academicJournals

Vol. 12(13), pp. 1136-1143, 30 March, 2017
DOI: 10.5897/AJAR2016.11739
Article Number: 583BDCA63469
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

The determinants of small-scale irrigation practice and its contribution on household farm income: The case of Arba Minch Zuria Woreda, Southern Ethiopia

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Received 22 September, 2016; Accepted 21 November, 2016

This study was conducted at Arba Minch Zuria Woreda. The area lacks in-depth studies to identify the determinant factors that influence the use of irrigation water. In the study area it is also not well known to what extent the households using irrigation water were better-off than those who depend on rain-fed agriculture. Therefore, the study was focused on assessing the determinants of small-scale irrigation practice and its contribution on household farm income. The total population in the selected three villages stratified in to two strata (irrigation user and non-user). Then systematic sampling method was employed to select the respondents' household from the population frames of two strata. The descriptive statistics and the binary logistic regression analysis were used for analyzing quantitative data. The results show that sex of respondents'; household size engaged in the agricultural labor force and number of contact of respondents with agricultural development agents per month had significant positive effect on the use of irrigation water at 1% significance level. While education level and attendance on irrigation related training had significant positive effect on the use of irrigation water at 10% significance level. On the other hand, farm distance from the river and the main irrigation canal had significant negative effect on the use of irrigation water at 1% significance level. Out of the total Irrigation user respondents' household (98.2) have harvested perennial crops more than two times and grown annual crops two times per year from the same farm. While out of the total irrigation non-user respondents' household depended on only rain fed agriculture (90.7%) have grown annual crops only one time per year from the same farm. Consequently, the independent sample test result showed that the irrigation user respondents' household obtained significantly larger mean annual gross farm income than irrigation non-user respondents' household at 1% significance level.

Key Words: Irrigation, income, t-test and logistic.

INTRODUCTION

Ethiopia is fundamentally an agrarian country. Although the transformation towards a more manufacturing and industrially oriented economy is well underway, the agriculture sector continues to be the most dominant aspect of the Ethiopian economy, accounting for 46% of GDP, 73% of employment, and 80% of export earnings. Furthermore, the majority of the agriculture sector is made up of smallholder farmers who live off of less than

2 ha of land. As such, transformation of the agriculture sector will be central in Ethiopia's drive to reach middle-income country status by 2025 (ATA, 2014).

Irrigation plays the key role in the performance of agriculture, which increases income from agriculture sector and reduce the risk of crop failure as a result of erratic rainfall. There are four interrelated mechanisms by which irrigated agriculture can improve household income and food security, through: (i) Increasing farm production and productivity that helps very poor households meet the basic needs. (ii) Protecting against risks of crop loss due to erratic, unreliable or insufficient rainwater supplies, (iii) Promoting greater use of yield enhancing farm inputs and (iv) Creation of additional employment (Haile, 2008) quoting (Lipton et al., 2004).

The current Ethiopian government has undertaken various activities to expand irrigation in the country. The country's Agricultural Development Led Industrialization strategy considers irrigation development as a key strategy for sustainable agricultural development. Thus, irrigation development, particularly small-scale irrigation is planned to be accelerated (MOFED, 2010).

Ethiopia is believed to have the total potential of 3.7 million hectares of land that can be developed for irrigation through pump, gravity, pressure, underground water, water harvesting and other mechanisms (Awulachew et al., 2007).

Out of the total potential, about 10 to 12% of this potential is put under irrigated agriculture (both traditional and modern irrigation systems). The major limitations that constrained the development of the irrigation sub-sector are: (i) Agriculture is subsistence and predominantly based on traditional farming systems; (ii) Inadequate improved agricultural inputs; (iii) Limited access to improved irrigation technologies; (iv) Inadequate trained human power; (v) Inadequate extension services and limited availability of capital; (vi) Absence of appropriate institutions at different levels responsible for the promotion, planning and development of irrigated agriculture; (vii) Inadequate information system on agricultural water management and irrigation development (MOA, 2011).

Arba Minch Area District lacks in-depth studies to identify the determinant factors that influence the use of irrigation water. In the study area it is also not well known to what extent the households using irrigation water are better-off than those who depend on rain-fed agriculture. Therefore, this study was initiated to identify the determinants that affect the use of irrigation water in the study area and to compare the annual gross farm income of irrigation user and non-user respondents' households.

