*International Journal of Agriculture and Environmental Research*

ISSN: 2455-6939

Volume:02, Issue:02

# THE IMPACT OF BOSET-FENTALLE IRRIGATION ON THE INCOME OF AGRO PASTORALIST IN FENTALLE DISTRICT, ETHIOPIA

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## ABSTRACT

This paper analysed the impact of irrigation project on agro pastoral household income in Fentalle district. It analysed factors determining agro-pastoralist participation in irrigation. The study result depends on cross-sectional data collected from a sample of 144 households of which 72 irrigators and 72 non-irrigators using a combination of multistage disproportionately stratified, and random sampling. It used descriptive statistics, test statistics and logistic regression to assess the factors that affect participation in irrigation, performed propensity score matching, and treatment effect analysis. The Result revealed that access to irrigation has intense impact on improving household income. It was observed that among the variables in logistic regression age, sex, ln income, input use and participation in cooperative organization have affected positively, while, farm experience, distance to the district market, and tropical livestock unit, affected participation in irrigation negatively and significantly. Further, the study substantiated that irrigation in the study area has significantly improved the income level. It shall be great and rewarding if policy makers, designers, implementers, and any funding agencies with similar interest further capitalise and scale up the project to achieve the development plan and objective.

**Keywords:** average treatment effect on the treated, Fentalle, Impact, income, irrigation scheme, and propensity score matching.

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## ACRONYMS

| | |
|---|---|
| ADLI | Agricultural Development Led Industrialization |
| ATT | Average Treatment Effect over the Treated |
| EPRDF | Ethiopian People Republic Democratic Front |
| FAO | Food and Agriculture Organization |
| FGD | Focus Group Discussion |
| GDP | Gross Domestic Product |
| GTP | Growth and Transformation Plan |
| MOFED | Ministry of Finance and Economic Development |
| NMA | National Meteorological Agency |
| PASDEP | Plan of Accelerated and Sustained Development to End Poverty |
| PSM | Propensity Score Matching |
| WFP | World Food Programme |
| WUA | Water User Association |

## INTRODUCTION

Agriculture is still the pillar of the Ethiopian economy, which contributed 41.6% to GDP in 2009 (GTP, 2011). It also provides raw material to industrial sector, export items and is major source of employment for 84% Ethiopia population (PASDEP, 2005). Cognizant to this fact, the country focused its development strategy, that is, Agricultural Development Led Industrialization (ADLI) on agriculture to transform the economy. ADLI aims for boosting agricultural productivity and improving the rural standard of living, which in turn increase the demand for goods and services and further lead to industrial development. One of the impetuses to achieve the agricultural policy objective is the promotion of irrigated agriculture and integrated water resource management ADLI (1994).

Berhanu and Peden (2003); Simeon (2010) on the other hand states that water plays a critical role in poverty reduction and the sustainable livelihoods of rural people. Improvement in access to water serves as a powerful tool to diversify livelihoods and reduce vulnerability for small producers, since irrigation water creates options for extended production across the year, increases yields and outputs, and creates employment opportunities. Increased household income may be spent locally thus helping to stimulate the rural economy and Participation in water users associations (WUA) widens social networks and empowers people, thus facilitating the creation of social capital.

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Agricultural production in Ethiopia is primarily rain fed, so it depends on erratic and often insufficient rainfall. As a result, there are frequent failures of agricultural production. Irrigation has the potential to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall. Irrigation development also can help offset some of the negative effects of rapid population growth; 2.6% per year in Ethiopia (CSA, 2007). Population growth causes agricultural activities expands into marginal land, which leads to forest, land and water degradation. This environmental degradation can reduce agricultural productivity, which in turn worsens food insecurity and poverty. In order to respond to growing food demand, food production should increase. The three methods to increase food production are: increasing agricultural yield, increasing the area of arable land, and increasing cropping intensity (number of cropping per year). Irrigation has the potential to increase both yields and cropping intensity in Ethiopia (Seleshi *et al.*, 2010).

