SOCIAL, ECONOMIC AND INSTITUTIONAL FACTORS AFFECTING UTILIZATION OF RAINWATER HARVESTING TECHNOLOGY, EASTERN TIGRAY, ETHIOPIA

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ABSTRACT

The study is motivated by the belief that the constraints of the low productivity leads to poverty and famine cannot be overcome by simply concentrating on the rain fed agriculture therefore the rainwater issue needs to be addressed as well. In the course of this study primary data were collected from 201 households out of which 101 were users of RWHT while the rest 100 sampled households were engaged only in rainfed agriculture. In this study multistage sampling technique was employed. In the first stage two wereda were selected purposefully and six Tabias, selected randomly. Households in the sample Tabia were stratified as user and nonuser of RWHT. From the stratified households sample respondents were selected using probability proportional to size method. Descriptive statistics such as mean, standard deviation and percentage were used to describe sampled respondents in terms of some desirable variables. A binary logit model was also used to analyze the determinants of the utilization of the RWHT. Fourteen variables were included in the model of which eight were found significant at (P<0.10) probability level. Extension contacts, training, animal product income, market distance, location, cash availability, farmland size and input were found to be highly important variables influencing utilization of RWHT. Additionally 18 items were selected and 16 of them were analyzed using attitude scale (1-5). As a result of this, RWHT demand of labour, cost, land, skill and knowledge were found to be highly important items related to utilization of RWHT. The item RWHT take large area & increase cost shows significance difference at (P<0.05) and (P<0.10) probability level. Moreover, the grand mean for both categories were found to be 3.46, which shows favorable attitude. The plausible explanation implies that for both group of the users and nonusers there may be some thresholds influencing RWHT utilization as the result of the favorable attitude. The forgoing discussion has revealed that RWHT activity, which includes trapezoidal pond and percolated pond, is widely undertaken in the study area. Households involved in those activities could benefit more if they got favorable environment for utilization the RWHT. The main bottlenecks that hamper the development of RWHT activities required by the farmer include knowledge, capital, raw material and access to market. The finding of this study indicates that the social economical psychological conditions of farmers differ from farmer to farmer.

Key Words: Rain Water Harvesting, Utilization, Tigray, Ethiopia.

1. INTRODUCTION

Ethiopia has a vast water resource potential yet only one percent of the estimated annual surface water of the 110 billion cubic meters is used for irrigation and hydropower (Alamneh, 2003). The agricultural growth rate of the country is low as compared to the rate of the population growth of three percent. Consequently, the country's agriculture becomes highly dependency on rain-fed agriculture. As land pressure rises, more and more marginal areas in the world are being used for agriculture. Much of this land is located in the arid or semi-arid belts where rainfall is irregular and much of the precious water is soon lost as surface runoff. Recent droughts have highlighted the risks to human beings and livestock, which occur when, rains fail.

While irrigation may be the most obvious response to drought, it has proved costly and can only benefit a fortunate few. Nowadays, there is increasing interest in the country in the low cost alternative- generally referred to as 'water harvesting'. The latter refers to a practice of inducing, collecting, storing and conserving local surface runoff for agricultural production (Nigigi, 2003).

The study was carried out in Tigray, northern Ethiopia (Figure 1). Most of the hydrographic 87 percent of Tigray is associated with the Mediterranean hydrological regime. Only 13 percent of the total area of 54572.6 square kilometers of the region drains to the Indian Ocean. There are western and eastern hydrographic regions and three main river basins; the Tekeze, Mereb, and Afar.As a result of ITCZ movements, there are two main seasons in Tigray. *Kiremt* long rainy seasons, mid June unto mid September and Hagay long dry period; October to may but, in addition, some areas also have two less pronounced seasons: *Kiwie* dry and low temperature, october – January and *Belgi,* low amount of rainfall in eastern part of the region, February-May (Hunting, 1976a).