RESEARCH METHODS

According to Graziano et al. (2004) non-equivalent comparison group design is among the most commonly used quasi-experimental designs. Structurally, this design is quite similar to the experimental designs, but an important distinction is that they do not employ randomization. In the non-equivalent groups posttest-only design, one group receives the intervention while the other group does not. In using this design, the researcher attempts to select groups that are as similar as possible. Unfortunately, as indicated by the design's name, it is likely that the resulting groups will be non-equivalent. However, non-equivalent comparison group design may still lead to some valid conclusions. Thus, the research design used for this study was quasi-experimental (non-equivalent comparison group design sometimes called static group comparison). Because of it compared two groups (irrigation users and non-users respondents' household). In this study, a multi-stage random sampling procedure was employed for the selection of district, sample villages and respondents' household. In the first stage, the district was selected purposely for the following reasons: The Woreda has a long history of traditional irrigation practices and indigenous knowledge; there is relatively better irrigation practice in the study area that gives opportunity to local government in developing modern irrigation schemes; accessible and availability of enough information about irrigation practice. In the second stage, 10 Kebeles which have small-scale irrigation access were identified from the district. Out of those, three sample Kebeles (Shara, Dorga and Elgo) were randomly selected through lottery technique. In the third stage, the total households residing in the three Kebeles were stratified into two strata: Irrigation user and non-user households. The population frame in the selected Kebeles and the lists of irrigation user households in those Kebeles were obtained from Kebele Administration Offices. Then the lists of irrigation non-user households were obtained through subtracting the lists of irrigation user households of selected Kebeles from the population frame of those Kebeles. The irrigation non-user respondents were selected from the respective villages to ensure homogeneity of factors except use of irrigation water. Glenn (2013) has recommended the total sample size determined through using published table. This table was designed exactly in the same way that the Internet calculators are. The different sample sizes of published table reflect the number of obtained responses and not necessarily the number of surveys mailed or interviews planned (this number is often increased to compensate for non-response). Based on this criteria, the total sample size for the population size of 3000 with ±7% precision levels, 95% confidence level and P=0.5(variability) is equal to191. The researcher adds 5% of (191) =10, to compensate the total population size and then the total sample size for the population size 3378 from three sample villages become 201(115 user and 86 non-user). The sample size of respondents from each village for two strata was determined via probability proportionate to size procedure and listed in Table 1. This determined sample size of irrigation user and non-user respondents' household was selected from the population frame of irrigation users and non-users household of the respective kebele through Systematic probability sampling (list sampling) technique (Kothari, 2004).

In this study, both primary and secondary data sources were identified and utilized. Primary data (both qualitative and quantitative) were collected from primary data sources (household survey respondents, key informants, focus group discussion and systematic field observation). Secondary data (both qualitative and

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Table 1. Sample kebeles and number of sample households for two strata.

Sampled *Kebeles*	Irrigation user household.		Irrigation non-user household.		Total sample household
	Total HH	Sample HH.	Total HH.	Sample HH.	
Shara	1050	63	780	46	109
Dorga	223	13	185	11	24
Elgo	654	39	486	29	68
Total	1927	115	1451	86	201

Source: Own field survey of 2015.

quantitative) were collected from secondary data sources like: Annual reports from district offices of Agriculture, Ministry of Agriculture, Journals, Thesis, Books, Working Papers and Research Papers. Primary data were obtained from primary data sources (respondents' household) through structured questionnaire. Important variables on physical, demographic, economic, social and institutional aspect were collected. Six enumerators who are well acquitted on the subject matter and familiar with the study areas were assigned for data collection. Personal observations of physical features, interviews with key Informants and Focus Group Discussion were also made for supplementary data that support data collected through questionnaire. Secondary data were obtained through referring secondary data sources. Depending on the objectives of the study and nature of data available, descriptive analysis, inferential analysis and binary logistic regression analysis were employed through SPSSversion16.0 software.

The descriptive analyses was made using frequencies, percent and mean to analyze the socio-economic and physical characteristics, cropping and irrigation practices and farm income of irrigation user and non-user respondents' household. The t-test (Independent t-test) was used to compare the mean of continuous variables between irrigation user and non-user respondents' household. To identify the determinants that affect the use of irrigation water, the binary logistic regression analysis was employed.