Irrigation increases agricultural productivity and farm income per ha, according to previous studies (Nhundu *et al.,* 2010; Gebremedhin and Peden 2002; Hussain 2006). It insulates the national agricultural and economic sector against weather-related shocks and provides a more stable basis for economic growth and poverty reduction. It supports the process of transforming traditional subsistence agriculture in to market-oriented production of high value crops (Asfaw 2007).

The development of water resources for agricultural purposes (irrigation) is rising rapidly. According to Seleshi *et al* (2010), in 1990 Ethiopia had an estimated total of 161,000 hectares of irrigated agriculture, of which 64,000 ha were in small-scale schemes, 97,000 ha were in medium-and large-scale schemes and approximately 38,000 ha were under implementation. This had grown to more than 247,000 ha by 2004, with traditional irrigation schemes alone covering more than 138,000 ha. Currently, the Ethiopian government gives more emphasis to small-scale irrigation as a means of achieving food self-sufficiency (MOFED, 2010).

Fentalle District is an irrigation potential district, with an estimated area of more than 3700 ha of modern irrigation however, the living standard of the community is subsistence. Sustainable economic development will be supported by effective agricultural technology intervention. Equal and fair technology distribution within the community is valuable for balanced economic growth (Kobets, 2004). This study is intended to identify factors affecting participation in irrigation and agro pastoralist perception towards irrigation with the following specific objective.

1. To analyse the determinant of household participation in irrigation.
2. To analyse the impact of Boset-Fentalle irrigation on household income.

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## RESEARCH METHODOLOGY

Fentalle is located in the great Ethiopian mid rift valley under the east Shoa zonal administrative division of Oromia regional state crossed by the Kesem and Awash River. It is 193 km east of the capital Addis Ababa on the highway to Djibouti. Fentale district is located between 8°45′N to 39°50′E which is in tropical climatic zone. The approximate total area of Fentale District is 1340 $Km^2$ and Metehara town is capital and administrative center of the District. Its Altitude ranges from 1500m-2000m. The District climate is grouped as Hot-semi Arid, characterized by steep type of vegetation with less fall and more coarse grasses. The mean annual temperature and rainfall of Fentale district varies between $18^0$c and $34^0$c and 377mm-742mm respectively with mean annual rain fall of 572mm. (climate data of NMA, 1989-2011).The major ethnic groups inhabited in Fentale district are Kereyu and Ittu Oromo's and few Somali ethnic minorities. Out of 18 kebeles located in Fentale district 12 are considered to be pure pastoralist (Fentalle DSEP, 2013).

### The Fentalle Irrigation Project

Boset-Fentalle irrigation project is a large scale gravity based irrigation scheme. The project is designed and implemented by Oromia National Regional State: inaugurated in 2009 by the Regional Government. The project is diverted from Awash River and covers approximately the total land area of more than 3700 ha in six agro- pastoral kebele of the district (Fentalle DSEP, 2013).

### Sampling Technique and Sample Size

Among the six irrigation users kebele in Fentalle district, three kebele with access to irrigation facility (one nearest, one medium and one farthest kebele to the district market) was selected. These kebele were 'Gidara', 'Turo' and 'Elala'. Sample population was classified in to two groups: irrigation user and non user. Sample respondent was selected using simple random sampling technique. Sample units were selected from the same kebele to reduce heterogeneity except for irrigation access. The total population of the kebele is 809 irrigation user and 45 irrigation non users at Gidara, 564 irrigation user and 473 non users at Turo, and 642 irrigation user and 343 non users at Elala. Accordingly, 24 irrigation user and 24 non users were selected from each kebele. The total of 144 sample households (72 irrigation users and 72 non users) was considered representative and can generate reliable information. The selection was disproportionately stratified random sampling.