About 77 percent of Tigray falls within a slope range of between 0-8 percent. Steeper areas than this are found around northeastern part of the escarpment in Atsbi-wenberta, Erob and at the foot of the escarpment of Ofla, Alaje and Welkait-Tsegede.

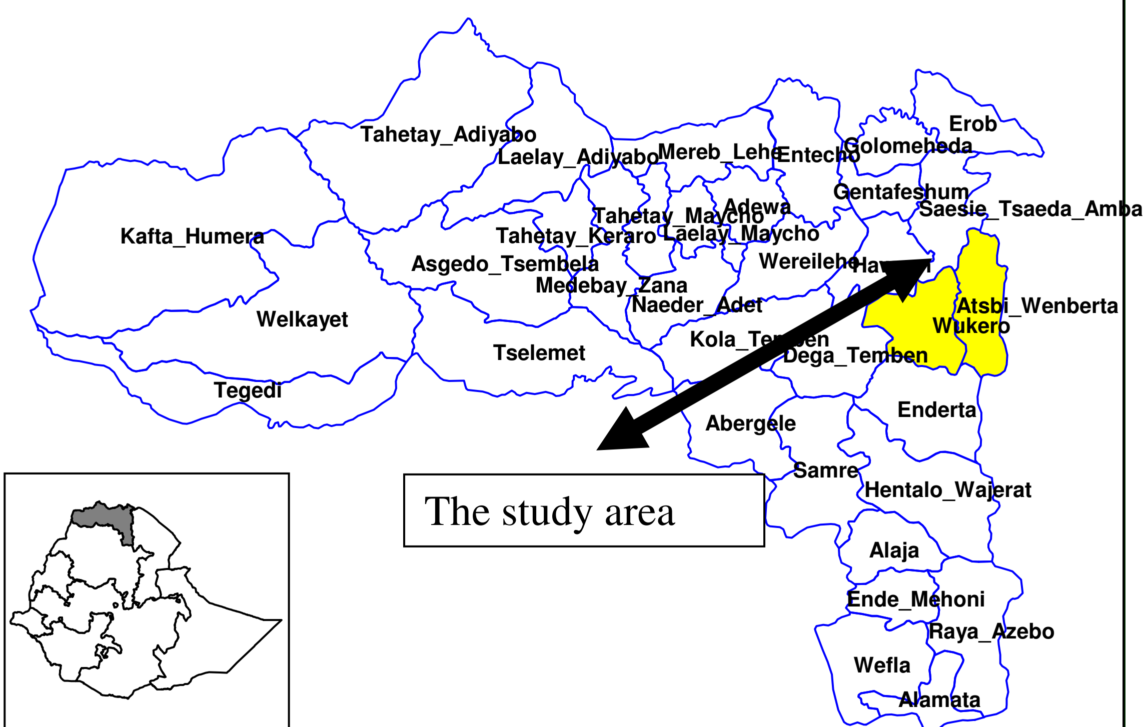

Fig 1: Map of Administrative Weredas of Tigray Region, Ethiopia

The overall objective of this study was to provide the regional development practitioners, decision-makers and other stakeholders information on factors that affect utilization of rainwater harvesting technology that is given a very high attention in the region. Specific objectives of the study were:

1. To identify the socio-psychological factors influencing utilization of rainwater harvesting technologies.

2. To analyze the institutional, technical and economic factors affecting utilization of rainwater harvesting technologies.

3. THEORETICAL AND ANALYTICAL FRAMEWORKS

Theoretical framework used in this study mainly comes from the classical diffusion of innovation schools (Rogers, 1995), but also recent insights on the human behaviour (Leeuwis, 2004), among others. Concepts and theoretical under-pinning from these sources were captured as an analytical framework to guide the study at the field level (Uphoff, 1986; Ervin and Ervin, 1982; Ostram, 1990 Critichley and Sieger, 1991, Tesfaye, 2003, Abadi, 2006).

