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# Econometrics Analysis on the Choice Preference of Farmers on Water Harvesting Technologies: A Case Study in East Gojjam Zone; Ethiopia

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***ABSTRACT:- This study is conducted to look into the socio-economic, physical and other related factors, which can affect preferences among water storage technology groups in east Gojjam zone; Ethiopia.. To address these objectives, both quantitative and qualitative data were collected. The primary date were collected from 200 sample households who are selected three districts of East Gojjam zone of Amhara National Regional State, Ethiopia proportionately and randomly . Multinomial logit-model was used to analyze the determinants of choice of water harvesting technologies. In addition descriptive statistics were also used as deemed necessary. A total of 10 explanatory variables were included in the analysis of multinomial logit model. The result of the analysis indicated that among the 10 hypothesized explanatory variables included in the model level of education has a positive and significant effect on the choice of underground group of structures while access to credit, plot distance from home, level of plot fertility and soil type has also negatively and significantly affects the choice of underground group of structures. In the case of the aboveground group of structures, access to credit and soil type of the plot significantly and positively affect the choice decision. Whereas; the choice of the surface group of structures, positively and significantly affected by area of the plot (AREIM) , distance of the plot from home (DISTPLOT) and slope level of the plot (SLOP). The implication is that farmers are interested to use surface water harvesting structures on sloppy, distant and large plots. Thus, the importance recommendations which are found to be of paramount importance from the finding of this study include; any effort in promotion of water harvesting activity should recognize the socio-economic, household and technological characteristics; Promotion of water harvesting should be done in conjunction with crops, which can be sold for cash. This can be also supported by improving marketing channels for produced crops. Physical characteristics of the plot are important factors for the preference decision behavior of farm households among alternative water harvesting technology groups. Therefore, considering physical characteristics of the particular area in promoting water harvesting structure groups is paramount important.***

**Keywords----** Water harvesting technologies; choice preference; multinomial logit model; East Gojjam zone (Ethiopia)

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## 1. INTRODUCTION

The Ethiopian economy has largely remained dependent on agriculture, which accounts 40-50 percent of GDP, 85 percent of total labour employment and 90 percent of exports (NBE, 2006). Because of the economy being dominated by agriculture, the weak performance of this sector has an adverse effect on other sectors of the economy. Hence, increasing productivity of Ethiopian agriculture is paramount important. But increasing productivity is challenged by many factors of which moisture stress is to be cited. To cope up the moisture stress problem and hence to improve increasing productivity of Ethiopian agriculture practicing some forms of small scale irrigation schemes through practicing water harvesting technologies at a household level is promoting. Because of the fact that developing large scale irrigation is a costly alternative, which may require large amount of capital resource.

The production systems are traditional and subsistence in nature. High rate of population growth, unfavorable natural and policy environment have also been the causes of the inefficiency of agriculture in the country. Moreover, Ethiopia currently depends on rain fed agriculture with limited use of irrigation. The inconsistency in the amount and seasonal pattern of rainfall and its inter annual variation constitute a major cause for frequent failures of crops and scarcity of livestock feed. The annual rainfall distribution in most parts of Ethiopia, including the highlands, is not only uneven but also highly unpredictable in its inter annual variations (Habtamu, 1999).

Water harvesting (WH) has been defined and classified in a number of ways by various authors .According to Reij et al. (1993), water harvesting is usually employed as an umbrella term describing a whole range of methods of collecting and concentrating various forms of runoff (roof top runoff, overland flow, stream flow, etc.) from various sources (precipitation, dew, etc.) and for various purposes (agricultural, livestock, domestic and other purposes). Mekdaschi Studer, R. and Liniger, H., 2013 defined Water harvesting is the collection and management of floodwater or rainwater runoff to increase water availability for domestic and agricultural use as well as ecosystem sustenance. The aim of water harvesting is to collect runoff or groundwater from areas of surplus or where it is not used, store it and make it available, where and when there is water shortage. This results in an increase in water availability by either (a) impeding and trapping surface runoff, and (b) maximising water runoff storage or (c) trapping and harvesting sub-surface water (groundwater harvesting, also see Box 6). Water harvesting makes more water available for domestic, livestock and agricultural use by buffering and bridging drought spells and dry seasons through storage.