According to Rodrguez (2007) a range of regression techniques have been developed for analyzing data with categorical dependent variable, including logistic regression and discriminate analysis. Logistical regression is regularly used rather than discriminate analysis when there are only two categories of the dependent variable. Logistic regression is also easier to use with SPSS than discriminate analysis when there is a combination of numerical and categorical independent variables, because it includes procedures for generating the necessary dummy variables automatically, requires fewer assumptions, and is more statistically forceful.

RESULTS AND DISCUSSION

Sources of irrigation water for the irrigation user respondents' household

The results show that out of the total irrigation user respondents' households (93%) have used their irrigation water from rivers while the remaining (7%) have used their irrigation water from ponds. This result also shows that the majority of irrigation user respondents' household depends up on rivers to irrigate their farm.

Additional information gathered from the focus group discussion participants revealed that "in the area rivers are a common resource and major source of irrigation water. On the other hand, the ponds are constructed by the individual farmers at and near their farm land and used as an alternative source of irrigation water. It is common for those farmers' farm land located at nearest to the Lake Chamo and Abaya. However, in the study area the irrigation water especially in rainy season is available and accessible for all irrigation user farmers. But during dry season the volume of irrigation water especially from the rivers decrease and farm lands located far from these sources have less access to use irrigation water when compared with farm lands located nearest to the rivers".

Irrigation water diversion and lifting mechanisms in the study area

Farmers in the study area use irrigation water through diverting from rivers and lifting from other sources through different types of water diverting and lifting mechanisms. The results show that out of the total irrigation user respondents (46.1%) divert irrigation water through traditional river diversion mechanism, (47%) divert irrigation water through concrete canal river diversion mechanism and the remaining (7%) lift irrigation water through used Motorized Water Pump.

This result also revealed that the use of improved irrigation technology creates an extra access to use irrigation water from different sources. Because of, even if it was difficult to divert water through gravity force from irrigation water sources and their farm is located at sloppy area, by using Motorized Water Pump they lift water from those sources and apply on their farm.

Irrigation water management practices in the study area

The information gathered from the focus group discussion participants revealed that "Rivers are a common resource and major source of irrigation users. These common resources are managed in the kebeles by the Irrigation Water Users' Committees. The roles of irrigation water users' committees are: Distributing the irrigation water for users through scheduled manner and monitor it, punishing the irrigation users who violate the

Table 2. The binary logistic regression results of independent variables.

Independent variable	Coef.	Odds ratio	P-Values
Sex of respondents'.	3.99	53.97	0.000***
Age of respondents'.	-0.019	0.98	0.484
Household size engaged in agricultural labor.	0.67	1.96	0.000***
Education level of respondents'.	0.57	1.77	0.077*
Land holding size of respondents' household.	1.51	4.52	0.147
Livestock holding in TLU	-0.115	0.88	0.424
Use of credit from institution last year.	-0.32	0.73	0.708
The contact with development agents per month.	1.38	3.98	0.000***
The farm distance from main irrigation canals.	-1.27	0.28	0.006***
Respondents' farm distance from Rivers.	-2.51	0.08	0.000***
Attended on irrigation related training last year.	0.8	2.22	0.089*

*, ** and *** represent significance at 10, 5 and 1% level respectively. Log likelihood = -69.035, LR chi2 (11) =136.38 and Probability > chi^2 =0.0000. Number of observation = 201. The total variation in the sample for the use of irrigation water was 83.58%. The correctly predicted irrigation users were 88.7%. The correctly predicted irrigation non-users were 76.74%. Source: Computed from field survey data, 2015.

bylaw and mobilizing irrigation water user members to maintain the existing irrigation canals or constructing new irrigation canals. The irrigation water distributed to the users at a day and night time."

The information gathered from the focus group discussion participants in the Shara kebele revealed that, "irrigation water has provided for one user up to complete watering of his/her farm and then shift to the next user. But, in dry season the priority have been given for drought sensitive crops. Anyone who has used irrigation water by force or without the schedules programmed by the Committee, he/she will be punished up to 500 birr based on bylaw. In the irrigation water users' have provided support for the maintenance and construction of new irrigation canals by sharing family labor."

