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Impacts of soil and water conservation practices on livelihood: The case of watershed in Gambela region, Ethiopia

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In this study, multistage sampling technique was used. 132 households were selected out of 2,943 households in three sampled kebeles (the lowest administrative structure in Ethiopia) of Godere Woreda (*Woreda* is administrative structure above *Kebele)*. Household-based interview, key informants interview (KII) and transect walk were used in order to collect data. Practiced households have harvested an average of 44.74 quintal of crop production per hectare per year while non-practiced households reaped a mean of 23.29 quintal of crop production per hectare per year with mean difference equivalent to 21.5 kg while practiced households earned an average of 3282.58 and non-practiced households earned a mean of 2661.97 Ethiopian birr per household per year with mean difference equivalent to 620.6. Practiced households demand an average of four persons while non-practiced households require an average of two persons per household. Practiced households use a mean of 30.89 kg of Di-amonnium phosphate (DAP) while non-practiced households use an average of 62.92 kg in their crop fields with mean difference equivalent to 32.03 kg. Practiced households use a mean of 22.27 kg of Urea fertilizer per household in their crop fields whereas non-practiced households use an average of 53.56 kg with mean difference equivalent to 31.28 kg of Urea fertilizer per household. With these findings, it is rationale to conclude that SWC measures have positive impact on crop production. It has slight contribution to household income. Labour demand (household and hired) increase, level of inorganic fertilizer use decrease but use of organic fertilizer increase. Thus, it is worth to recommend that non-practiced households need to be aware about the advantages of conservation measures but with due consideration to challenges hindering adoption. SWC measures need to be integrated with other income generating activities.

Key words: Impacts, Livelihood, practiced, non-practiced, household, adoption.

INTRODUCTION

Eighty five percent of Ethiopia population depends on small scale and rain fed agriculture as a source of livelihood (UNDP, 2016). However, agricultural production from smallholder farmers do not keep pace with rapidly

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rising population in the country (Ethiopia) and thus resources degradation is eminent (GTPII, 2016). This resources degradation could be attributed to factors like population pressure, topographic gradient, land fragmentation, overstocking of livestock, land use conversion, variability in climatic elements, and traditional agriculture practices. While Ethiopia population is currently growing at a rate of three percent (3%) (World population prospect, 2017), agricultural production rate was reported to decline from 9.6 to 6.3% at the end of the country's first growth and transformation plan (Adimasu, 2012). A dramatic increase in population and concurrent decline in agricultural production is an indication of poverty prevalence for agro-dependent population.

The complexity and fragility of Ethiopia's landscape makes its soil highly susceptible to land degradation and consequently the serious negative impact on farmers' livelihood and food security status. Natural resources degradation is closely linked to community livelihood. For instance, a degraded watershed has a few or limited opportunities for water harvesting and management, difficulty in accessing clean water for domestic uses, no or limited opportunities to participate in income generating activities because all these opportunities are directly linked to the health of watershed. Thus, community livelihood would be seriously affected in unhealthy watershed. Therefore, community based participatory watershed development and planning was adopted with the aim to improve livelihood of farmers and enhance ecosystem functions (Lakew, 2005).

At regional context, Gambela, as one of the administrative region in Ethiopia has its landscape dominated by lowland topographic characteristics and a moisture-stressed area; however, the topography of Godere district is at the transitional zone between escarpment of Sheka Zone of SNNPR and Gambela plain of the Anuak Zone (Gambela Agriculture and Natural Resource Bureau, 2017). Thus, it is the part of Gambela which is prone to soil erosion by water because of its location in upland relative to other part of Gambela (Gambela Agriculture and Natural Resource Bureau, 2017). Majority of this area has been under the threat of soil erosion caused by runoff and thus reduced the productivity of the land and crops production as well. This scenario negatively affects the livelihood of most households particularly the poor rural population since their livelihood mainly depend on agriculture (USAID, 2009). An effort to curb natural resources degradation, particularly land degradation in farmland and communal grazing land and thus improve rural livelihood has been attempted by the Ethiopia government in partnership with sustainable land management project in Zeiy watershed in Godere district of Majang zone, Gambela region. However, communities of this watershed (Zeiy) were reported to be reluctant to implement soil and water conservation practices mainly because they are unaware about the importance of conservation practices (Gambela Agriculture and Natural Resource Bureau, 2017). Sustainable land management project has been a long time partner of Ethiopia government in its fight against land degradation and improvement of livelihood through enhancing agricultural production across the country (MoA, 2013).

The impact of these interventions have been assessed in many parts of Ethiopia and the results of those assessments have been used to inform farmers about the advantages of managing their own farmlands and improving pastureland productivity through SWC measures and thus increase their participation in watershed development activities which could even improve their livelihood.

However, there is no study which assessed the impact of watershed interventions particularly soil and water conservation measures in Zeiy watershed of Majang zone, Gambela Regional state. Therefore, this study was initiated in order to assess the impacts of soil and water conservation practices on farmers' Livelihood in Zeiy watershed of Majang Zone, Gambela Regional State in order to fill this knowledge gap.

METHODOLOGY

Description of the study area

Godere is part of Majang zone which is bordered on the southeast by SNNPR and on the west by the Mengeshi district. The largest town in this district is Meti. This district lies at the coordinates of 7°9'30″-7°29'00″N latitude and 35°00'00″-35°30'00″E longitude.