4. RESEARCH METHODOLOGY

4.1 Sampling Design

The study employed a multi-stage stratified sampling design. A sampling frame of the study was drawn from two Weredas selected purposively from eastern Tigray, out of nine Weredas in the zone. The purpose of selection is a wide practice of rain water harvesting among farmers. The selected Weredas are Atsbi-Wenberta and Wukro. Farmers households in the two Weredas were stratified according to their participation in the rain water harvesting practices. Those who use RWHT were designated as "users" whereas those who do not use any improved rain water harvesting practices were categorized as "non-users." Finally, 101 and 100 heads of farmers households were selected respectively from users and non-users, using probability proportional to size technique.

4.2 Data Collection and Analysis

The study employed both qualitative and quantitative data. Quantitative data was collected using structured questionnaire that was duly tested and thoroughly improved. In addition, a likert type attitude scale of 1-5 was developing to assess the underlying attitude of the community on rain water harvesting technology.

Secondary data were collected from relevant sources, such as reports, socioeconomic survey documents of the area, maps, books and Non Governmental Organizations (NGO).

Data was analyzed using descriptive statistics and a binary logit model. Qualitative data was used to specify contexts of the study and enrich information generated from quantitative data analysis.

4.3 Variables in the model

Dependent variable of the model: The dependent variable for logit analysis was RWHT utilization, which is dichotomous. It is represented in the model by (1) for those farmers who are users of micro pond (trapezoid and percolated) RWHT practiced and (0) otherwise for those farmers who are not using any RWH practice.

Independent variable: Based on literature review and researchers personal experience, the following factors, which are expected to influence the RWH practices, are presented with their operationalization.

Continues variables: Education, Labour, market distance, non-farm income, extension contact, animal product and farm size.

Discrete variables: Fertilizer input, land security, experience in RWHT, Slope of the farm, land location of the RWHT, rainwater retention, belief of the farmers, credit, cash for down payment, training, soil type, assistance, type of crop grown, RWHT use & purpose.

The variables used in the model were tested for multi-colinearity. Accordingly, variance inflation factor (VIF) for continuous variables and contingency co-efficient for qualitative variables were tested.

5. RESULTS AND DISCUSSION

5.1 Characteristics of Sampled households

Among the sampled households, 58.7 percent were males, while the remaining 41.3 percent were females. The average family size of the sampled households was about 6.5; the largest family size being 11 and the smallest being three. The average number of economically active family members 15-64 years of age was 2.74 for user and 2.23 for non-user of RWHT. The age structure of the sample households showed that the average age of the users farmers was about 45.95 years whereas that of non-users was 42.95 years (Table 1).

Table 1: Mean of some socio-economic variables

Description	**Total**	**Users**	**Non-users**	**Significance**
Family size (numbers)	6.5	6.9	6.0	ns
Age	44	45.9	42.9	*
Active labour force (numbers)	2.5	2.74	2.23	**
Education (years)	2.08	2.37	1.80	ns
Total land owned (ha)	1.08	1.19	0.97	**
Total cultivated land (ha)	0.62	0.68	0.58	*
Total livestock owned (TLU)	2.08	2.54	1.56	**

*** Significant at 1%, ** 5%, and * 10% probability level

The educational status of the sampled households indicates that 45.4 percent of the users farmers were illiterate, while the remaining 54.6 percent were literate. On the other hand, 60 percent and 40 percent of the non-users farmers were illiterate and literate, respectively. The total average educational level was 2.08 years of schooling with standard deviation of 2.59. The mean educational level of users and nonusers was 2.37 and 1.80 with standard deviation of 2.61 and 2.54 respectively.

The average land size of sample households was 1.08 ha of which users of RWHT and nonusers own on average 1.19 and 0.97 ha respectively (Table 1). With regard to land use patterns, from the total land holdings sampled households allocated on average 0.62 ha cultivable land, 0.05ha forest land, 0.06 ha grazing area, 0.24 ha homestead and 0.05 ha perennial crop land. The T-tests indicate the mean difference of the perennial cropland holding is significant at ($P<0.01$) probability level.