The water harvesting facilities can vary in shape, size, functions, uses of water, and in local names. The choice of system therefore will depend on a number of technical and economic considerations such as space availability, local traditions for water storage, cost of purchasing new tank, cost of materials and labour for construction, materials and skill available locally, and ground conditions. Accordingly, such structures are grouped as underground tanks (dom shaped and cylindrical structures of excavated tanks, dugouts or cisterns which serve the purpose and have the greatest potential for cost savings), aboveground tanks (usually meant for roof top rainwater collection designs usually complained for higher cost) and surface ponds.

An empirical study made by Rogers and Shomaker (1971), defined adoption as the decision making process in which an individual passes from first hearing about an innovation to final adoption and this decision of adopting a new technology or not hinges upon a careful evaluation of a large number of technical, economic and social factors. The success or failure of any rainwater harvesting technology (WHT) will ultimately depend on the degree of acceptance by the users of the land. It is essential that the needs and aspirations of the users of the land are clearly understood and fully provided for in the planning, designing and implementation process. Efficient resource utilization can be judged very easily where water harvesting is a means of profit (Martison et al., 2001) which is difficult to judge in case where the water harvested is essential for survival.

Though people in some parts of the world where water shortage exists have successfully utilized water-harvesting systems, its application is still low in Ethiopia. A priority concern in the marginal areas of Ethiopia is food security, which can be achieved through the development of technologies relevant to dry-land farming with a strong component of water management. Even though, the technology is politically recognized, it is new to most development workers and even for the government personnel. Hence there are inadequate strategies, human resources and policies for its promotion (Ngigi, 2003).

Water is most crucial resource for sustainable agricultural production in the dry land/rain fed areas. However the major part of the rain water coming over the farmers field in these areas goes away unused as runoff. The runoff does not only cause loss of water but it also washes away precious top soil (ICAR, 2009). On the contrary,

The income of farmers is highly dependent on crop and livestock production but it is highly affected by erratic rain fall. Its effects is explained by a decline in productivity in both crop and livestock production. This shows the importance of use of water harvesting technologies to solve the problem of decline productivity due to erratic rain fall. But, for a water-harvesting project to be successful, the society must possess a high degree of individual commitment (FAO, 1994).

To introduce the technologies the nation has made efforts in past years. Given this state of facts, analysis of the issue of what specifically determines the farmer's preferences among water storage technology groups is very important and relevant to formulate policy options and support system that could be accelerate the use of water harvesting technologies. Therefore; this study was conducted in East Gojjam Zone Amhara Region with the objectivies of (i) to identify Water Harvesting Technologies implemented in the area (ii) identify the determinants of choice preference of farmers among Water Harvesting Technologies in the study area.

### 1.1. Empirical Studies

Many researchers and experts in the field of natural resources conservation and water harvesting forwarded their reasons about different factors that affect the willingness of farmers to participate and efficiently use water-harvesting works. As mentioned in CTA (2000) widespread adoption of water harvesting techniques by the local population depends on cost and simplicity of the technology for implementation and maintenance.

Liniger et al., 2011 also stated that in Sub-Saharan Africa, the most important adoption drivers of water harvesting were found to be yield increase and accessibility to information, followed by secure land tenure. Furthermore, it is important to ensure genuine participation of resource users alongside professionals during all stages of implementation to integrate all viewpoints and ensure commitment (Mekdaschi Studer, R. and Liniger, H., 2013).Often weak approaches and extension have led to poor adoption rates. Water harvesting technologies need to be adapted and fine-tuned to the local natural, socio-economic and cultural environment. Adaptation of standard designs to actual site conditions requires skill and experience, which often will determine the success of the water harvesting practices.

