Determinants of Small-Scale Irrigation Practices in Geray Irrigation Scheme, Northwest Ethiopia

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Abstract

Developing irrigation agriculture is a means of increasing food production and of improving the livelihood of smallholder farmers dwelling in areas with very erratic and unpredictable weather conditions. Therefore, this study aimed to analyze the determinants of small irrigation practices and their contribution to household farm income in the Geray irrigation scheme in Northwest Ethiopia. A simple random sampling technique was employed for the selection of 231sample households. Data was collected from 171 irrigation users and 60 non-users. A structured household survey questionnaire, key informant interview, and focus group discussion were employed to collect primary data. Descriptive and inferential statistics were employed to estimate determinants of small-scale irrigation practice and household income. The study revealed that practicing in small-scale irrigation has played a significant role in increasing the total income of households in the study area. The study showed that practicing irrigation schemes has a positive impact on crop production. The binary logistic regression results also revealed that practicing irrigation is determined by the total income of households, livestock ownership age, family size, training, marital status, size of irrigable land, and access to market information. Therefore, to improve irrigation practices by smallholder farmers, local governments and other concerned bodies should attempt to address those factors that can affect small-scale irrigation practices in the study area.

Keywords: Determinants, Household income, Small-scale irrigation, Northwest Ethiopia

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1. Introduction

The efficient use of irrigation projects varies widely across the world. In this regard, FAO (2012) estimated that about 30% of world food production came from 18% of the total cultivated land under irrigation. The same report also indicated that there were wide variations in the proportion of irrigated agricultural land in the developing world with 37% in Asia, 15% in Latin America, 6% in Africa. This shows that irrigation currently plays a less significant role in many Africa countries as compared to other regions of the world though the region has ample water resources.

Dittoh (1997) argued that Africa's performance in terms of poverty reduction and increase of household income to a large extent is attributed to its efficient use of irrigation farming. Hence, irrigation is seen as part of the modernization and investment of the agricultural economy, and it is considered an important vehicle for development. However, irrigation schemes in many developing countries, in particular, faced complex problems such as lack of appropriate technology, good governance at grass-roots level, finance to use water resources, lack of inputs, and lack of efficient professional support (Dereje & Desale, 2016; Dittoh, 1997).

Despite water abundance in sub-Saharan Africa (SSA), the region uses less than 2% of its total potential of irrigation schemes (Mosissa & Bezabih, 2017). Under this potential irrigation scheme in the region, rainfall is unpredictable, erratic, and unevenly distributed between seasons and agro-ecological zones that results in low agricultural productivity (Dereje & Desale, 2016; Tsegazeab & Ghosal, 2016; Mosissa & Bezabih, 2017). This may further lead to food insecurity and poverty within the rapidly growing farming population. To avert these problems, there needs to be developed large and small irrigation schemes across the region including Ethiopia.

In Ethiopia, modern irrigation began in the 1950s through private and government-owned schemes in the middle Awash Valley where big sugar, fruit, and cotton state farms are found (Dereje & Desale, 2016). This is because depending only on rain-fed agriculture which is affected by the scarcity of land and erratic rainfall exposes smallholder farmers to chronic food insecurity and poverty. Hence, the use of small plots of land intensively with the help of irrigation schemes and production augmenting inputs could be taken as necessary steps for poverty reduction, overall livelihood improvement, and increase of household income (Eshetu & Cho, 2017; Kinfe et al., 2012). To address this, the government of Ethiopia has been trying to transform the traditional rain-fed agriculture into mechanized irrigated agriculture, through full packages of value addition and postharvest technologies (Adugna et al., 2014; Eshetu & Cho, 2017; Tsegazeab & Ghosal, 2016). However, the majority of farmers are smallholders with 85% engaged in less than 2 hectares and 40% less than 0.5 hectares (FAO, 2014). From these small plots of land, the majority of the farmers produce only half of the annual food intake requirements of the country (FAO, 2014). Although Ethiopia has abundant land for irrigation (4.5 million hectares), only a fraction of its potential land (5%) is being utilized (Abdissa et al., 2017). Awulachew and Mekonin, (2011) argue that irrigation in Ethiopia seems less costly since the huge potential is from surface water (82%); however, only 5% is currently being irrigated. This could be the reason that irrigation contributes only 3% of the total food production of the country (Adugna et al., 2014; Teshome, 2006).