Wheat barley and pulses are the principal crop grown in the area, which ranked first, second and third respectively. Among, of the respondents 44.2 percent reported to have decreasing trend of production during the last 10 years.

Out of a total agricultural production in the study area livestock and beekeeping contributed to 25 percent of household income. The mean size of the TLU of the sampled farmers was 2.08 with standard deviation of 3.57. The user farmers on the average had 2.54 TLU, while the non-users had 1.56 TLU which was significant at ($P<0.01$) (Table 1).

The major livestock problem in the study area was lack of grazing. Moreover, 50.5 percent and 68 percent of users and nonuser farmers encountered oxen shortage, respectively.

About 30.3 percent of the sample farmers apply the improved inputs, 40.6 percent being those who are user in the RWHT activities while the other 20 percent are nonusers. The major inputs applied by the farmers are chemical fertilizers 30.3 percent, improved seeds three percent, herbicides and pesticides 0.05 percent. Among the sampled farmers, 66.2 percent applied manure on their farm. The average amount of DAP and Urea fertilizer used by the sampled farmers was 15.26 kg and 12.87 kg respectively. On average user farmers applied 19.19 kg and 16.56 kg DAP and Urea. With regard to pesticide and improved seeds the mean amount used by the sampled farmers was 0.53 liter and 22.28 kg, respectively.

About 86 farm households 42.8 percent reported that they were engaged in non-farm activities besides farming. The mean income from non-farm activities was found to be 114.4 Birr per year.

The average number of extension contact for users and nonusers of RWHT was 7.78 and 2.38 with standard deviation of 12.38 and 3.97 respectfully, these shows statistically significant difference at ($P<0.01$) probability level. About 72.3 percent of RWHT users and 37 percent of non-users farmers took part in extension program. The chi-square test indicated that there was significant difference at ($P<0.01$) probability level in the participation of the extension service between the users and non-users sampled households. The average distance of farmer training and extension center was found to be 3.19 km and 2.79 km with standard deviation of 2.90 and 4.40 for users and non-users of RWHT. Furthermore; in 2005 production year, 63.7 percent of the sampled households benefited from the visits while the development agents did not visit 36.3 percent of the farmers field or their home (for details of socio-economic characteristics of the sampled farmers, see Abadi (2006).

5.2. Factors Affecting Utilization of RWHT

Utilization of RWUT is affected by institutional, psychological, social, economic and physical factors. These factors are briefly outlined below (for details, see Abadi (2006).

Institutional factors: Organizational cultures, hierarchy of decision making which ranges from the lowest (Tabia) level to Wereda and Region. In some situation zonal level also provides technical backstopping. In this connection availability of manpower at each level and work experiences are very crucial for the implementation of RWHT.

Psychological factors: In order to understand farmers' reaction to RWHT understanding their attitude toward the practice plays an important role. Thus, eighteen items were developed and administered to 201 sampled households. A Likert scale was used in this procedure. The items were assessed by experts in the field for their construct validity. Farmer's perception of the moisture status, location and topography of their farm land and their attitude towards RWHT technology are those partial indicators of the utilization of the technology.

List of items used were; RWHT is important to secure food, RWHT is appropriate technology, RWHT is profitable technology, RWHT can help improve livelihood, RWHT increases yield, RWHT is labour demanding, RWHT sustains production, RWH structures & design are easy to implement, RWHT cause animal health problem, Rain-fed agriculture is sufficient to produce enough food, RWHT increase cost, RWHT demand much knowledge & skills, possible to sustain production with out RWHT, RWHT take large area, RWHT cause human health problem (malaria) and indigenous knowledge is superior to new RWHT.