Godere district's Agro-ecology is wet *kola* with altitudinal ranges of 500-1000 m.a.s.l having undulating terrain features and slope range of 2-4% (gentle slope) (Livelihood, 2009; Wikepedia, 2017). There are two distinct rainy seasons (Belg and Meher) which stretch from mid-February to December. The area receives on average 1600-2100mm of rainfall per year (USAID, 2009). Figure 1

Research approach

This study followed mixed research approach. Both qualitative and quantitative data were collected and analyzed. Qualitative data such as household characteristics and adoption of organic fertilizer were collected. Quantitative data related to crop yield, income and amount of inorganic fertilizer were also collected and analyzed and output presented in the results section of this manuscript.

Sampling Technique and Size Determination

For this study, a multistage sampling technique was followed. First, the whole watershed was clustered into three clusters based on topographic gradient (elevation) or the location along the landscape which was very subjective. These clusters are upstream (2,062-1,549 m.a.s.l), midstream (1,375-1,362 m.a.s.l) and downstream (1,192-1,162 m.a.s.l) (Gambella Agriculture and Natural Resource Bureau, 2017). Thus, a simple random sampling technique was applied in order to select one kebele from each cluster. As a result of this random selection, three kebeles namely, Kabo, Mehakelgna

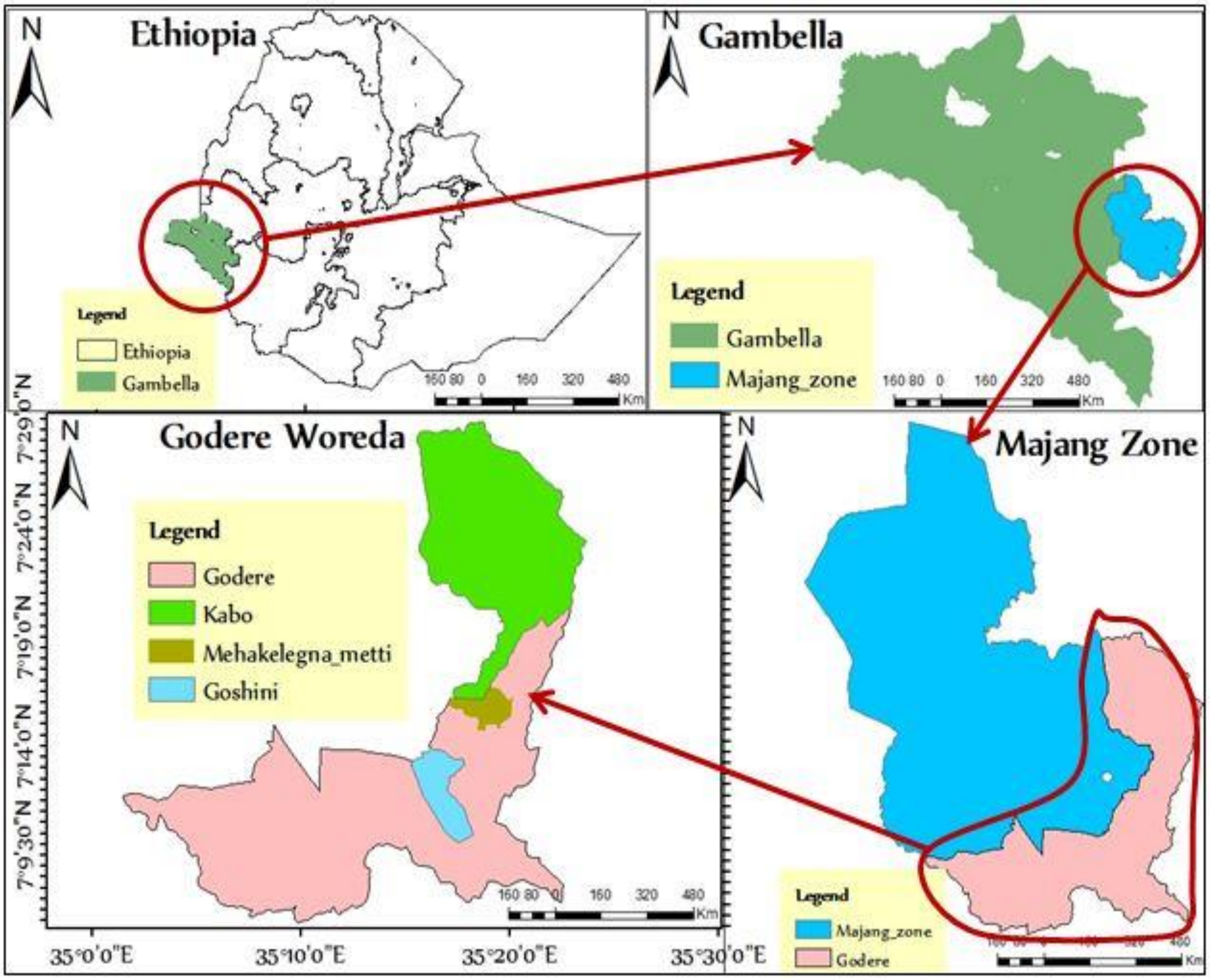

Figure 1. Map of the study area.
Source: CSA (2007).

Metti and Goshini were selected from upstream, midstream and downstream respectively.

Second, since it was very difficult to obtain secondary data on adoption, in each selected kebele snowball sampling technique was used to ensure that SWC practiced and non-practiced households were included in the survey. With this technique, all households in each selected kebele were considered as non-practiced (maintenance of status quo) and the first respondent was selected randomly by following the transect walk.