The Amhara region has enormous land and water resources, being also the home of the largest surface water resource potential in the country. Out of 12 river basins in Ethiopia, four major basins are located in this region, and a recent estimate shows that about 35 billion cubic meters of runoff water is available in the region per year (BOWIED, 2017). The total irrigable land potential in the Amhara region is 1.2 million hectares. Of the total, 91,853 hectares of land are irrigated at present (Plan Commission, 2017). Put differently, although there are potential opportunities to increase the amount of irrigated land, a significant portion of cultivated land in the region is not yet irrigated.

Jabithenan *woreda,* where the present study was conducted, is densely populated (193 persons per km^2) which is much higher than the Amhara region average (112 persons per km^2) which resulted in a scarcity of farmland (CSA, 2016). This needs intensification of crops using irrigation to carry out this huge population. However, farm households in the study area are not able to use the maximum potential of water resources for irrigation purposes to enhance crop production. This was the motivation to conduct this study of the determinants of small-scale irrigation practices and their contribution to household income and livelihood in the study area.

Numerous studies have been made on the impact of irrigation on rural farmers' income, and the results of these studies indicated that irrigation users had a higher income than non-irrigation users in Ethiopia (Agerie; 2016; Ayana, 2016; Dereje & Desale, 2016; Gadisa, 2016; Seid, 2016). However, studies on determinants of small-scale irrigation practices are limited in the study area. Therefore, this study tried to fill the gap by addressing the following specific objectives. The specific objectives of the study include (i) identifying the determining factors affecting the practice of small-scale irrigation in the study area, and (ii) investigating the contribution of small-scale irrigation on household farm income.

1.1. Conceptual Framework of the Study

As shown in Figure 1, predictor variables such as demographic, socio-economic, and institutional factors affect positively or negatively the practice of irrigation of households (dependent variable) in the study area. For example, being a female-headed household could affect the practice of irrigation negatively whereas the availability of credit would help the beneficiaries to buy inputs, thereby positively affecting the practice of irrigation (in-depth discussion is made in the data analysis section).

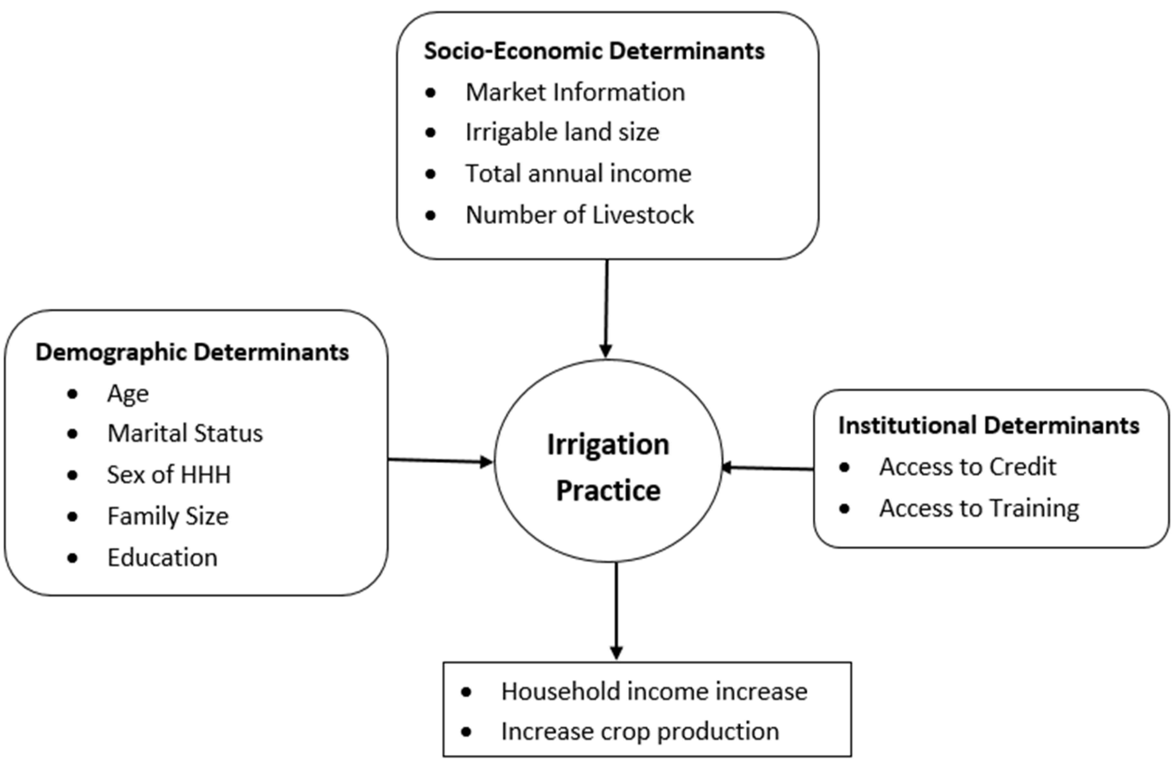

Figure 1: Diagram showing the relationship between predictor variables and irrigation practice