Reliability analysis of items considered in the scale was carried out where Alpha (α) was 0.598. Therefore, in order to maintain optimum trade-off between brevity and reliability, items that increased the Alpha value were dropped from the scale. Accordingly, two items that increased and Alpha value were dropped from the list. For the subsequent analysis, the remaining 16 items were grouped into users and non-users group. The response of the users and nonusers for item stating "RWHT increase cost" and "RWHT take a large area" shows a significant difference at ($P<0.01$) and ($P<0.05$) probability level respectively.The grand mean 3.46 represents favorable attitude towards RWHT and it lies between favorable attitude towards RWHT which lies between neutral and agree. Generally, the analysis revealed that using 16-likert item show favorable attitude towards the RWHT. Both group the users and nonusers believe that RWHT increase cost, require managerial skill and knowledge as well as wasteland for RWHT structure construction, which is unfavorable attitude for both users and nonusers of the RWHT. This shows that farmers have low perceived control over the technology. However, they mostly believe that they can acquire the knowledge and skill the technology demands.

The nonuser farmers explain that almost 95 percent of them had a positive attitude to the practice of RWHT. Taking their resources and implementing capacity vis-à-vis the perceived reality, about 57 percent of them planed to practice the RWHT.

Believe of users sample household on utilization of RWHT indicate that all farmers perceive RWHT positively. Sampled households participation in the RWHT based on voluntary and compulsory basis were 86 and 14 percent respectively. Nevertheless, those who practiced irrigation using RWHT were only 58 percent. The worth of covering RWHT structure cost, investing from their own were 43 percent of the sampled farmers, and the rest were not interested to invest. With respect to the worth of getting assistance for the RWHT structure, about 57 percent were willing.

Social factors: The sampled households have reported various use of the water harvested using RWHT. These include, irrigation (58%), domestic use by family (27%), sanitation (13%), and for animals (2%). The linkages of RWHT with watershed management were more indirect than envisaged. However, women's access to rainwater have social benefit such as improved health, income and saved time to undertake the social role and production activities. This may power and opportunity to use their land to FHH's with out entering share cropping with male-headed household. Moreover, utilization of rainwater for family, sanitation and irrigation increased as the rainwater availability is near by to their residence unlike other distant water sources.

Economic factors: Sampled farmers explain that, the constraints for implementing the current RWHT structure were finance (60 percent), Know-how (20 percent), technical (13 percent), and labour (7 percent), respectively. As compared to rainfed agriculture and livestock, respondents believed that RWHT was better in terms of generating income that avoids risk & uncertainties, but rainfed is preferred in terms of labor requirements. Farmers reported a number of problems associated with RWHT activities, lack of capital, technology, lack of skill, labour, and market problem.

Physical factors: Physical factors of RWHT such as site selection have serious repercussions on the performance of the RWH structures and thereby on farmers' decisions. For instance, ponds whose surface is not covered with cement, compacted-clay or plastic were found to be ineffective because they lose water in few months.

Farmer's preferences with respect structures leans towards *eala* (percolated pond) 54 percent, *horoyo* (trapezoidal pond with plastic) 27 percent, *baska* (rectangular pond) 12 percent, *gidib* (dam water) five percent, and *degda*g (trapezoidal pond clay blanketed) two percent.

In the six Tabias of the study 21% of the RWH structures were blanketed with plastic, seven percent cemented (Figure 3), 43 percent clay blanketed (Figure 2), 29 percent percolated pond type . All constructed ponds have trapezoidal cross section and square plan while the percolated ponds have the shape of the land escape. Seepage water loss from ponds was identified as one of the critical issues. This was overcome through the provision of cement, compacted-clay lining and/or installation of plastic sheeting. It was found that farmers do not believe that clay-lined ponds will hold water unless they are covered with plastic.