The information gathered from the focus group discussion participants in the Eligo kebele revealed that "irrigation water has provided for one user based on time schedule. During rainy season the volume of river increases as well as the volume of irrigation water also increases. At this time the irrigation water for one user proved up to 6 h interval and then shift to the next user farmer. However, during dry season due to reduction of the water volume this schedule extended up to 12 h interval with special priority given for drought sensitive crops. Anyone who has used irrigation water without the schedule programmed by the Committee, he/she will be punished up to 800 birr. The irrigation water users' have provided support for the maintenance of existing irrigation canals and construction of new irrigation canals by sharing of family labor." The information gathered from the focus group discussion participants in the Dorga kebele revealed that "the irrigation water distribution and punishment mechanism for anyone who has used irrigation water without the schedule programmed by the Irrigation Water Users' Committee and the users' support for the maintenance of existing irrigation canals and construction of new irrigation canal was the same with that of Shara kebele."

Determinant factors that affect use of irrigation water in the area

After commanding the variables in the binary logistic regression analysis and it explained the 83.58% of the total variation in the sample for the use of irrigation water. The correctly predicted irrigation users were 88.7% while the correctly predicted irrigation non-users were 76.74%. Among the 11 explanatory variables included in the model, the seven variables were significantly affects the use of irrigation water (Table 2).

Sex of respondents'

Sex of respondents' had significant positive effects on the use of irrigation water at 1% significance level. The odds ratio supports the use irrigation by a factor of 53.97 when the respondents were being male. Therefore, male headed households have more chance to use irrigation water than female headed households. The information gathered from the focus group discussion participants revealed that "in the study area, irrigation practice need high labor cost and also during dry season, the irrigation water from the common sources has distributed for the farmers at a night time and it is not preferable for women farmers especially who have small family size engaged in agricultural labor force have less access to use irrigation water."

Household size engaged in agricultural labor force

Household size engaged in agricultural labor force had

significant positive effect on the use of irrigation water at 1% significance level. The odds ratio favoring the use of irrigation by a factor of 1.96 for the respondents' household size engaged in agricultural labor force increase by one person day equivalent. Therefore, the respondents' household who has large size engaged in agricultural labor force has better chance to use irrigation water. The information gathered from the focus group discussion participants revealed that "in the study area, irrigation is labor intensive practice and it needs high labor for construction of canals, diversion of water from rives and application of water on the farm."

Education level

Education level had significant positive effects on the use of irrigation water at 10% significance level. The odds ratio favors the use of irrigation by a factor of 1.77 when the respondents were being attended in formal education. Therefore, educated respondents have more chance to use irrigation water. The result obtained from the key informant interview revealed that in the study area the educated farmers easily understood the operation and adopt improve irrigation technologies. It increases their access to use of irrigation water through lifting with irrigation technologies (motorized water pump) from the sources even if their farm is not accessible to irrigate through gravity force. In agreement with this finding, Riddell and Song (2012) have reported in their study that highly educated workers tend to adopt new technologies faster than those with less education workers.

Contact with agricultural development agents

Contact with agricultural development agents had significant positive effects on the use of irrigation water at 1% significance level. The odds ratio favoring the use of irrigation by a factor of 3.98 for the respondents' number of contact with the agricultural development agents per month increased in 1 unit. Therefore, respondents who have highly contacted with agricultural development agents per month have more chance to use of irrigation water in the area. The result obtained from the key informant interview revealed that, farmers' contact; gained advice from agricultural development agents initiated farmers' attending in training; improved their knowledge and skills on farming practices and improved farmers' utilization of improved irrigation technology (motorized water pump). In agreement with this finding, EDRI (2012) has suggested in its study that, receiving training and advice from development agents and the perceived usefulness of development agents' advice are major factors that explain the likelihood of technology adoption and rate of input use.

Farm distance from the rivers

Farm distance from the rivers had significant negative effect on the use of irrigation water at 1% significance level. The odds ratio disfavoring the use of irrigation by a factor of 0.08 for the respondents' farm distance from the rivers increased in 1 km.

Farm distance from main irrigation canals

Farm distance from main irrigation canals had significant negative effect on the use of irrigation water at 1% significance level. The odds ratio disfavoring the use of irrigation by a factor of 0.28 for the respondents' farm distance from main irrigation canals increased in 1 km. Therefore, the respondents' household farm located far from the rivers and main irrigation canals has less chance to use irrigation water and vice versa. Because, in the study area the major water source for irrigation is rivers. When the farm distance far from main irrigation canals which was constructed from the rivers, it needs high labor, financial and time costs to construct sub-canals towards individual farm and minimize the chances to use irrigation water.