2. Research Methodology and Description of the Study Area

2.1 Description of the Study Area

Geray Irrigation Scheme is found in Jabitehinan *woreda*, West Gojjam Administrative Zone, Amhara National Regional State. The study area is geographically located 10°35′51.89″ N to 10°38′39.53″N latitudes and 37°16′03.41″E to 37°17′10.82″ E longitudes. The mean annual temperature is 23°C with a mean annual rainfall of 1250mm. The total area of the study area is 2519 ha and the topography consists of 99% plain and 1% valley. The soil types of the area include 50% red soil, 33% black soil, and 17% brown soil (BoARD, 2019). The study area is inhabited by a total population of 5226 out of which 2702 are males and 2560 are females. About 100% of the population lives in rural areas. The major crops grown in the study area include maize (*Zea mays*), *teff* (Eragrostis tef), coffee (*Coffea)*, barley (*Hordeum vulgare*), potato (*Solanum tuberosum*), and others. Vegetables such as cabbage (*Brassica oleracea var*), tomato (*Solanum Lycopersicum*), green pepper (*Capsicum annum*), and fruits like mango (*Mangifera indica*), avocado (*Persea Americana*), papaya (*Carica papaya*), and banana (*Musa acuminate*) grow extensively. Livestock reared in the study area include cattle, equines, goat, sheep, poultry, and honeybees (BoARD, 2019).