Mekdaschi Studer, R. and Liniger, H., 2013 also stated that Adoption rates of WH generally remain low. However, some practices such as rooftop WH or certain microcatchment technologies such as planting pits and contour bunds and macrocatchment technologies such as earth dams have spread and continue to do so. Water harvesting technologies recommended for up scaling must be profitable for users and local communities, and technologies must be as simple and inexpensive as possible: and easily manageable also. Without security of land tenure, water rights and access to markets, land users remain reluctant to invest labour and finances in WH. Cost efficiency, including short and long-term benefits, is another key issue in the adoption of WH practices. Resource users are naturally more willing to adopt practices that provide rapid and sustained pay-back in terms of water, food or income.

Molla,T. 2005 on his study on farmers' response and willingness to participate in water harvesting practices found that farm plot characteristics such as type of soil; slope ; distance from residence determines the preference decision of users among water harvesting technology groups

## 2. METHODOLOGY

### 2.1. The Study Area

East Gojjam zone is one of the eleven zones of the Amhara regional state which is located in the northern part of Ethiopia. The administration zone is bounded by west Gojjam to the west; by Oromia region (wellega) to the south; wello zone to the east and South Gonder zone to the north.The area has a total area of 14705.36 sq. km, with an altitude ranging from 800 to 4070 m.a.s.l. Its topography is estimated to be 48% mountainous, 12% rugged and 40% gentle slope. It has also four agro climatic zones namely kola, Woinadega, Dega and Wirch covering 16%, 37%, 45% and 2% of the total area, respectively. It receives a mean annual rain fall of 900 to 1800 mm and annual temperature of 8 to 27co The Zone is divided in to 16 districts and 2 urban administrative with a total of 382 kebeles of which 36 are urban kebeles. The estimated land use pattern of the zone shows that 33.67% is used for cultiviation,11.7% for grazing, 20.6% for forest bushes and shrubs and The rest 34.03% is used for other purposes & including unused land (ZODA,2012)

Agriculture, like in the other parts of Ethiopia is the main source of income for the community in the study area. The zone is characterized by mixed farming where the rural population of the zone is dependent on both crop and livestock production for their livelihood. Due to the increasing population pressure, the amount of land a household uses decreases from time to time. Due to this reason many farmers are forced to make deforestation and use of grazing land in search of additional arable land. This has led to plough undulating areas and ended up with sever soil erosion.

The agriculture extension service in the zone mainly focuses on providing basic agricultural trainings, teaching and demonstration about the use of agricultural inputs, forest development, soil conservation and livestock production aspects. The major source of agricultural credit to the farmer is the regional government that receives loan from commercial banks by providing its annual development budget as collateral. The actual credit provision is undertaken through cooperatives and Amhara Credit and Saving Institution (ACSI). Yet, availability of fertilizer, improved seeds and credit at the required time and place particularly for remote and inaccessible areas are the major problems encountered to boost agricultural production and productivity. In addition; nowadays uneven distribution of rain fall/erratic rain affects the production system of farmers.

According to the discussion with soil and water conservation experts, water harvesting technologies are introduced and implemented by farmers in the study area. However, the management and utilization of the technology by the used famers needs very much follow up to make it effective. The supply of type technologies with the interest of users would also needs consideration.

## 2.2. Hypothesis

Many researchers and experts in the field of natural resources conservation and water harvesting forwarded their reasons about different factors that affect the willingness of farmers to participate and efficiently use water-harvesting works. Based on literature reviewed and authors experience the following independent variables were hypothesized;

**Education level (EDUC):** Education level of the head of the household help farmers to easily get, analyze, and interpret information (Dasgupta, 1989) about water harvesting storage structure groups based on different characteristics of each group. In addition to their indigenous knowledge, this further assist educated farmers to choose the technology groups, which are most appropriate to their socio-economic and other household characteristics. As mentioned in the literatures review section, water storage groups have their own pros and cones. Some are convenient; others can be built at a relatively lower cost. Thus, educated farmers can compare the pros and cones of each group and can choose one based on some criteria. Therefore, it is difficult to determine a priori the impacts of education on choice decision for water storage technology groups.