In order to determine the appropriate sample size for the study, a Kothari (2004) sample size determination formula was used. Kothari's sample size determination formula is explained here below. Zeiy watershed (study area) has 8,829 households from nine rural kebeles (Gambella Agriculture and Natural Resource Bureau, 2017) and considered as a study population. Meanwhile, from the total households of the watershed, three study kebeles namely Kabo, Mehakelegna Metti and Goshini constitute 2,943 total households.

By taking 10% as a proportion (p) of the target population with ninety 95% confidence interval (Z=1.96) and 5% acceptable error margin (e), a total sample size (n) for the study was calculated from the target population according to the Equation 1:

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

Where, n= the minimum number of sample size within the range of acceptable error margin; N= the total number of households of the target population; z= confidence level (95% which is equivalent to 1.96); e= acceptable error margin (5%); p= proportion of sampled households; q= estimate of the proportion of households to be sample.

By substituting the above equation, a total sample size of one hundred thirty two (132) respondents was obtained. Using the above calculated sample size, another sub-sample which is proportional to the size of the minimum target population was also determined. For calculation of the sub-sample size refer to the Equation 2:

$$ni = \frac{Ni}{N}(n) \quad (2)$$

Where, ni= the required sample size from each selected *kebele*; N_i=Total number of households in each selected *kebele*; N= Total number of households in all selected *kebeles*; n = Total sample size from the target population.

By using the equation above, a sub-sample size was determined from each selected kebele. Accordingly, thirty four (34), forty four (44) and fifty four (54) respondent households were selected from Kabo, Mehakelegna metti and Goshini respectively for household based interview.

Data analysis

Independent sample t-test has been used in order to compare the means of data between two independent samples (practiced and non-practiced households). These samples are SWC practiced and non-practiced households. Frequencies tables were analyzed to know the proportion of each and every variable in the study. Descriptive statistics was performed for continuous variables. Cross-tabulation was also performed for categorical variables. Chi-square and student t-tests were used for categorical and continuous variables respectively in order to test the significant of the mean difference between two groups (SWC practiced and non-practiced). Pearson correlation and linear regression were used to test the relationships and effects among variables.

RESULTS AND DISCUSSION

Current state of soil and water conservation in Zeiy Watershed

According to Hurni et al. (2016), SWC measures are recommended to be implemented based on agro-ecology and land use type. All SWC measures are classified into physical, agronomic and vegetative type and their implementation is agro-ecological and land use type specific. Thus, based on Hurni et al. (2016) the study watershed could be classified as wet kolla agro-ecology (wet lowland) with its altitude ranges from 500-1000m above sea level (m.a.s.l) and average annual rainfall range of 1600-2100 mm (USAID, 2009).

The analysis result indicated that majority of respondent households in Mehakelegna metti (9%) and Kabo (11%) adopted integrated SWC measures which combine different physical, biological and agronomic measures whereas in Goshini (13%) most respondent households are largely practicing agronomic conservation measures.

Analysis result indicated that, out of 50% of households who practiced soil and water conservation measures, half (25%) of households adopted combination of different soil and water conservation measures. Field observation has indicated that households who practices conservation measures constructed contour soil bund and trenches in a field where coffee is intercropped with *Sesbania sesban* plant species in order to control runoff, reduce raindrop impact and diversification of crops while at least 4% of practiced households implemented land management practices such as zero tillage practices and application of organic fertilizer (Figure 2). Mixing of various conservation measures improve the effectiveness of the measures toward controlling soil erosion. For instant, key informant interview has shown that contour soil bunds stabilized with *vetiver grasses* are highly effective in controlling runoff. Reduction of runoff minimizes soil erosion risk which affects soil quality and thus reduces crop production. But with reduction of runoff by conservation structures, crop production should improve as a result. The remaining 50% are non-practiced households.

Income sources distribution

Rural income generating activities (RIGA, 2015) project on its survey across Ethiopia obtained that 51% share of household income is derived from crop production. This study result shows that 58% of the total households in the study watershed earned their income from the crop sales. If this % share of crop sales is disaggregated into kebeles, it become 12, 26 and 20% from Kabo, Mehakelegna metti and Goshini derived their income from crop marketing respectively. Income source is linked to livelihood strategy; therefore households who derived greater proportion of their income from crop production are more likely to engage in soil and water conservation in order to increase their agricultural production and consequently acquired their required income. Rural communities who pursue agriculture as source of their livelihood are highly probable to implement conservation measures in their farmlands as intensification of agriculture is the survival option and they should work hard to improve crops production.

Type of crop grown by SWC adoption classes

Analysis of result also revealed that 15% of households who practiced soil and water conservation measures grow different type of crop either in rotation or mixed in the same field. These include intercropping of *S. sesban* with coffee and mixing of maize with leguminous plant like soya bean. Growing of fruits such as mango, avocado, pineapple and banana in home garden is also common practice. However, majority of households who do not practice conservation largely grow food crops such as maize and sorghum in their fields. Type of crop grown by the household could influence the decision of the household to invest in soil and water conservation. For instant, households who grow cash crops are more likely to practice soil and water conservation measures because of their desire to increase the production of those crops grown for cash and improve household income. In addition, different crops have different adaption mechanism to their environment. Crops that are sensitive to soil degradation require improvement of soil quality which could push the household depending on those degradation sensitive crops to implement conservation measures in order to promote the production of those crops. Thus, crop varieties and type could influence households to adopt conservation measures.