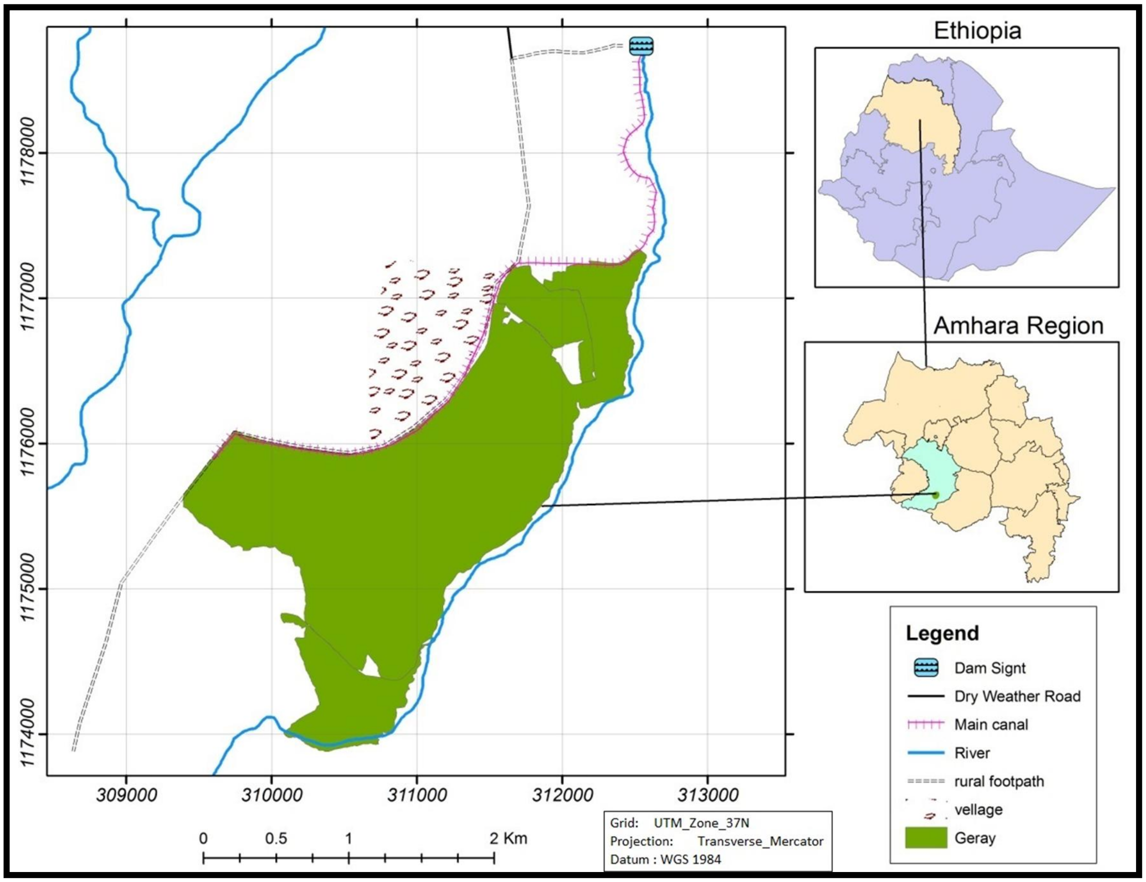

Figure 2: Map of the study area

2.2. Research Methods

The study employed mixed methods research design. This is because the weakness of one method could be overcome by the strength of the other method. The quantitative study design was used to collect data on demographic, socio-economic, and institutional variables. The quantitative data were supplemented by opinion and perception regarding the determinants of irrigation practice generated through key informant interviews and focus group discussions.

2.3. Sampling Methods and Sample Size

Geray Irrigation Scheme was selected purposively for the study. This is due to the fact that Geray is the only area where small scale irrigation is being practiced. Moreover, the principal investigator knows the study area well. The target population of the study area was 551 households, from which 408 of them were irrigation users and 143 were non-irrigation users. The list of the households was obtained from the study area Development Agent Office. Using the list, a simple random sampling technique was employed to select the sample unit from each stratum via probability proportionate to size. From the total 551 households found in the study area, 231 sample households were selected to fill out the questionnaire. Therefore, the sample sizes of the irrigation user and non-user respondent households were 171 and 60, respectively. The sample size was calculated using Yemane's (1967) formula. However, key informants and focus group discussion participants were selected purposely taking into account the relation they have with the topic under investigation.

2.4. Data Sources and Methods of Data Collection

The data for this study were collected from primary and secondary data sources. Primary data sources were household heads, key informants, and focus group discussion participants. Secondary data sources included *woreda* agriculture office report, theses, reference books, and journal articles. The questionnaires were composed of both closed- and open-ended types of questions and covered various issues such as demographic, socio-economic and institutional characteristics of the respondents. Under the supervision of the researcher, five enumerators conducted the survey using the developed questionnaires. The enumerators were trained in how they could present and explain each question to respondents. A pre-test was employed for some selected households from users and non-users. This helped the principal investigator to modify and to reconsider some of the questions before distributing it to the selected respondents.

Key Informant Interview (KI): The researcher interviewed six members such as one *woreda* irrigation expert, two development agents and three model farmers. Issues raised during the interview were factors influencing irrigation practices.

Focus Group Discussions (FGD): One focus group discussion was held with ten participants. The members of the discussion were composed of three irrigation users, and three non- irrigating users, two water user association committees and two peasant association leaders to explore the determinants of irrigation practices in the study area.

2.5. Methods of Data Analysis

For this research, both qualitative and quantitative data analysis techniques were used. The data collected through key informant interview and focus group discussion were analyzed through narration to support the quantitative data results. The quantitative data were processed and analysed using SPSS version 24. Descriptive statistics (frequency, graphs, tables, and percentages and standard deviation) were used to analyze demographic characteristics, socio-economic and institutional determinants of irrigation practices and income of irrigation user and non-user households. The chi-square test was used to test the statistical association of dummy variables. Independent sample t-test was used to test the statistical differences between the means of the two groups by using continuous variables.

The binary logistic regression model was used to identify determinant factors affecting households' participation in irrigation practices. The predictor variables that determine households' participation in irrigation practices were grouped into demographic, socio-economic, and institutional as presented in the conceptual framework (Figure 1). As can be seen in Table 1, positive signs indicate higher probability to participate in irrigation schemes and negative signs show lower probability to participate in irrigation schemes.

Table 1: Expected sign of predictor variables

Variable name	Variable description	Expected sign
Sex	Dummy (1= Female 0 = Male)	-
Age	Continuous	-
Education	Dummy (1 = literate, 0= illiterate)	+
Family size	Continuous	+
Training frequency	Dummy (1 = Yes, 0 otherwise)	+
Access to credit	Dummy (1 = Yes 0 otherwise)	-
Size of irrigation land	Continuous	+
Livestock ownership	Continuous	+
Total annual income	Continuous	+
Marital status	Categorical	+
Market information	Dummy (1 = Yes 0 otherwise)	+

Assumptions such as multicollinearity, outliers, and independence were checked. The goodness fit of the model was also checked using the Hosmer and Lemeshow Test, Omnibus tests for model coefficients and classification table.