A**rea of plot implemented (AREIM):** This variable refers to the area of a particular plot, which was selected for constructing water storage structures by a sample household. As mentioned before, the analysis of the choice decision between technology groups is made at a plot level. Rees (2000) mentioned aboveground and surface pond structure groups are generally demanding a large area for their construction. Therefore, this variable may serve as an input to choose between water storage technology groups. As aboveground and surface pond structure groups require relatively large area, the area of the plot on which water storage structure has to be built is expected to relate positively with these structures. However, plot area is expected to correlate negatively with the underground type of structure group.

**Distance of the plot from residential house (DISTPLO):** Distance of a plot from homestead is expected to highly affect the technology types to be selected. Those technology groups, which need day to day follow up, should necessarily be built near home (Martinson et al., 2001). In addition, aboveground structures are usually built near residence to collect water from roofs. Hence, distance matters for choosing water storage structures. Therefore, it is expected that distance of the plot may relate negatively with aboveground and underground structure groups and positively with surface pond type structure groups.

**Ownership of the plot (OWNPLO):** Ownership of the plot may affect the choice decision of farmers for alternative water storage technology groups. Rees (2000) remarked that one of the pros of aboveground structures is that it can be constructed from lighter materials so that they can be carried from place to place. Those farmers who hire others land may need to construct easily movable aboveground structure groups. On the other hand, farmers working on their plot are expected to construct stable and long lasting structures. These may be underground and surface pond structure groups. Thus, ownership of the plot is expected to have positive impact on the choice decision of farmers for underground and surface pond structure groups.

**Fertility of the plot (FERTILIT):** This variable refers to the fertility status of a particular plot. It assumes a value 1 if the plot is highly fertile, a value 2 represents medium fertility status and a value 3 was assigned to represent low fertility level of the plot. Most underground structure groups are usually built for the purpose of crop production but aboveground and surface pond structure groups can in addition serve for storing water for drinking purpose for human beings and animals respectively. However, this does not mean that underground structure groups can never serve the purpose of storing water for drinking purposes. Thus, fertility status of a plot is expected to correlate negatively with the underground structure groups and positively with the other two groups.

**Total Tropical Livestock Unit (TLU):** As a household owns large livestock unit, it may be interested to invest in convenient but costly projects, such as aboveground structure groups. Martinson et al. (2001) categorize aboveground structures as generally convenient and costly than underground and surface pond structure groups. Therefore, livestock ownership is expected to positively affect the choice decision of the aboveground technology groups and negatively correlated with the underground and surface pond technology groups.

**Labour Availability (LABORAVA):** Water harvesting is a labour demanding practice. Constructing water storage structures, watering the plants, protecting the water from evaporation and the like practices require labour. This variable represents availability of labour in adult equivalent ratios. Hence, a farmer who has large labour units is expected to prefer those technology groups, which require larger amount of labour, such as surface pond and underground technology groups (Martinson et al., 2001). Therefore, it is hypothesized that availability of labour may be associated positively with the choice decision of farmers for underground and surface pond structure groups and negatively with aboveground technology groups.

**Access to credit of the household (ACCR):** In addition to its larger labor requirements, water harvesting practices require huge amount of money. Some technology groups require relatively huge amount of financial outlay than others, with a typical example being aboveground structure groups (Rees, 2000; Martinson et al., 2001). Hence, access to credit is anticipated to go negatively related to the choice decision for underground and surface pond water storage technology groups. However, a farmer with critical shortage of money may not desire to decide to construct costly technology groups such as aboveground technology groups. Thus, Access to credit is expected to affect positively the choice decision for aboveground technology groups. It is expected to affect the choice decision for underground and surface pond structure groups negatively.