Chi-square test result indicated that there is no

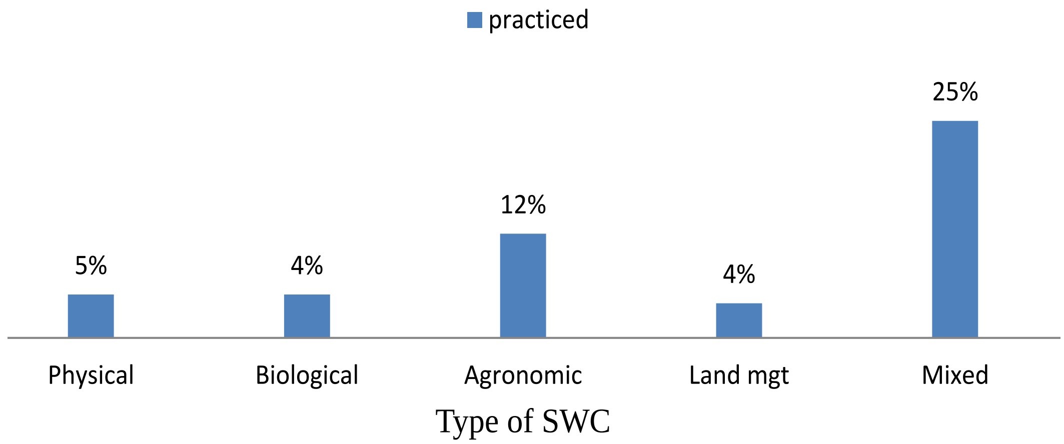

Figure 2. Types of SWC measures under practice in the study area.

significant difference (Pearson chi-square=0.044, p=0.834) between groups (practiced and non-practiced) regarding the type of crops grown by the households. This may be partly because non-practiced households also grow fruit crops like mango, avocado, pineapple and banana since both groups defend on rain fed farming practices because SWC measures practiced in the area were not implemented along with water harvesting technique which could have boosted the crops productivity and thus increase production per household for households who practiced soil and water conservation measures. In this study area, field observation and key informant interview indicated that coffee is grown by many households as a cash crop. In Figure 3 it can be observed that non-practiced households grow mainly food as source of food and cash. These food crops are mainly maize and sorghum which is grown by non-practiced households too. Thus, many crop types are commonly grow by both groups which could be an evident that both groups should not differ significant by crop type.

Impacts of soil and water conservation measures on crop yield

The analysis result indicated that the mean total crop yield for SWC practiced respondent households is higher (44.74quintal per hectare per household) than SWC non-practiced respondent households (23.29 quintal per hectare per household) with mean total crop yield difference equivalent to 21.5 quintal per hectare per household (Table 1).

The hypothesis that whether there is crop yield difference or not between SWC practiced and non-practiced households was tested with student t-test and the result indicated a highly significant difference ($p<0.05$) in mean total crop yield between SWC practiced and non-practiced households (Table 1). With this hypothesis test result, the null hypothesis that there is no crop yield difference between SWC practiced and non-practiced households could be rejected while the alternative hypothesis that there is crop yield difference between SWC practiced and non-practiced households could be accepted.

The relationship between SWC adoption and crop production per household was tested with Pearson correlation and linear regression. Analysis result revealed that there is positive and statistically significant relationship between SWC adoption and crop production with Pearson correlation equal to 0.414 and $p<0.05$. This relationship suggested that adoption of SWC may increase crop production. Field observation during the first round visit in dry season indicated that fields of practiced households have more crop residues that are deliberately left in the field as mulch than non-practiced households. The next round field visit in rainy season indicated that crops in the field of practiced households where mulch had been in crop field in dry season look greener than crop grow in previously burned fields. This may be an indication that SWC adoption improve soil quality and consequently increase crop production. The present of perennial crops such as banana, mango and avocado and other biological conservation measures like *vetiver* grass in the farms of practiced households protect their fields from both water and wind erosion and hold soil nutrient in place which is beneficial for crop production.

In general, different studies argued that crop yield is influenced by various factors including soil quality, crop varieties, climate, land management and topographic gradient.

However, factors like soil quality, land management and topographic gradient can be influenced by SWC measures such that organic matter accumulation from agronomic and biological SWC measures enhance soil quality while physical conservation are capable to alter topographic gradient and thus land management change

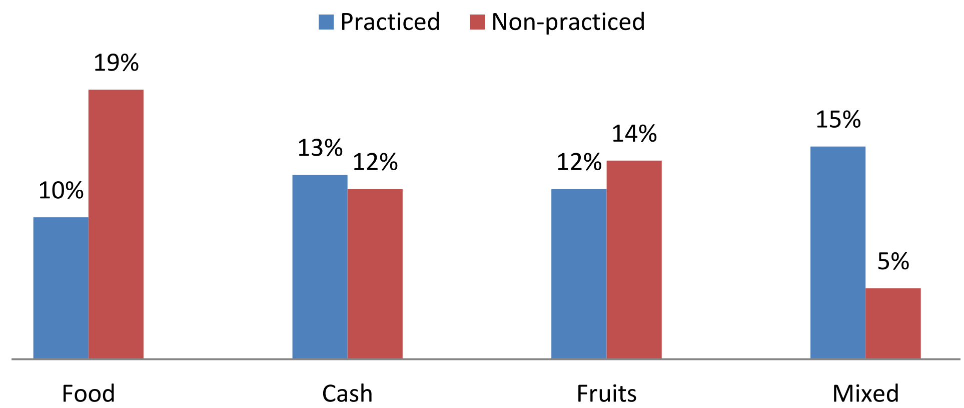

Figure 3. Type of crop and adoption of SWC practices.