The binary logistic regression model was used to establish the relationships between irrigation practice and a set of predictor variables. It was selected as it can be used with a mix of continuous, discrete and dichotomous variables. The binary logistic regression model allows one to select the predictive model for dichotomous dependent variables. It describes the relationship between a dichotomous response variable and a set of explanatory variables (predictors). For this study, the binary logistic regression model was used to identify determinant variables for household participation in irrigation. The dependent variable is codded 1 who participated in irrigation and 0 otherwise (see Table 1).

3. Results and Discussion

3.1 Demographic Characteristics of Respondents

The sex of household heads in the study area determines irrigation practice. The survey result indicated that among irrigation non-users 26.3% were male-headed households and 25% were female-headed households. The chi-square test result also showed that there was no significant relationship between being male- and female-headed households in practicing in irrigation ($p > 0.05$ ($X2$ (1) = 0.030, P= 0.863). Information obtained from key informants and FGD also supported that female-headed households specifically obtained due attention from development workers to participate in irrigation systems like tmale-headed households by increasing extension services and providing inputs in their locality. This result contradicts the work of Agerie (2016) which reported that there was a statistically significant difference between household heads that are the users of irrigation and non-users in terms of their sex at 1% probability level and this shows male-headed households are more likely to be irrigation users than female-headed practices.

The marital status of the respondents was categorized into married or single. The study revealed that farmers who were married had the largest share (90.6 %) in practicing irrigation schemes. The chi-square test result indicated that there was a significant difference between categories of marital status (married and single) in practicing irrigation schemes at $p <0.05$ ($X2$= 64. 328, p = 0.000). This indicated that married farmers with a large family size participated vigorously in the irrigation schemes. In rural areas, starting from five years of age to old age people participate in agricultural activities in different ways. For example, children under ten look after cows or do some activities at home when the mother is in the field doing agricultural activities.

The average family size for the study households was 3.76, smaller than the national average which was 4.6 people per household (CSA, 2016.B). The study found that households who participated in irrigation schemes had more family size (4.33) than non-users (2.13). The result of the independent samples t-test also confirms a statistically significant mean difference between users and non-users concerning family size ($p < 0.05$) (Table 2). Key informants and FGD also showed that families who had many family members working were in a good position to get more income for the household. Informants further suggested that households with a small family size were less likely to practice irrigation than households with larger family size. This is because households with a large family size need to feed many mouths. Hence, all family members should engage in work.

The results revealed that about 32% could read and write and about 15% could not read and write. This shows that 85% of the respondents had formal and informal education. It was confirmed that no significant differences were observed in the level of education of those practicing irrigation schemes. The analysis of the chi-square test showed that there was no remarkable difference in the level of education and irrigation practice ($p > 0.05$). According to key informant interviews and FGD participants, educated farmers were more interested in agricultural activities like business, rather than taking up cultivation as a major occupation. Contrary to this result, Derje and Desale (2016) argued that there was a significant association between the level of education and irrigation practice in their study. They stated that educated household heads were more aware of the use of irrigation inputs in enhancing crop production.

Table 2: Summary of statistics for continuous variables and irrigation practice of households

Variables	User(N=171)		Non-user (N=60)		Total sample (N=231)		T-value
	Mean	St.Dev.	Mean	St.Dev	Mean	St.Dev	
Age	42.07	14.88	36.77	11.77	40.69	14.31	.013**
Family size	4.33	1.53	2.13	0.873	3,76	1.694	.003***
Farm size	0.567 ha	0.265ha	0.55ha	0.220ha	0.523ha	0.255ha	.000***
Annual income	44,739.9	12,011.1	30,773.7	6,010.6	41112.37	12392.22	.000***
Number of livestock	10.15	3.83	9.94	3.6	9.99	3.65	.000***

Source: Survey 2019

Note: ** significant at 0.05; ***significant at 0.01

Age was one of the factors that determined irrigation practice in this study. As indicated in Table 2, the mean ages of irrigation users and non-users were 42.07 and 36.77 years, respectively. This difference was statically significant at $p < 0.05$. This indicated that older household heads had a better experience in irrigation practice than younger household heads. Moreover, older heads of families tend to avoid risks, and mostly they intensify and diversify their production activities (Eshetu & Cho, 2017). However, this conclusion contradicts the results of studies which claim that age does not bring a significant difference between users and non-users in their practice of small-scale irrigation (Abraham et al., 2015).