Figure 2: Clay blanketed Trapezoidal pond (Photo Abadi T.H, 2005)

Figure 3: Trapezoidal pond with cement (Photo Abadi T.H, 2005)

Many structures hold water for some period during the past seasons, after the on set of the main rainy season in July. Few ponds hold water only till September and others till October. Few ponds that hold water for longer period last till January. Variations in the design were observed in the field, which is derived because of the physical factors. Inefficient utilization of the plastic was observed which resulted from poor shaping of the ponds, irregular top width and lack of beams and over sizing of the plastic for the pond dimensions. Variation in water holding capacity also observed.

This emanates due to variation in the construction quality of the pond. Most of the clay blanketed and cemented pond are considered by farmers as ineffective in retaining water after the rainy season. Ponds closer to the houses receive good attention and follow up from the households who own them, especially from the women. Those in the middle of the arable holding receive the same attention as the arable crops and this is neither effective for the vegetable production nor an efficient utilization of the water stored. Sampled households opinion regarding similarity of RWH designs, 62 percent and 41 percent respectively replied that the trapezoidal micro pond and percolated type pond as suitable for the locations selected (Figures 4 and 5). Corresponding figures for those who replied the locations were unsuitable 38 percent and 59 percent.

Figure 4: Trapezoidal pond blanketed with plastic sheet (Photo Ababi T.H, 2005)

Figure 5: Percolated pond (Photo Abadi T.H, 2005)

Almost all irrigated plots are located near the ponds, both upslope and down the slope. Most farmers were abstracting irrigation water for utilization directly from the ponds using old jerry and oil cans and applying the water either directly to the plants or via unlined furrows and basins. Few farmers do use tridle pump and drip irrigation. Some farmers have already developed their own labor saving devices using such devices as rope lining.

It should be noted that there were a number of incidents of drowning of people and animals in the ponds that were reported by farmers in the study area. Excavated infertile sub soil from pond area has been both deposited on agricultural land and also heaped near to the pond. This has on the one hand occupied rather scarce agricultural land and rendered unproductive by covering good topsoil. All of the ponds are uncovered and which aggravates incidences of malaria in the residential areas. Obviously, these practices should be accounted for when benefits derived from RWHT is calculated.

5.3. Results of Econometric model

Logit model was used to analyze the determinants of farmers RWHT utilization. The farm household either utilizes or not used RWHT. The variable to show utilization of RWH activity was used as a binary dependent variable, taking a value 1 indicating the farmer is utilizing at least one or more micro pond activities and, 0 other wise. Fourteen explanatory variables (seven continuous and seven dummy) were included in the model. Prior to running the logistic regression analysis, both the continuous and discrete explanatory variables were checked for the existence of multi-co linearity using Variance Inflation Factor (VIF) and contingency coefficients, respectively. It was apparent that there is no strong association among the variables, for this reason, all of the explanatory variables were included in the final analysis. Then, the Maximum Likelihood method of Estimation (MLE) was used to elicit the parameter estimates of the binominal logistic regression model. Out of the fourteen explanatory variables hypothesized to influence utilization of RWHT activity in the study area, eight were found to be significant at less than or equal to ten percent probability level.

Table 4. Parameter estimates of the logistic regression model (n=201)

Explanatory variable	Estimated coefficients B	S.E.	Wald statistics	Sig.	Exp(B)
Man Equivalence	0.144	.168	.739	0.390	1.155
Animal Product	0.001	.000	4..221	0.040**	1.001
Farm Land	0.256	.152	2.852	0.091 *	1.292
Education	-0.004	.090	0.002	0.964	0.996
Extension Contact	0.119	.044	7..302	0.007***	1.126
Market Distance	-0.063	.032	3.895	0.048**	0.939
Non-Farm income	0.000	.000	0.027	0.869	1.000
Training	1.575	.491	10.312	0.001***	4.831
Location	0.951	.471	4.074	0.044**	2.588
Input	0.795	.459	3.000	0.083 *	2.214
Credit	0.246	.522	.222	0.637	1.279
Belief on RWHT	0.102	.547	.035	0.852	1.108
Land Security	0.225	.538	.174	0.676	1.252
Cash Availability	1.637	.495	10.946	0.001***	5.139
Constant	-3.920	1.052	13.884	0.000***	0.020