Table 1. Mean crop yield for practiced and non-practiced households.

Parameter	Practiced	Non-Practiced	Mean difference	T-value	P-value
Total Average crop yield (Q/ha)	44.74	23.29	21.5	5.19	0.00(p<0.05)

afterwards. Regarding farm size of the two groups, analysis result revealed that practiced households have mean land holding size of 1.03 hectare per household while non-practiced households have 1.43 hectare per household. This indicated that non-practiced households have slightly larger farm size than practiced households. If farm size alone is a guarantee for crop yield, non-practiced households could have higher crop yield than practiced households. The soil type is mainly fertile fluvisols and deep well drained dystric nitosols of moderate fertility (Gambela Agriculture and Natural Resource Bureau, 2017).

Field observation indicated that the soil looks dark brownish and feel slightly gritty. This soil type and texture was considered the same for all households and then could not cause any yield different between groups. As reported by Demelash and Stahr (2010), Hailu (2017) and Gebregziabher et al. (2016) that soil and water conservation measures improved soil textures, reduce bulk density, increase infiltration rate, increase organic matter content and increase nutrient availability, thus in Zeiy watershed households who practiced soil and water conservation a field with improved soil fertility than non-practiced households. This could be another reason for increase in yield of those households who practiced soil and water conservation than non-practiced households. Other potential external factors like rainfall, temperature and humidity that could influence crop yield were considered to be constant. In addition, topographic influence is another influential factor that might affect crop yield. Households who practiced soil and water conservation practices constructed conservation measures which reduced slope length and gradient and then minimize the impact of runoff on top soil removal which contain many essential plant growth nutrients such nitrogen, phosphorous and potassium. Reduction of crop nutrient losses could in turn increase crop production. An effort by the government to increase the production of smallholder farmers might be another reason for improvement in crop production of smallholder farmers because it was reported that the contribution of crop sub-sector to country‘s GDP was 27.4% at the end of GTPI (GTPII, 2016).

In line with this finding, Abebe (2015) found an improvement in crop yield of adopter households as compared to non-adopter in Adwa and Amba Alagie district in Tigray region. Yenealem (2013) also indicated that there is additional crop production value equal to 1,510.42 birr for adopter households than non-adopter in west Harareghe, Oromia region. Another finding from Hadush (2015) revealed that crop production increase to 0.673ton/ha in smallholder farms who adopted SWC measures in Adwa district, Tigray region. According to Benin (2006), stone terraces had significant positive impacts (42%) increase on average crop yields for lower-rainfall parts of the Amhara region. In addition, Pender and Gebremedhin (2006) indicated higher crop yields from plots with stone terraces (an average yield increase of 23%). Another study conducted by Tugizimana (2015) in Nyamasheke District, Rwanda has shown that SWC measure has significantly improved a bean yield. According to Menale (2007), there was high positive additional mean crop production value of 412 ETB as a result of SWC measures adoption in low rainfall area of

Tigray.

In contrary, different experimental and survey results indicated that SWC measures reduce crop yields in high rainfall area or because of medium to long term benefits of the practices. For instance, Kassie and Holden (2006) reported that physical conservation measures (*Fanya juu*) resulted in lower yield in a high rainfall area of the Ethiopian highlands in western Amhara region. Menale et al. (2007) reported low crop yields in the fields with conservation structures and insignificant mean crop production value in high rainfall area of Amhara region and the finding was supported by Baptista et al. (2015) who reported crop yield decline in the fields with SWC practices in the high rainfall watershed of Ribeira Seca Watershed, cape verde. From this scientific argument, it is rational to conclude that rainfall distribution greatly influences the value of soil and water conservation measures and the associated crop yields whereby high value of crop yield as a result of soil and water conservation is obtained in low rainfall areas and vice versa.

Impacts of soil and water conservation measures on household income

The analysis result indicates that the mean total households income per year for practiced households is relatively higher (3,282.58ETB per household) than non-practiced households (2,661.97ETB per household) with mean income difference equivalent to 620.6ETB (Table 4). The hypothesis that whether there is income level difference or not between SWC practiced and non-practiced households was tested with student t-test and the result indicated a non-significant difference ($p>0.05$) in mean total income between SWC practiced and non-practiced households (Table 2). Analysis result in Table 2 below also depicted that there is income level difference between two groups of households (SWC practiced and non-practiced) though the difference is not statistically significant. Thus, the null hypothesis that there is no income level difference between SWC practiced and non-practiced households could be rejected while the alternative hypothesis that there is income level difference between SWC practiced and non-practiced households could be accepted.