**Slope of Plot of Land Owned (SLOP):** Water harvesting is not recommended for areas where slopes are greater than 5% due to uneven distribution of runoff and large quantities of earthwork required which is not economical (FAO, 1994). Hence, the steepness or flatness of a plot may affect the water storage types to be selected. Due to the aforementioned reasons, flat type of topography is suitable to build underground and surface pond structures, while there is no so much consideration about the slopes to construct aboveground structures. Thus, slope can be taken as a variable to conduct empirical studies about the decision of farmers to choose among water storage technology groups. The value 1 represents steep topography, the value 2 represents medium and 3 was assigned to represent flat topography. Hence, slope is hypothesized to influence the choice decision for underground and surface pond technology groups positively. However, it is difficult to decide a priori the relationship between the slope of the plot and the choice decision for aboveground structure groups.

**Soil Type (SOILTYP):** For this particular variable, the value 1 was assigned to represent red Soil category, while 2 and 3 represent black and gray soil categories, respectively. The type of soil is expected to affect the type of structure to be selected for construction in a particular area. Surface pond structures are usually constructed in black soils. On the other hand, red type of soil cannot be easily cracked. So that it is more suitable to construct underground water harvesting structure types. Hence, the type of soil is expected to affect positively the choice decisions for surface pond and aboveground structure groups. It was hypothesized to negatively affect the choice decision for underground structure groups.

The definition and units of measurement of explanatory variables used in the multinomial logit model is presented in Table 1.

Table 1. Definitions and units of measurement of variables included in the multinomial Logit model

| Variable | Variable code | Type of variable | Unit of measurement |
|---|---|---|---|
| Education level | EDUC | Dummy | 1, if the house hold head is literate ( read and write) and 0, other wise |
| Area of plot implemented | AREIM | Continuous | Measured in hectare |
| Distance of the plot from residential house | DISTPLO | Continuous | Measured in minutes |
| Ownership of the plot | OWNPLO | Dummy | Ownership of the plot 1= owned 0 = otherwise |
| Fertility of the plot | FERTILIT | Dummy | Perceived fertility status of the specific plot taking values 1= fertile 2 = medium 3 = low fertile |
| Total Tropical Livestock Unit | TLU | Continuous | Measured in tropical livestock unit (TLU) |
| Labour Availability | LABORAVA | Continuous | Measured in adult man equivalent |
| Access to credit | ACCR | Dummy | 1 if the farmer responded as he has access to credit and 0 otherwise |
| Slope of a plot | SLOP | Dummy | Slope of the plot 1= steep 2 = medium 3 = flat |
| Soil Type of a plot | SOILTYP | Dummy | Soil type of the plot 1= red 2 = black 3 = gray |

## 2.3. Sampling Design and Data Collection

Both primary and secondary data were collected in the survey. The primary data were collected from 200 sample household heads through conducting formal survey based on structured questionnaire that was prepared. Personal observation and group discussions were also made. Secondary data were collected from the different records, strategic plans, seasonal and annual reports, and previous studies. Three stage sampling technique was used to draw the sample respondents of the study. In the first stage, 3 districts which have good experience in implementing water harvesting technologies were purposely selected. This has been done based on the discussion with the zone agricultural and rural development department. Secondly, from each district 2 Kebeles and a total of 6 Kebeles were selected randomly. Finally, Sample respondents from each kebele were selected randomly and a total of 200 sample farm households were selected

## 2.4. Analytical Methods

Both descriptive statistics and econometric model were employed to analyze the collected data. Descriptive statistics such as mean, standard deviation and percentage were used. In addition multinomial logit model was used to analyze the choice decision of households among alternative water harvesting storage structure groups.