### Data Collection and Analysis

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All information about irrigation water use, technical, socio economic and institutional factor and others relevant to the study were gathered from primary and secondary sources such as documents, study reports of development centers, District office and from resource centers. Data for this study were collected from households using a semi-structured interview schedule. In addition, discussion was held with key informants and focus group discussion to access detailed information. It was used to qualitatively support the study result and characterize the constraints.
Analysis was done with the aid of (SPSS ver.20 and STATA version 13). The qualitative data collected using key informant interviews, field observation, focus group discussion and oral histories were analyzed using narrative explanation and argument. Quantitative data were analyzed using different descriptive and inferential statistical tools specifically, means, percentages, frequencies distribution, standard deviation, test statistics and logistic Regression analysis. To generate statistically acceptable matched pairs between participants and non-participants, Propensity Score Matching (PSM) econometric model was used. The logic behind propensity score methods is that balance on observed covariates is achieved through careful matching on a single score (the estimated probability of selecting the treatment), or simply the propensity score. Among others, the non-parametric nature to balance covariates between participant and non-participant household and hence removing observable variables bias; conventional approach to assess the impact of a discrete treatment, irrigation scheme participation in this study case, and ability to build matched pairs from the user and the non-user that are similar in their observable characteristics were the reasons for using PSM for this study. The propensity score is defined as the probability of receiving treatment based on measured Covariates.

In other words, propensity score expresses how likely a person is to select the treatment condition given observed covariates. This score is useful because it can be used to match participants from treatment condition to participants from control condition who have a very similar estimated propensity score. This matching process creates balance between treated and untreated participants on the propensity score and more importantly, is also expected to create balance on covariates that were used to estimate the propensity score. This balance property is a key aspect of propensity score method because, a balanced pre-test covariate cannot be a confounder anymore, i.e., cannot bias the treatment effect estimate (Thoemmes, 2012).
Average treatment effect over the treated (ATT): is used to evaluate impact of irrigation over the user group, it is computed as:

$$\text{ATT} = E(Yi^T - Yi^C \mid D = 1) = E(Yi^T \mid D = 1) - E(Yi^C \mid D = 1)$$

## RESULT AND DISCUSSION

### Socio-economic Characteristics

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The socio economic characteristic of the surveyed household is summarized in table 1. It shows that among the presented features; farm experience, education level, total livestock unit, frequency of extension contact per month, income from livestock and crop shows significant difference for participants and non-participants. The average farming experience of the participants was 7.66 and it was 10.13 for non-participants. The test statistical analysis revealed that there is significant difference in farming experience between irrigation participants and non-participants at probability level of less than 1%.

Income from crop production is also significant at probability less than 1%, the mean annual income was 20,747.9 ETB[1], for participants and 2,509.7 ETB for non-participant. The mean of Education level, TLU and frequency of extension contact in a month was 1.69, 1.01; 15.28, 10.40 and 2.15, 1.61 for users and non-users respectively. Further, the average income obtained from livestock is also different for the irrigation participants and non-participants it was 9,666.8 and 6,173.4 birr for users and non-users respectively. The entire four variables revealed that there is significant difference between participants and non- participants at less than 10% probability level with relatively high mean in education level, TLU, and frequency of extension contact per month of user.

**Table 1.Summary Statistics and Distribution of Continues Variables**

| Variables | Participant | | Non-participant | | Total | | t | P- value |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | | |
| Age | 35.98 | 10.2 | 35.43 | 9.24 | 35.70 | 9.74 | -0.34 | 0.73 |
| Farming experience | 7.66 | 4.82 | 10.13 | 5.45 | 8.90 | 5.27 | 2.88 | 0.004** |
| Edu. level | 1.69 | 2.83 | 1.01 | 2.13 | 1.35 | 2.52 | 1.62 | 0.10* |
| Family size | 6.05 | 3.01 | 6.05 | 3.02 | 6.05 | 3.01 | 0.00 | 1.00 |
| Dependency ratio | 1.03 | .98 | 1.28 | .95 | 1.16 | .97 | 1.54 | 0.12 |
| TLU | 15.28 | 17.52 | 10.40 | 18.01 | 12.84 | 17.87 | 1.64 | 0.10* |
| Farm size | 1.00 | 0.50 | .94 | .41 | .97 | .46 | .74 | 0.46 |
| Ext. freq.in Month | 2.15 | 1.97 | 1.61 | 1.70 | 1.88 | 1.86 | -1.75 | 0.08* |
| Livestock Income | 9666.8 | 13792.4 | 6173.4 | 11127.7 | 7920.1 | 12609.6 | -1.67 | 0.09* |
| Crop Income | 20,747.9 | 30,388.8 | 2,509.7 | 1,067.7 | 11,628.8 | 24,470.6 | -4.80 | 0.00** |
| Dist. to district | 23.71 | 11.39 | 24.1 | 11.31 | 23.94 | 11.31 | 0.23 | 0.81 |