The relationship between SWC adoption and household income was tested with Pearson correlation and linear regression. Analysis result indicated that there is positive but statistically non-significant relationship between SWC adoption and household income with Pearson correlation equal to 0.09 and $p>0.05$. This relationship suggested that adoption of SWC may improve household income of practiced farmers than non-practiced households. In addition, adoptions of SWC measures affect household income positively due to small increase in household income of practiced household. The income difference between the two groups is statistically non-significant due to the fact that non-practiced households engage in other income generating activities (off-farm) such as self-employment and hired labour in agricultural and non-agricultural labour. These income generating activities supplement their limited income they earn from crop production. Key informant interview explained that some household members engage in coffee production and bee keeping enterprises in the form of hired labour and earn some money for their livelihood. Moreover, SWC measures may increase income level of the households who practiced conservation measures because these conservation practices have reduced soil erosion and consequently improve soil quality which creates a better medium for crops growth. Key informant interview indicated that implementation of SWC practices improve fodder availability which provide high nutritious feed for livestock and thus sales of livestock and their products increase the amount of income earned by the household. Field observation also show that SWC practiced households diversify their crops which increase timing of crop harvest and consequently increase the spatial availability of crop products. This increases the products to be sold and boost income of households.

Despite positive mean difference which show an additional income to households who practiced soil and water conservation than non-practiced households, independent sample t-test result indicated that there is no significant difference between practiced and non-practiced respondent household in term of total income (t1.03, $p= 0.31$, Table 2 above). The rationale behind lack of significant income difference between households who adopted SWC measures and those who did not adopt might be because of the fact that the two groups engage in alternative income generating activities. For instant, non-practiced households engaged in off/non-farm activities and both groups are involved in the collection of wild fruits/roots. These additional sources of income should reinforce the income from crop production and thus give an alternative source of income. In addition, households who engage largely on crop production by improving the land productivity through soil and water conservation measures incurred opportunity cost for other income generating activities leading to reduction of income level from other sources and thus the mean income difference for two groups should not be possibly significant. However, this is not an indication that the two groups could have similar income instead slight variation in the mean income level of the households who adopted and those who do not adopted conservation measures. With households who adopted having relatively higher income than those who not adopted the soil and water conservation measures in their farmlands.

This finding is in line with the study conducted by Abebe (2015) in Adwa and Amba alajie, Tigray Regional state which indicated that adopter households had relatively better income compare to non-adopter

Table 2. Mean annual income for practiced and non-practiced households.

Parameter	Practiced	Non-practiced	Mean difference	T-value	P-value
Total mean annual income per household (ETB)	3282.58	2661.97	620.6	1.03	0.31(p>0.05)

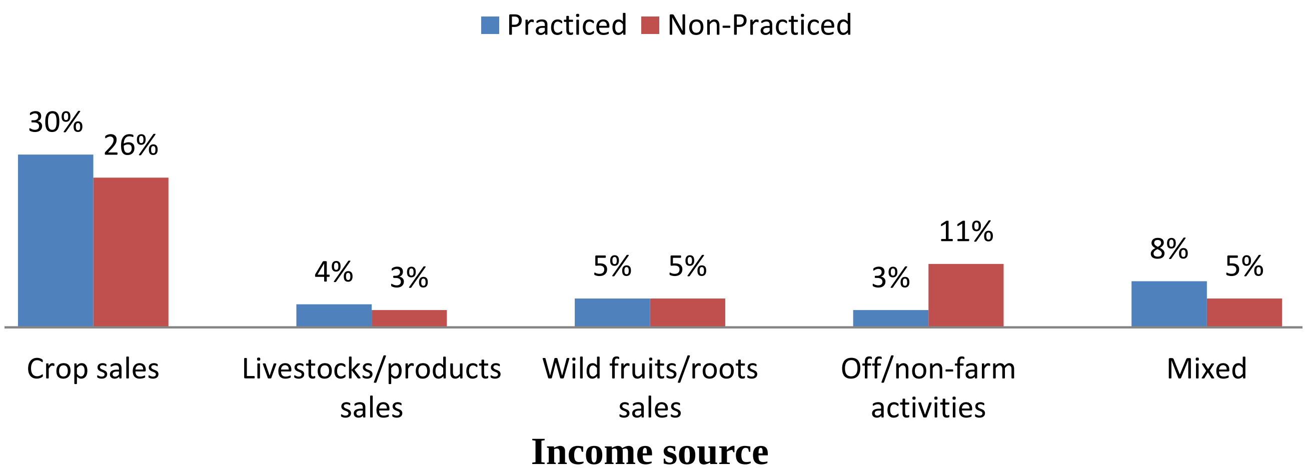

Figure 4. Income source and adoption of SWC practices.

households. In addition, Yenealem (2013) found that gross annual income of households who implemented SWC measures increase to 4,288.29 ETB than non-adopter households in west Harareghe, Oromia region. However, another study by Yitayal and Adam (2014) in Adama district of Oromia region found that SWC practices resulted in less significant positive impact on gross household income because of short duration of the practices. Moreover, a study conducted by Meaza (2015) in Adwa district, Tigray region indicated that the total average household income increase from 3990ETB to 7313.5ETB after adoption of SWC practices. These are the empirical findings which indicate the financial implication of SWC measures adoption at the household level across the country.

In addition, summary statistics analysis result revealed that majority of practiced respondent households (30%) derived much of their income from crops marketing and at the same time largest proportion of non-practiced respondent households (26%) also earn most of their income from the sales of crop products (Figure 4).