3.2. Socio-economic Characteristics of Respondents

3.2.1. Number of livestock of households

The mean livestock of sample households was 9.99 with a standard deviation of 3.65. The mean livestock of the users was 10.15 with a standard deviation of 3.83, while the mean livestock of non-users was 9.94 with a standard deviation of 3.6 (Table 2). This shows that the users had a higher livestock number than the non-users. The independent samples t-test result also reveals that there was a statistically significant difference between number of livestock and practicing irrigation $p < 0.01$ ($t= 4.94$, $df=259$, $p = 0.000$). This result contradicts the findings of Agerie (2016) which reported that the mean livestock owned by users was 7.18, while that of the non-users was 5. In this regard, key informants indicated that households who participated in the irrigation schemes had smaller number of livestock compared to their counterparts.

3.2.2. Access to market information

Access to market information is one of the most important aspects of the irrigation practice of rural farm households. The survey result indicated that 14% of the users and 1.7% of the non-users had access to market information. This shows that users get better market information than non-users. The chi-square test result confirmed that there was a positive and significant relationship between access to market information and irrigation practice at a 1% significance level. Key informants noted that irrigation users in their locality lacked market information which affected farmers from obtaining a reasonable and better price for their produce. In line with this, Abonesh et al. (2006) noted that market information helps farm households to market perishable farm products at the right time without loss of quality.

3.2.3. Irrigable land size of households

The average farm size of the sample households in the study area was 1.49 ha with a standard deviation of 0.74. The overall landholding per household among users and non-users of irrigation were 1.26 and 1.65 ha, respectively (Table 2). The independent samples t-test result showed that there was a statistically significant difference between land size and practicing of irrigation at $p < 0.01$ ($t= 3.827$, $df = 259$, $p = 0.000$). The average farm size of the study area is larger than the national average landholding size of 1.04 hectares (MoFED, 2012). The survey results imply that non-users have higher farmland size than users which is inconsistent with the works of Agerie (2016) and Gadisa (2016), which reported that irrigation users had larger landholdings than that of non-users.

3.3. Institutional Factors and Irrigation Ppractice

3.3.1. Training services

Training in small scale irrigation practice is one of the important factors that influence crop production. Survey results indicated that 95.2% of users and 4.8% of non-users had access to training. The result of the chi-square test confirmed that there was a positive and significant relationship between access to training and irrigation practice ($p < 0.01$). The basic assumption is that the more training and technical advice is provided by extension agents to farmers, the higher is the probability of the farmers to practice small scale irrigation (Abdissa et al., 2017).

3.3.1. Access to credit

Credit is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technologies. The results indicated that 15.8% of the users and 23.6% of the non- users had received credit services. The analysis of the chi-square test result shows that there was no significance association between access to credit and irrigation practice ($p > 0.05$). Key informants and FGD participants reported that high interest rates and unavailability of credit became obstacles to taking credit which could help increase irrigation practices. This result was inconsistent with the results of Zinba (2015), which indicated that 75% of the irrigators and 41% of the non-irrigators had taken credit.

3.4. Determinants of Household's Participation in Irrigation Practices

Eleven predictor variables were selected to explain the dependent variable (practicing in irrigation scheme). Out of the total predictor variables, eight variables were significant at 1%, 5%, and 10% probability levels (Table 3). The omnibus test of model coefficients has a Chi-square value of 74.538 on 8 degrees of freedom, which is strongly significant at $p < 0.001$ indicating that the predictor variables selected have a high joint effect in predicting the practice of irrigation in the study area. The predictive efficiency of the model showed that out of the 231 sample households included in the model, 83.11% were correctly predicted. The sensitivity (correctly predicted user) and specificity (correctly predicted non-users) were found to be 93.5% and 55.0%, respectively.

The binary logistic regression results are shown in Table 3. Age, family size, total annual income, market information, livestock ownership, marital status, size of irrigable land, and training frequency variables were important determinants of household irrigation practices.

Total income of the household: The variable was significant a 1% significance level and positively related to household participation in practicing small-scale irrigation. This shows that all other things being kept constant, the probability ratio in favor of small-scale irrigation practice increases by a factor of 1.000 as the total income of the household increases by one birr. The possible reason for this is that households with different sources of income would be encouraged to practice irrigation activities by supplying initial capital. This finding is consistent with the findings of Abebaw et al. (2015).