Source: computed from own survey, 2014 *, ** significant at 10 %, and 1% probability level , respectively

[1]ETB 20.02 =1 USD at study time

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**Determinant of Participation in Irrigation**

Out of the 17 variables, eight were statistically significant in the model while the other did not significant at (P<0.10) probability level. The statistically significant variables include, age, sex, farm experience, ln income, distance to the district market, total livestock unit, input use and participation in cooperative and local organization

**Table 2 Logit estimate of determinants of participation in irrigation scheme**

| Variables | Coefficient | Standard error | Odds ratio | z | P> \|z\| |
|---|---|---|---|---|---|
| Constant | -9.04 | 2.65 | 0.00011 | -3.41 | 0.001*** |
| Age | 0.102 | 0.042 | 1.108 | 2.48 | 0.01** |
| Sex | 1.55 | 0.68 | 4.73 | 2.28 | 0.02** |
| Education level | -0.200 | 0.15 | 0 .818 | -1.33 | 0.184 |
| Farm experience | -0.184 | 0.07 | 0.832 | -2.62 | 0.009*** |
| Family size | -0.084 | 0.132 | 0.919 | -0.63 | 0.525 |
| Ln income | 0.749 | 0.283 | 2.11 | 2.64 | 0.009*** |
| Dependency ratio | -0.439 | 0.38 | 0.644 | -1. 14 | 0.252 |
| Distance to District market | -0.100 | 0.035 | 0.904 | -2.81 | 0.005*** |
| Total livestock unit | -0.023 | 0.014 | 0.971 | -2. 17 | 0.030** |
| Total land | -0.58 | 0.73 | 0.559 | -0.80 | 0.426 |
| Herd diversification | 1.194 | 1. 017 | 3.300 | 1. 11 | 0.268 |
| Input use | 2.88 | 0.710 | 17.98 | 4.07 | 0.000*** |
| Off farm income | 1.69 | 2.29 | 5.421 | 0.74 | 0.460 |
| Non-farm income | 0.45 | 0.967 | 1.56 | 0.46 | 0.65 |
| Credit participation | 0.30 | 0.86 | 1.35 | 0.36 | 0.721 |
| Cooperative and local organization | 1.480 | 0.66 | 4.42 | 2.22 | 0.026** |
| Extension frequency in month | 0.85 | 0. 176 | 1.20 | 1.05 | 0.29 |
| | | | | Number Of Obs. = | 124 |
| | | | | LR Chi2 (17) = | 83. 18 |
| | | | | Prob > Chi2 = | 0.0000 |
| Log Likelihood = -43.325574 | | | Pseudo R2= 0.4898 | | |

**Source: model output.** *** Significant at 1%, ** significant at 5% probability level

**AGEHH** Age is significant at (P<0.01) probability level and related to farmers desire to participate in irrigation. The odds ratio of 1.1 indicated that other factors constant, a unit (year) increase in age increased participation in irrigation by the odds of 1.1. It is probably due to that elder household heads participated less in agricultural wage labour market, thus, elder farmers are expected to be less active and hence rely more on farm; and is also related with better elder farmers' resource endowment (land and livestock) than the youngsters. The result is against the

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study of (Hilina, 2005 and Bayan *et al.,* 2014,). However, it is in line with the study conducted by Destaw (2003) and Berehanu (2007) that indicated positive and significant relation of age effect on participation.

**SEXHH** in this study, it was hypothesized to affect participation in irrigation positively. The model output also indicated that it is significant at ($P<0.05$) and related to participation in irrigation positively. Other factors constant, the odds of 4.73 indicated that being male increases participation in irrigation by odd factor of 4.73. It is likely due to that male-headed households hardly faced labour shortage for irrigation as well as rain fed farming due to physical, technological, socio-cultural, and psychological fitness of farm instrument to males than females. In addition, men and women have different access to resources and opportunities. This result supports the study of (Ellis, 2000; kinfe *et al.,* 2012).