This agrees with the study of Abebe (2015) which has shown that majority of households in Amba Alajie and Adwa depends on crop production as a dominant source of their livelihood. This shows high dependency of Ethiopian rural farmers on crops farming practices. SWC practiced respondent households also derive some of their income from combination of different income sources followed by income earned from wild fruits/roots collected from nearby forest and small proportion of income from the sales of livestock and livestock products. The variation of income sources within practiced respondent households is not significant while it is true within non-practiced respondent households. This large variation within non-practiced respondent households as well as between practiced and non-practiced respondent households resulted in significant difference of income sources between two groups (practiced and non-practiced) ($p<0.05$). Similarly, the major source of income in Bokole and Toni sub-watershed was reported to be crop production which indicated that households could engage in soil and water conservation in order to boost crop productivity (Kebede and Mesele, 2014).

Effects of soil and water conservation on rehabilitating farm land

This study focused mainly on labour and fertilizer use for farm production by households. Data on farm labour requirement and the use of fertilizer by individual farmers were collected at household level and analyzed. The analysis results are presented below.

Labour

Analysis result in Table 3 indicates that SWC practiced

Table 3. Adoption of SWC and its impact on labour.

Parameter	Practiced	Non-Practiced	Mean difference	t-value	P-value
HH labour (persons/HH)	4.00	2.00	-1.91	-11.74	0.001
Hired labour (persons/HH)	2.00	0.35	-1.65	-9.60	0.0002

(HH)-household, (t)-student test and (p)-is probability value

households use higher labour force (both household and hired labour) than non-practiced households. The labour requirement (household and hired) difference between groups is statistically significant with t-value equal to -11.74 ($p<0.05$) for household labour and -9.6 ($p<0.05$) for hired labour.

The relationship between soil and water conservation adoption and labour requirement (household and hired) was tested with Pearson correlation and the result indicated that there is positive and statistically significant relationship between two variables with Pearson correlation and p-value equal to (0.717** and $p<0.05$) and (0.644** and $p<0.05$) for household and hired labour respectively where (**) indicate that correlation is statistically significant at 0.01 level of significant. The impact of soil and water conservation adoption on labour demand (household and hired) was also tested with linear regression and result revealed that there is statistically significant positive impact on labour (household and hired) with standardized coefficient of beta (β) similar to Pearson correlation for both household and hired labour.

From the analysis results, SWC practiced households were found to require more labour (household and hired) than non-practiced households. This is mainly because investment in SWC practice is accompanied by construction and maintenance of physical SWC, planting of vegetative and agronomic measures as well as harvesting of crops which require man power. The positive correlation between SWC adoption and labour demand indicates that as household decide to adopt soil and water conservation, they could ensure the present of family members that are capable for farm work or else they could hired additional people to execute their farm activities. This association between SWC adoption and labour demand may favor some households especially those with medium to high family size and income as well as households characterized by large proportion of active age groups so that individuals are available for farm work but it is at the same time a threat to small sized and low income households since they are unable to offer man power or even cannot afford to hired additional labour for their farm activities.

According to study conducted in Uganda by Boyd et al. *(*2000), it was reported that 54% of studied households supplemented their household labour with hired labour while 60% of households engage in labour-sharing arrangement because of the high labour demand of SWC measures. However, the same study by Boyd et al. *(*2000) in Tanzania indicated that there was no clear indication about the relationship between labour availability and decision to invest in SWC measure merely because of long term nature of the investment in conservation measures. According to study conducted by Teshome (2013) in Anjeni and Debre Mewi watersheds, construction of soil bunds and fanya juu require 150 persons/day/ha in Anjeni and 75 persons/day/ha for soil bunds construction in Debre Mewi watershed and stone bunds construction require 125 persons/day/ha in both watersheds.

This labour requirement is far higher than the labour requirement in this study area mainly because in this study area majority of households adopted mixed SWC measures where physical conservation measures are combined with agronomic and biological measures in the same field. Additional reason may be because this study emphasized SWC measures in croplands only and average farm size may be lower than mean farm size studied in Anjeni and Debre Mewi watersheds. These findings indicated how intensive SWC labour requirement is and its challenge to small size and economically inactive households. In this study area, households use both household members and some households supplement it with hired labour in order to accomplish farm activities.

Fertilizers

Analysis result in (Table 4) indicated that SWC non-practiced households use much amount of inorganic fertilizer such as DAP (62.92 kg/ha) and Urea (53.56 kg/ha) than practiced households. Hypothesis that whether there is statistically significant difference between practiced and non-practiced households in term of fertilizer use or not was tested with t-test and result indicated that there is statistical significant difference between two groups in the use of DAP and Urea (Table 4) below show t-value and probability value.

In addition, relationship between soil and water conservation adoption and fertilizer use was tested with Pearson correlation and the result indicated that there is negative and statistically significant relationship between two variables with Pearson correlation and p-value equal to (-0.637** and $p<0.05$) and (-0.662** and $p<0.05$) for DAP and Urea respectively where (**) indicate that

Table 4. Adoption of SWC and its impact on fertilizer use.

Parameter	Practiced	Non-Practiced	Mean difference	t-value	P-value
DAP (kg/ha)	30.8939	62.9242	32.03030	9.416	0.002
Urea (kg/ha)	22.2727	53.5606	31.28788	10.066	0.001

Table 5. Adoption of SWC and manure/compost use.

Parameter	Whether household apply manure/compost or not.			
	Yes		No	
	N	%	n	%
Practiced	51	38.6	15	11.4
Non-practiced	20	15.2	46	34.8

(n)-is number of respondent and (%)- is percent of respondent Pearson chi-square (29.289), p-value<0.05.

correlation is statistically significant at 0.01 level of significant. The impact of soil and water conservation adoption on fertilizer use was also tested with linear regression and result revealed that soil and water conservation adoption negatively and significantly affect level of fertilizer use with the same standardized coefficient of beta (β) to Pearson correlation for both DAP and Urea fertilizer.