Attendance on irrigation related training

Attendance on irrigation related training had significant positive effect on the use of irrigation water at 10% significance level. The odds ratio favoring the use of irrigation by a factor of 2.22 for the respondents' who attended irrigation related training. Therefore, the respondent who attended irrigation related training has better chance to use irrigation. The result obtained from the key informant interview revealed that, attending on training improves farmers' interest to adopt irrigation technologies and then increases their chance to use irrigation water. In agreement with this finding, In agreement with this finding, Tsion et al. (2010) have reported that the emphasis in extension education is on helping people to help themselves. Hence extension service is an on-going process of getting useful information and disseminate to people and assisting them to acquire the necessary knowledge, skills and attitudes.

Cropping frequency of the respondents' household

The results obtained from the key informant interview andrespondents' household revealed that in the area farmers engaged in both rain feed and rain feed + irrigated agriculture and grown different types of annual and perennial crops with the help of rain fall and supplementary irrigation.
The results show that the majority (98.2%) of the

Table 3. Average land allocated and average production obtained from different crops in 2014/15.

Types of crop grown	Average land allocated in Ha/HH.			Average production obtained in Qt/HH.		
	Irrigation user respondents' household	Irrigation non-user respondents' household	t-value	Irrigation user respondents' household	Irrigation non-user respondents' household	t-value
Banana	0.52	0.06	16.3***	29.5	6.1	16.8***
Mango	0.02	-	2.6***	1.5	-	2.3**
Maize	0.24	0.33	-4.3***	6.4	8	-2**
Tef	0.12	0.2	-4.2***	0.8	0.8	0.2
Cotton	0.04	-	3.1**	2.5	-	2.3**
Root crops	0.37	0.21	1.4	0.2	0.06	1.3
Vegetables	0.002	0.001	0.9	0.2	0.1	0.7

*** And ** represent 1 and 5% significant level respectively. Source: Computed from field survey data, 2015.

irrigation user respondents' households have been grown two times annual crops (maize, tef, cotton, vegetables and root crops) and harvesting more than twice from perennial crops (banana and mango) per year from the same farm while the majority (90.7%) of the irrigation non-user respondents' households have been grown only one time annual crops (maize, tef, cotton, vegetables and root crops) per year from the same farm. Additionally, these results also show that the respondents who engaged in the growing of perennial crops mostly depend up on the use of the irrigation water. And also the use ofthe irrigation water is initiate farmers to grow annual crops more than one time per year from the same farm.

Average land allocated and production obtained from different crops

The results in Table 3 show that the average land allocated in Ha/HH by irrigation user respondents' household for banana, mango, maize and tef, was 0.52, 0.02, 0.24 and 0.12 respectively. While average land allocated in Ha/HH by irrigation non-user respondents' household for banana, mango, maize and tef, were 0.06, 0.00, 0.33 and 0.2 respectively. The t-value revealed that at 1% significance level, the average land allocated in Ha/HH by irrigation user respondents' household for perennial crops (Banana and Mango) was significantly larger than that allocated by irrigation non–user respondents' household. While average land allocated in Ha/HH by irrigation user respondents' household for annual crops (Maize and Tef) were significantly lesser than that allocated by irrigation non-user respondents' household. This result implies that the irrigation user respondents' household allocated more land for perennial crops (banana and mango) than annual crops when compared with irrigation non-user respondents' household and vice versa. Therefore, use of irrigation water increases the average land allocation in Ha/HH for perennial crops than annual crops.

The average production obtained in Qt/HH by irrigation user respondents' household from annual crops (maize and tef) was 6.4 and 0.8 respectively. While that obtained by irrigation non-user respondents' household from annual crops (maize and tef) was 0.8 and 0.8, respectively. The average production obtained from Tef by the irrigation user respondents' household was relatively equal with non-user. This result also revealed that use of irrigation water was increased the average production obtained in Qt/ HH for some crops.

Additionally, the results obtained from the key informant interview revealed that, most of irrigation non-use farmers live in the sample kebele have refused and hesitated to use of improved seeds and fertilizer due to lack of the access to use of the irrigation water. However, the use of the improved seeds and fertilizer are crucial to improve the farm productivity and then maximize total farm production. Therefore, the use of irrigation increases the farmers' interest to use improved seeds and fertilizer as well as improve the farm productivity and then maximize farm production. In agreement with this finding, Nhundu et al. (2010) have reported that use of irrigation water supplements moisture, which enables farmers to maximize agricultural production and improves gross farm income of a household.