**Farming experience:** it was hypothesized positive. The model output however, indicate that farm experience negatively affected participation in irrigation at ($P<0.01$) probability level. The odd ratio of 0.83 indicates that other factors constant, participation in irrigation increased by odd factor of 0.83 with a unit decrease in farm experience. The probable reason is that more experienced farmers in irrigation; accumulated capital and shifted their livelihood strategy, and income sources out of agriculture.

**Farm income (ln income):** the analysis result revealed that ln income affects participation in irrigation positively at ($P<0.01$) probability level. It was in line with the hypothesis. Citrus paribus, the odd ratio of 2.11 revealed that an increase in one unit of ln income increases participation in irrigation by the odds of 2.11 units. The possible explanation is that those household who had sufficient gain from farm income: sale of crop, livestock, and their products are more likely to be irrigation participants than those who did not gained enough from farm income. This result supports the study by (Genene and Wegayehu, 2010; Kinfe *et al.,* 2012).

**Distance to the district market:** in line to hypothesis, distance of respondents to district market, affect participation in irrigation negatively. The result is significant at ($P<0.01$) probability level. Other factors constant, participation in irrigation increases by odd factor of 0.9 units with a unit kilometre decrease in distance to district market, or participation in irrigation decreased by odd factor of 0.9 units as the distance increased by one kilometre. The probably reason is that participation is related to production of high value horticultural crops that are short in shelf life and easily perishable. The cumulative effect of Lack of good roads, with distance to market and perishability of crop would resulted in hesitancy to participate in irrigation. This result is consistent and in line with the study of (Beyene *et al.,* 2000; Takele 2008, and Bayan *et al.,* 2014).

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**Total Livestock Unit:** was significantly affected participation. Assuming other factors constant, as the number of livestock owned decreases by one TLU, participation in irrigation increases by the odds of 0.97. The result is statistically significant at ($p<0.05$) probability level. This is probably because more extensive (encroachingly) nature of irrigation in land use would likely result in shift from rangeland to farmland which would have a negative implication on livestock population. The study is in line and consistent with the hypothesis and study conducted by Dadi *et al.,* (2011) which reveals the negative relationship between numbers of livestock owned and total land area cultivated showing the difficulty of combining large livestock population with field cultivation.

**Input use:** In line to the hypothesis, use of input (improved seed, fertilizer, and chemical) had determined participation in irrigation positively at 1% probability level. Citrus paribus, being a user of an input increases participation by odd factor of 17.98 units. The probable reason is that better productivity through farm input use on irrigated land might make farmers to go for participation in irrigation farming. This suggests that those who are better off can afford to buy fertilizer/ HYVs and those who are poor may not. As a result, input users may produce more per unit area than non-users and can have access to large quantity of food and diversify income sources for accumulation.

**Cooperative participation:** this variable is found to be significant at ($p<0.05$) probability level to positively determine participation in irrigation. Assuming other factors constant, being a member of cooperative organization increases participation by odd factor of 4.42. Further, FGD result indicated that farmers participate in cooperative and local organization for self-help, accessing input, irrigation management and maintenance, and marketing. Cooperatives promote access to social capital in which mutual resource management and self-help increases. Such a positive impact of cooperative (Parrachino *et al.,* 2006) indicated that, to some extent, place farmers in relationships with others, which have the benefit of establishing trust and decreasing the transactions and monitoring costs. Additionally, a cooperative supply can provide a mechanism to assure appropriate allocation of scarce water under some institutional arrangements.

**Average Impact of Irrigation Scheme on Income**

The result of propensity score matching treatment assignment indicated that among 144 observations of the study, 114 observations used for estimation. The common support area result also revealed that 12 to 44 observations of the untreated (control) observation was found in the common support, and 70 observations of treated was in the common support area depending on

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matching algorithm. Further, 82 to 114 observations were in the common support2 and used for the treatment effect analysis.