The impact of soil and water conservation adoption was also assessed with the hypothesis whether there is significant different between soil and water conservation practiced and non-practiced households in term of organic fertilizer (manure/compost) use. Respondent households were asked whether they apply manure/ compost on their plots or not and result indicated that majority of practiced household (38.6%) apply manure/ compost on their farm than non-practiced households (15.2%) (Table 5). Pearson chi-square indicated that there is statistically significant difference between practiced and non-practiced households in term of the use of manure/compost with Pearson chi-square (29.289) and probability value ($p<0.05$).

As per analysis results, SWC practiced households use lesser amount of inorganic fertilizer (DAP and UREA) than non-practiced households. This might be due to the fact that, the amount of fertilizer applied by the individual household is determined by factors like precedence soil fertility, type of crop and amount of available income to purchase fertilizer. SWC measures not only improve soil fertility through addition of organic matters on soil and increase in crop yield but also improve income and shift of crop type through either crop rotation or switching from annual to perennial crops. With adoption of SWC measure, it is expected that soil fertility might improve and thus soil nutrient should be available in soil profile. This availability of soil nutrient should reduce crop nutrient requirement and therefore application of additional nutrient in the form of fertilizer in order to supplement crop nutrient demand decline afterward.

In addition, the negative relationship between SWC and the level of fertilizer application indicates that as households adopt SWC measure, soil fertility might be improved through addition of organic matters by crop residues and direct fixation of other nutrients such as nitrogen by leguminous plants. This improvement in soil quality by SWC practices might lead to reduction in the amount of fertilizer applied by households. Moreover, Table 5 above indicated that households who practiced SWC measure mainly applied manure/compost than non-practiced. This is partly because practiced households mainly grow fruits and cash crops while non-practiced households primarily grow annual crops such as cereals which require too much fertilizer particularly inorganic type of fertilizer.

Demelash and Stahr (2010) have reported statistically significant difference between conserved and non-conserved farmlands in term of soil organic matter content, total nitrogen and available phosphorus of which conserved farmlands have higher soil organic matter content, total nitrogen and available phosphorus than non-conserved farmlands due to the fact that SWC measures increase accumulation of organic matter on soil surface, nitrogen fixing plants integrated with SWC measures fix nitrogen into the soil and increase nitrogen content while increased organic matter increase available phosphorous in the soil.

In addition, a study conducted by Hishe et al. (2017) found statistically significant difference between conserved and non-conserved farmlands in term of soil organic matter where higher mean organic matter content was recorded in conserved farmland than in non-conserved fields. Another study carried out by Hailu (2017) reported that there was significant different between conserved and non-conserved plots in term of soil organic carbon content, total nitrogen and available phosphorous of which conserved plots have relatively higher soil organic carbon, total nitrogen and available phosphorus than non-conserved plots due to accumulation of organic matters and presence of leguminous plants in conserved plots.

These findings suggested that adoption of SWC measures may improve availability of soil nutrients which in turn reduce crop nutrient requirement and application of additional fertilizer as well. According to Sawyer (2013) cereals growers were identified to apply lesser amount of manure/compost in their farmlands than other farmers but applied higher amount of inorganic fertilizer such as DAP and UREA. Sawyer (2013) also reported that fertilizer application rate vary among crop types. For instant, it range between 50-100 kg/ha for maize, 6 kg/ha for sorghum, more than 45 kg/ha for Potatoes, onions, and other vegetables and below 10 kg/ha for banana, coffee, and other perennial crops. These study results indicated that type of crop may determine the amount and type of fertilizer to be applied to the fields. In this study area most non-practiced households grow cereals such as maize and sorghum and thus require higher amount of inorganic fertilizer such as DAP and UREA in order to meet nutrient requirement of these crop type but majority of SWC practiced households grow mixed crop type mainly fruits and cash crops with low nutrient requirement and thus require low amount of fertilizer to be applied onto their farmlands.

Conclusion

In order to fill the gap, impacts of SWC on crop production, household income and level of input use has been conducted in Zeiy watershed, Gambella region. Three hypotheses have guided the survey. These hypotheses include whether there could be significant difference between SWC practiced and non-practiced households in term of crop production, household income and level of input use. As a result, the survey analysis results have indicated that there is statistically significant difference between SWC practiced and non-practiced households in term of crop production, labour demand (household and hired) and fertilizer (inorganic and organic) use. However, statistically non-significant mean difference between SWC practiced and non-practiced households has been obtained in term of household income. Despite positive and statistically significant relationship obtained between SWC adoption and crop production, labour demand (household and hired) and use of organic fertilizer, household income has shown positive but non-significant relationship while inorganic fertilizer level has shown negative and significant relationship. With these findings, it is rational to conclude that SWC measures have positive impact on crop production, contribute slightly to household income, increase labour demand (household and hired), decrease level of inorganic fertilizer use and increase use of organic fertilizer.

Adoption of SWC measures must be combined with activities that generate other income in order to supplement farm income. Other income generating activities like beekeeping and promotion of high value cash crops. Some households may need to implement SWC measures but lacks of capability preclude them. These include shortage of labour, low income to hire additional labour and so on. Availability of extension services could help to identify those households and thus concerned office like Agriculture and Natural Resource Bureau should work in close collaboration with such households.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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