Table.3. Binary Logistic results for determinants of irrigation practice

Explanatory Variables	Estimated Coefficient (B)	S.E.	Wald statistics	Sig. level (P)	Odds ratio
Age	-.028	.014	4.257	.039**	.972
Family Size	-.235	.135	3.050	.081*	.790
Total Livestock	.106	.055	3.776	.052*	1.112
Total annual income	.000	.000	25.065	.000***	1.000
Price Fluctuation	.313	.410	0.582	.445^{ns}	1.367
Market Information	-2.703	1.119	5.834	.016**	.067
Increment price	.400	.451	0.787	.375^{ns}	1.492
Marital status		-	61.140	.000***	-
Married(1)	3.385	1.142	8.788	.003***	1.034
Single(2)	-.208	1.256	0.027	.869^{ns}	.813
Training Frequency	1.604	.215	55.649	.000***	4.972
Size of irrigated land	.350	.140	6.286	.012**	1.419
Constant	-4.600	.545	71.228	.000	.010

Note: *significant at 0.1; ** significant at 0.05; ***significant at 0.01

***Size of irrigable land*:** This variable was significant at 5% significance level and positively affects a household's participation in practicing small-scale irrigation. This implies that all other variables being kept constant, the probability ratio in favor of small-scale irrigation practice increases by a factor of 1.419 as the proportion of the irrigated land size of the household increases by one unit. In line with Petros and Yishak's (2017) results, this finding revealed that the land size of irrigation owned by users was greater than that of non-users. Land size variation has an effect on practicing small scale irrigation. The possible justification could be large irrigated land size encourages people to practice irrigation and increases production by minimizing risks through growing two or more crops within a year.

Market information: Market information significantly determined household practice in small-scale irrigation at 5% probability level. It positively influenced the practice of farmers in small-scale irrigation. The possible reason for this is that getting information on the input and output price by farmers could encourage practicing irrigation. This finding is consistent with the findings of Kinfe et al. (2012).

Number of livestock owned by households: This variable was found to have a positive and significant effect at 10% level of significance. It is important that the larger the number of livestock owned, the more likely that a household would practice irrigation. This implies that other variables being constant, a unit increase of total livestock will increase the probability of practicing irrigation by a ratio of 1.112. In line with this, key informants and focus group discussion participants noted that households who had a larger amount of livestock were wealthier and had a sufficient number of oxen to cultivate their irrigable land. This result was similar to the study of Gadisa (2016) which found that the mean livestock holding of users was higher than that of non-users.

Marital status**:** This variable was found to have a positive and significant effect at 1% level of significance. As far as marital status is concerned, being married is more likely to increase the probability of participating in irrigation schemes as compared to divorcees with the odds ratio of 1.034, other variables being constant. This result was also supported by the findings of a study by Dereje and Desale (2016), which reported that being married created more opportunities in participating willingly in irrigation schemes because large family size is a driving force to seek options to earn additional income.

Training frequency**:** This variable had significant and positive effects on the use of irrigation practice at 1% significant level. Similarly, Agidew (2017) and Petros and Yishak (2017) noted that farmers who were involved in training had better chances to practice irrigation than non-trained farmers. This indicates that trained households easily acquire relevant knowledge and adopt improve irrigation technologies which in turn increase their access to practicing small-scale irrigation.

***Family size*:** Family size has affected irrigation practice positively and significantly at 10 % level of significance. An increase of family size by one person, while other factors held constant, would increase the probability to practice irrigation by a factor of 0.790. Similarly, Abraham et al. (2015) discovered a positive and significant relationship between family size and irrigation practice. This is the reason why family size is an important issue in practicing small-scale irrigation because practicing irrigation is labor-intensive. Thus, households who have large family sizes do not face a shortage of labor in practicing irrigation activities.

Age of the household head: The age of the household head significantly affects the practice of small-scale irrigation at 5% level of significance. This is due to the fact that aged farmers have more wealth than younger farmers. Hence, they may not want to make more money. In line with this, Temesegen (2018) indicated that old farmers were interested neither in future development nor in investing their time and energy to improve crop production through practicing irrigation.

3.5. The Contributions of Irrigation to Household Income

Irrigation practice contributes much to increasing the total income of beneficiary households. The data presented in Table 4 show that the total annual income of households was higher for users than non-users.