Table 3 provide the result of ATT from four matching algorithms. It is statistically significant. The mean difference of household income between the matched treated and control groups ranges from 13,810.9 to 18,442.9 ETB depending on the matching algorithm under consideration. In estimating propensity score, the balance property imposed. The use of balancing property ensures that a comparison group constructed with observable characteristics distributed equivalently across quintiles in both the treatment and comparison group (Smith and Todd, 2005). In constructing the matching estimate, analysis impose common support. Heckman et al. (1997) encourage dropping treatment observation with weak common support as inference can be made about causality only in the area of common support. All standard errors were boot strapped with 100 repetitions following Smith and Todd (2005) and Dillon (2011). For estimation of treatment effect, the study used four matching methods, viz. nearest neighbour, radius, stratification, and Kernel matching methods. Comparing the results across different matching methods can reveal whether the estimated effect is robust (Khandker et al., 2010). The kernel matching algorithm was estimated income of matched treated to be 31,283.8 ETB and of control group to be 16, 724.55. The average treatment effect due to treatment access was 14,559.22, which is 46.5% income advantage. ATT with NNM and the stratification matching method of the statistical comparison is 13,810.9 and 18,442.9 ETB respectively. Further, with NN matching method the model result revealed that access to the irrigation project gave an income advantage of 44.14% (Table 3).

**Table 3 ATT for income using matching algorithm**

| Matching Algorithm | No. treated | No. control | Mean income | | ATT | S.E | T-stat |
|---|---|---|---|---|---|---|---|
| | | | Matched treated | Matched control | | | |
| Kernel matching | 70 | 44 | 31,283.8 | 16,724.55 | 14,559.22 | 8739.65 | 1.67* |
| Radius | 70 | 42 | 31,283.8 | 17,933.91 | 13,349.9 | 7564.5 | 1.76* |
| NNM | 70 | 12 | 31,283.8 | 17,472.8 | 13,810.9 | 8539.6 | 1.617* |
| Stratification | 70 | 44 | | | 18,442.9 | 7201.1 | 2.56** |

Source: Own survey, 2014, Radius =0.1 Kernel bandwidth=0.01, *, ** significant at 10% and 5% probability level of significance.

[2] It is the area where there is score overlap of control and treatment group: were used for matching and estimation of treatment effect based on their propensity score.

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The radius matching algorithm also estimated income of matched treated to be 31,283.8 ETB and of the control group was to be 17,933.9. The average treatment effect due to treatment access was 13,349.9 that were show approximately 42.67%.

## CONCLUSION

To sustain the progressive impacts of the project and to enable beneficiary households make an optimum use of the irrigation scheme and based on the empirical findings in this research, the following recommendation suggested.

Irrigation is an important driving tool to development effort to ensure better income if properly used. The study has substantiated that irrigation in the study area, has significant impact on income and productivity. It shall be great and rewarding if policy makers, designers implementers, and any funding agencies with similar interest further capitalise and scale up the project to achieve the development plan and objective. Lack of adequate experience in irrigation made agro-pastoralist to lack technical knowledge on irrigation agronomic practices. Further, little attention from research and development to the crop production and agronomic practices of agro- pastoralist observed. It shall be best if research and development interventions in the area focused on enhancing the technical skill and knowledge of agro pastoralist on crop production, pest management, and disease control through training, exchange visits, trial, and demonstration. It shall be great if market intervention in terms of either looking to different outlet, value addition, and or organization into marketing cooperative with linking to union and frequent consumers would encourage participation. Further, an improvement in road access and transportation facilities would also facilitate improved marketing and thereby, participation. The endowment capacity and empowerment of women in agro pastoral society is by far low. It shall be better if all development intervention, capacity-building activity in the study area intended with enhancing the endowment, and empowerment of women so that their contribution in agriculture would practically realised as in other communities. Further, gender analysis in terms of both the intra and inter household is also encouraged so that empirical findings will be adequately available for any intervening agent to advocate the role of female agro pastoralists in the irrigation and capacity building.

## ACKNOWLEDGEMENT

I would like to acknowledge all enumerators, district and field level subject matter specialist of the study area. My deepest thank goes to all the interviewed farmers of the study area. Finally I would like to acknowledge Adami Tulu Agricultural Research Center.

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ISSN: 2455-6939

Volume:02, Issue:02

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