheep and goats in the watershed.

4. CONLUSIONS AND RECOMMENA-TIONS

Even though the size of livestock per household was decreased in the watershed, the number of households which owned livestock had increased after the introduction of IWSM. Furthermore, the number of exotic and cross breeds of livestock has been increased after IWSM. The most commonly used SWC practices on farmlands were normal trench, stone bunds and cut-off drain. Whereas, deep trench has been mostly used on uncultivated land. Hillside and bench terraces have been used on both cultivated and uncultivated lands. Most of the respondents rated SWC measures as very intensive to protect soil erosion in flat and steep slopes; whereas in gentle slope they rated as intensive.

Effectively rehabilitating and management of watershed resources had considerable benefits for agricultural productivity and household income improvement. According to most of the respondents, IWSM had a positive impact on biophysical factors such as soil fertility, soil moisture, irrigation expansion, grass biomass and water level in wells. Furthermore, household annual income was significantly increased after IWSM. According to the respondents, this increased income was recorded from rain fed and irrigated crop production, cattle, poultry and off-farm income. However, the income obtained from selling wood, sheep and goat was decreased. The main determinant factors of household annual income were age of household head, education of household head, labor equivalent, livestock number, farming experience of household head, access to market and distance to input supply from the homestead. Age and education negatively affected household income. This means more aged and educated household heads had less income.

For the successful implementation of IWSM, farmers' awareness about long term and short term benefit obtained from rehabilitated watershed is critical. It is recommended to expand improved livestock production that could be interlinked positively with watershed development such as introducing more productive breeds of livestock, especially sheep and improved bee-keeping with intensive management at household level. There should be well managed fuel wood consumption from the closed areas by introducing Farmers Managed Natural resource Regeneration (FMNR) practices. In designing to improve household income in relation to watershed development, it is recommended to focus on adjusting and fine tuning to the factors such as farming experience, livestock holding, family size, access to market, distance to input supply, age and education of the household head.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Teshome A, Rolker D, de Graaff J. Financial viability of soil and water conservation technologies in northwestern Ethiopian highlands. Appl. Geogr. 2012; 37:139-49.
2. Berry L. Land degradation in Ethiopia: Its extent and impact. Commissioned by the GM with WB support; 2003.
3. Tesfa A, Mekuriaw S. The effect of land degradation on farm size dynamics and crop-livestock farming system in Ethiopia: A review. Open Journal of Soil Science*;* 2014.
4. Wagayehu B, Drake L. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: A case study of the Hunde-Lafto area. Ecol. Econ. 2003;46(3): 437-451.
5. Sertse Sebuh. Study and design guidelines on watershed management with reference to forestry. Unpublished. Bureau of Agriculture and Rural Development (BoARD), Mekelle, Tigray; 2007.
6. Darghouth S, Ward C, Gambarelli G, Styger E, Roux J. Watershed Management Approaches, Policies and Operations: Lessons for Scaling Up. Water Sector Board Discussion Paper Series Paper No 11. The World Bank, Washington, DC; 2008.
7. Tamene L, Park SJ, Dikau R, Vlek PLG. Analysis of factors determining sediment yield variability in the highlands of northern Ethiopia. Geomorphology. 2006;76(1):76-91.
8. Shiferaw E. Awareness and views of farming households regarding land resource degradation and conservation-the case of Bule Hora, Ethiopia; 2015.
9. MoARD (Ministry of Agriculture and Rural Development). Guide line for integrated watershed management, Addis Ababa, Ethiopia; 2005.
10. Morgan RP. Soil erosion and conservation, 3rd edition. Blackwell Science Ltd. 2005;304.
11. Bosshart, U. Catchment Discharge and Suspended Sediment Transport as Indicators of Physical Soil and Water Conservation in the Mayketin Catchment, Afdeyu Research Unit. A Case Study in the Northern Highlands of Eritrea. Bern, SCRP. Research Report. 1997;39:137.
12. Taddese, G. Land degradation: A challenge to Ethiopia. Environmental Management. 2001;27:815-824.
13. Bewket, W. Soil and water conservation intervention with conventional technologies in northwestern highlands of Ethiopia: Acceptance and adoption by farmers. Land Use Policy. 2007;24:404-416.
14. Mazzucato V, Niemeijer D. Rethinking soil and water conservation in a changing

society: A case study in eastern Burkina Faso; 2000.
15. Mbaga-Semgalawe, Z. Folmer H. Household adoption behavior of improved soil conservation: The case of the North Pare and West Usambara Mountains of Tanzania. Land use policy. 2000;17(4); 321-336.
16. Daba S. An investigation of the physical and socioeconomic determinants of soil erosion in the Hararghe Highlands, eastern Ethiopia. Land degradation & development. 2003;14(1):69-81.
17. FAO (Food and Agriculture Organization of the United Nations). World Reference Base for Soil Resources. World Soil Resources Report, number 84. FAO, Rome. 1998;88.
18. Assefa, D. Assessment of upland erosion processes and farmer's perception of land conservation in Debre-Mewi watershed, near Lake Tana, Ethiopia. M.Sc thesis Cornell University, United States. 2009;86.
19. Awdenegest, M. and Holden, M. Farmers' Perceptions of Soil erosion and soil fertility loss in Southern Ethiopia. Land Degrad. Develop. 2007;18:543-554.
20. Tesfay GZ, Mohammed M, Taddesse, Chenchu S. Adoption of Structural Soil and Water Conservation Technologies by Small holder farmers in Adama Wereda, East Shewa, Ethiopia. International Journal of Advanced Structures and Geotechnical Engineering. ISSN 2319-5347. 2013;02(02):58-68.
21. Worku T, Tripathi SK. Farmer's perception on soil erosion and land degradation problems and management practices in the Beressa Watershed of Ethiopia. Journal of Water Resources and Ocean Science; 2016. ISSN: 2328-7993.
22. Wolka K, Moges A, Yimer F. Farmers' perception of the effects of soil and water conservation structures on crop production: The case of Bokole watershed, Southern Ethiopia. African Journal of Environmental Science and Technology. ISSN 1996-0786. 2013;7(11):990-1000.
23. Azene Bekele, Gathiru Kimaru. Participatory watershed management: Lessons from RELMA's work with farmers in eastern Africa. ICRAF Working Paper. 2006;22.
24. Demissie SW, Fisseha G. Perception of farmers toward physical soil and water conservation structures in Wyebla watershed, Northwest Ethiopia. World Journal of Agricultural Sciences. ISSN 1817-3047. 2016;12(1):57-63.
25. Belaineh L, Lars D. Determinants of smallholder farmers' perceptions of risk in the Eastern Highlands of Ethiopia. J. Risk Res. 2005;8(5):383-416.
26. Getaneh Kebede. 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; 2011. (In press)
27. Pender J, Berhanu Gebremedhin, Mitiku Haile. 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; 2002.

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