Annual gross income obtained from crop product by the respondents' household

The results in Table 4 show that the mean annual gross income obtained in birr by the irrigation user and non-user respondents' household from the different crops in the Shara kebele was 9166 and 3413; in the Elgo kebele was 15520 and 7995 and in the Dorga was 15733 and 5381, respectively. This result also revealed that in the Shara and Dorga kebele the mean annual gross income obtained in birr by the irrigation user respondents' household was more than double that obtained by the irrigation non-user respondents' household. While in the

Table 4. Annual gross income obtained in birr from different crops in 2014/15.

Types of crop grown	Annual gross income obtained in birr from each crop from sample villages					
	Shara village		Elgo village		Chano Dorga village	
	By irrigation user	By irrigation non-user	By irrigation user	By irrigation non-user	By irrigation user	By irrigation non-user
Banana	387200	-	313488	82100	94150	-
Mango	13820	-	-	-	5850	-
Maize	114400	151400	124900	120350	46200	9200
Tef	62060	5600	14880	24210	6490	48300
Cotton	-	-	125399	-	40400	-
Root crops	-	-	15050	5200	6050	1700
Vegetables	-	-	11600	-	5400	-
Total	577480	157000	605317	231860	204540	59200
Mean	9166	3413	15520	7995	15733	5381

Source: Own field survey, 2015.

Table 5. Annual gross farm income obtained by the respondents' household in 2014/15.

Annual gross farm income obtained in birr	Irrigation user respondents' household		Irrigation non-user respondents' household		t- Value
	Frequency	Percent	Frequency	Percent	
1000 - 10000	53	46.1	76	88.4	
10001 - 20000	51	44.3	9	10.5	
20001 - 30000	9	7.8	1	1.2	
30001 - 40000	2	1.7	-	-	
Total	115	100.0	86	100.0	
Mean	12429.8		5210		5.995***

Source: Own field survey, 2015. P-value = 0.000; ***, Significant at 1% level.

Elgo kebele it obtained by the irrigation user respondents' household was almost double that obtained by the irrigation non-user respondents' household. Therefore,the mean annual gross income obtained in birr by the irrigation user respondents' household from the different crops in the all sample kebele larger than that obtained by the non-user respondents' household. In agreement with this finding, Yidnekachew (2009) has reported that the Rain fed + Irrigated Agriculture households earns an average income of 23,900 birr from irrigated crops, which is 43% of their total at Fogera district in the Amhara Regional State.

Annual gross farm income obtained by the respondents' household

The results in Table 5 show that the mean annual gross farm income obtained by the irrigation user and non-user respondents' household was 12429.8 and 5210 respectively. The t-value shows that at 1% significance level, the mean of annual gross farm income obtained by the irrigation user respondents' households was significantly larger than that was obtained by the irrigation non-user respondents' households. As a result, the irrigation user respondents' households had obtained excess of 7219.8 birr of mean annual gross farm income than that was obtained by the irrigation non-user respondents' households. In agreement with this finding, the study conducted by Ayele et al (2013), at Lake Tana basin has reported that access to irrigation has a significant positive role on the mean income of a household (3353 birr per year) a 27% increase over the mean income for non-irrigating households and also Kinfe (2012), at Central Tigray has also reported that the irrigation user households with one hectare irrigable land are better-off in well-being by 23,327.8 birr than the non-user households. In the study area, irrigation user respondents' household has grown annual crops two times and harvesting perennial crops more than twice from the same farm per year.

Conclusion

One of main constraints for irrigation non-user

respondents' household in the study area are distance from Rivers and main irrigation canals. These factors were negatively and significantly affect the use of irrigation water at 1% significant level. The major sources of irrigation water in the study area are rivers. The availability of water from rivers is decreases during dry season so it was not reliable even for irrigation users' farm that located far distance from the Rivers. Moreover, in the study area there is an opportunity to use Shallow Wale due to location nearest to the Lake Chamo and Abaya. Some farmers in the study area have used Motorized Water Pumps for irrigation purposes and it creates access to them to use irrigation water through lifting from different sources even if their farms are not accessible to irrigate through gravity force. However, the access to use such equipment is limited due to high purchasing cost. There are Irrigation Water Users' Committees in the three sample villages, these Committees have multiple roles play in irrigation water development and management practice in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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