Chi-square	76.12
-2 log likelihood	128.38
Count R^2	78.4
Sensitivity	79.7
Specificity	76.8
Number of cases	201

*** Significant at 1%, ** 5%, and * 10% probability level

The model results show that the logistic regression model correctly predicted 148 of 201, or 78.4 percent of the sample households. The sensitivity (correctly predicted Rainwater harvesting users) and the specificity (correctly predicted non-users) of the logit model are 79.7 and 76.8 percent, respectively. The significant explanatory variables included: Market distance, input, cash availability, location, training, animal product income, extension contacts and farmland size. Each of these variables is briefly discussed below (also see, Abadi (2006).

Distance from market center: The variable is significant at (P< 0. 05) and related negatively with the farmers desire to involve in the RWHT activity. The odds ratio (0.938) indicates that under constant assumption the utilization of RWHT decrease by a factor of (0.938) as the distance of the homestead from the market center increases by 1 km distance.

Input: Availability of input is highly important when farmers are ready to adopt new technology. Inputs are positively and significantly related to the utilization of RWHT (P< 0. 10). The positive relationship shows that the odds ratio in favor on the probability of utilization of the RWHT increases by a factor of (2.214) as availability of input increases by one unit.

Cash availability: Finance have positively related to the utilization of RWHT by farmers (P< 0. 05). Other things being constant, the decision to use RWHT increases by a factor of (5.139), as availability of cash increases by one unit.

Location: Location of RWH structures correlates positively and significantly at (P< 0. 05) with utilization of the technology. The odds ratio in favor of participating in RWHT activities increases by a factor 2.588 when the farm location is suitable for RWHT.

Training: The model result indicates that it affects the decision of farmers to participate in RWHT practices positively and significantly at (P<0.01). The odds ratio of utilization RWHT by a farmer increases by a factor of 4.831 as member of a household is trained in the given rain water harvesting technology.

Animal and honeybee product income: The variable is significant at (P< 0.01). As the animal product and honeybee income increases by one unit, the utilization of RWHT increases by 1.001.

Extension contact: The result indicates that it affects decision of farmers positively and significantly at (P<0.001). The odds ratio (1.126) indicates the utilization of RWHT increases by a factor of (1.126).

Farm size: Farm size was positively related to the utilization of RWHT and significant at (P< 0.10). The odds ratio of 1.292 for availability of farm size implies that, other things being constant, the decision to use RWHT increases by a factor of 1.292 as farm size increases by one unit.

5.2. Conclusion and implications

The result of the descriptive studies show that users on average have large farm size, better adult equivalent of active labour force, educational status, labour used for farm, use of input, resource categories in the better off, TLU, oxen ownership, land tenure in terms of years operated of users of RWHT by far exceeds that of the nonusers of RWHT.

The attitude scale result indicates that RWHT demand of labour, cost, skill and knowledge found to be highly important items affecting RWHT.

The econometric result show that, training, market distance, farm size, location of the farm land, extension contact, income from animal product, cash availability had a positive and significant influence on the utilization of the RWHT.
The finding of this study implies that even if they operate under or less similar conditions the social, psychological and economic performance differ from farmer to farmer. This implies that difference in perception, opinion; attitude and decision are among the major finding of this study.

Therefore, this study underlines the needs for understanding social, economic, institutional, psychological and physical-technical factors that influences farmers decision-making in relation to utilization of rainwater harvesting technology.

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ANALYSIS OF FACTORSAFFECTING UTILIZATION OF RAINWATER HARVESTING TECHNOLOGY, EASTERN TIGRAY, ETHIOPIA

PAPER SUBMITED TO THE CONFERENCE OF RAINWATER HARVSTING

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