Table 4: Income earned by households

Income Source (Ethiopian Birr)	Irrigation User		Irrigation Non-user		Mean difference	Test of Variables
	Mean	St, deviation	Mean	St, deviation		
Crop pro.	39102.35	9368.69	2664.84	4783.98	18437.51	0.000***
Live Stock	3531.19	1681.56	6025.36	735.99	-2494.17	0. 000***
Non- farm	2106.4	960.89	4083.35	490.67	-1977.18	0. 000***
Total	44739.94	12011.14	30,773.77	6010.64	13966.17	0. 000***

Source: Survey 2019

Note: ***significant at 0.01

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The mean total annual income for users was Ethiopian birr 44, 739.94 with a standard deviation of 12,011.14, while the mean total income of the non-users was Ethiopian birr 30,773.77 with standard deviation 6,010.64. The result showed that participating in irrigation schemes increased the total income of households significantly. This result was consistent with the findings of the study Agerie (2016), which reported that households with access to irrigation had a mean annual income of Ethiopian Birr 56,166.59, and the average for the non-users was Ethiopian Birr 26,102.44. This difference in income between households who practiced and those who did not practice irrigation is supported by the argument Awulachew et al. (2010) and Jema et al. (2013) presented. These researchers argued that investment in irrigation serves as a strategy to ensure food security. The result of the independent samples t-test showed that there was a significant difference at $p < 0.001$($t= 5.35$, $df = 259$, $p = 0.000$) between participation in irrigation as a result of total income of households.

3.6 Income of households from crop production

Practicing irrigation increases crop production. The results presented in Table 4 show that total crop production was higher for irrigation users than for households who did not use irrigation. The mean crop production by irrigation users was 39,102.35 with a standard deviation of 93, 68.69, while for irrigation non-users the mean crop production was 2664.84 with a standard deviation of 4783.98. This result shows that practicing irrigation has significantly increased crop production.

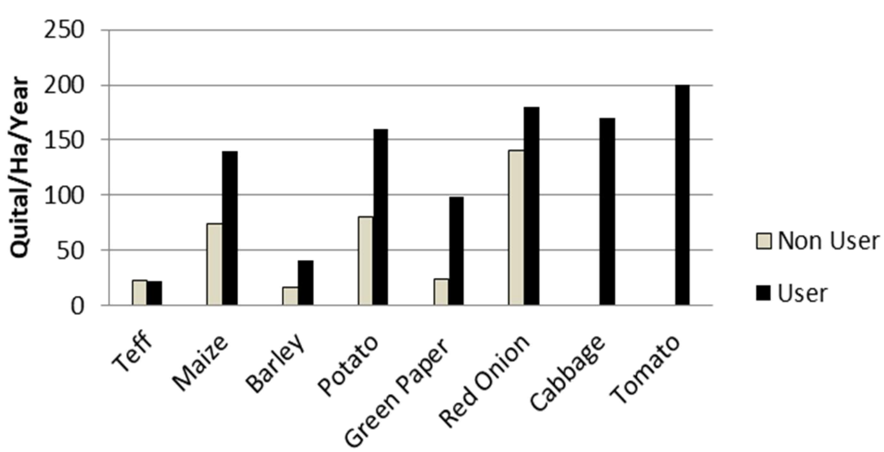

Figure 3: Average crop yields in quintals per year in 2019

The results of the independent samples t-test as shown in Table 4 show a significant association between practicing irrigation and crop production at $p < 0.001$ (t=7.24, df = 4, p=0.000). Similarly, studies of Getaneh (2011) and Regassa (2015) revealed that income from crop production is significant at a probability of less than 1%; the mean annual income was 20,747.9 ETB for participants and 2,509.7 ETB for non-participants. Thus, irrigation helps users to produce more per year than non-users do. These also supplement income, ensure food security and diversify crop production.

4. Conclusion

The overall objective of this study was to assess the effects of small-scale irrigation practices on land productivity and its contribution to household farm income. To this end, a household income and land productivity surveys were undertaken on 231 rural households (users and non-users) in the Geray Irrigation Scheme in Northwest Ethiopia. The binary logistic regression result showed that age, family size, total livestock owned, total annual income, size of irrigable land, frequency of training, market information, and marital status were determinant factors of small-scale irrigation practices in the study area. It is reasonable to conclude that adequate consideration of these variables during irrigation practices is important to increase crop production and household income. The study also indicated that the mean annual crop production of households was much higher for the user group than for the non-users. The mean total annual income of households was higher for the users by a mean difference of 13,966.17 Ethiopian birr as compared to the non-users. The study recommends that the capacity of small-scale irrigation users should be built by addressing the determinants of irrigation practices to increase crop production and rural household income

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