In choosing water harvesting storage structure groups, there is no natural ordering in the alternatives. In such conditions unordered choice models can be motivated by a random utility model (Green, 2000). Therefore, a choice has to be made between multinomial probit and logit models. A multinomial probit model is less restrictive than the multinomial logit model. However, the multinomial probit model is gained at considerable computational expenses. Therefore, multinomial logit can be used for studying choice of farmers among water harvesting structure groups.

Following Green (2000), the multinomial logit was used to determine factors affecting farmers' preference among alternative water harvesting storage structure groups. The model is specified as follows:

$$P(Y=j) = \frac{e^{\beta_0 X_i}}{e^{\beta_1 X_i + \cdots + \beta_j X_i}} e$$

Where Y = 0 No preference among the alternatives
Y = 1 prefer underground alternatives
Y = 2 prefer aboveground alternatives
Y = 3 prefer surface pond structure alternative

The estimated equations provide a set of probabilities for the j+1 choice for a decision maker.

Before proceeding, we must remove indeterminacy in the model. If we define $\beta_j = \beta_j + q$ for any vector q, then the identical set of probabilities result because the terms involving q will drop out. A convenient normalization that solves the problem is to assume that $\beta_o = 0$ (Green, 2000).

Therefore, the probabilities are $Prob(Y=j) = \frac{e^{\beta_j X_j}}{1+\sum e^{\beta_j X_j}}$; for j=1,2,…j

$$Prob(Y=0) = \frac{1}{\sum e^{\beta_j X_j}} X_j$$

# 3. RESULT AND DISCUSSION

## 3.1. Descriptive Analysis

For this study, water storage structures were grouped into three categories. These were aboveground, underground, and surface pond structure groups. These categories at the moment are being practiced in the study area. Respondents were asked to reveal their preferences among water storage technology groups. Of the total respondents, 17 respondents or 8.5% preferred aboveground structure groups. 41 respondents or 20.5% respondents wanted to have underground structures and 20 respondents or 10% preferred to have surface pond structure groups. The rest 122 respondents or 61% has no any preferences. This implies that the need of strengthen the introduction of technologies.

Respondents were also asked their reasons for preferring a specific group. Farmers who preferred aboveground type of structures reported that, the aboveground structures are preferable due to their convenient to work and manage; whereas underground type of structures are difficult to dig deep specially for stony plots to construct.

Those who prefer the underground structure group on the other hand articulated their preferences as underground structures prevent evaporation. Surface pond structure demanders on the other hand, have their own reasons for their preferences. Most surface pond preferring farmers said that this structure group is the most suiting structure type for their plot because as their plot has black soil and less costly as compared to other structures.

The average age of the sample household heads was found to be 45.69 years ranging from 22 to 82 years with standard deviation of 12.10. Of the total sample household heads 47 percent of them have an age of greater than 45 years. The family size of the sample households ranges from 2 to 12 persons, with a mean of 6.2 persons and standard deviation of 1.92. About 63 percent of the total sample households have a family size of above 5 persons per household head (Table 2).

The age structure of family members of sample household heads indicated that 40% of them were below the age of 15, 59% economically active (working age groups) and the rest 1% were aged. The survey result indicated that among the total sample household heads, 94% were male and 6% of them were female. The marital status of household heads showed that 94%, 1.5%, 2% and 2.5% of them were married, single, divorced and widowed, respectively.

Concerning the educational level of sample household heads, the survey results indicated that about 31% of the total respondents are illiterates, while the rest 69% of the respondents had various educational levels ranging from the ability to read and write up to 12th grade

The available family labour was calculated in terms of man equivalent following Storck *et al*.(1991). The average available labour was estimated to be 3.4 man-days for sample households, about 67% of total respondents reported that they face labour shortage during peak agricultural production periods and used hired casual (temporary) labour to solve the problem of labour shortage.

The average number of own farm plots for sample households was found to be 3.63with a standard deviation of 1.44 ranging from one to seven for sample households. The majority of the sample households (75%) have more than two farm plots. The soil colour of the farm plots have also been identified as red, black and brown colours. Of the total 727 farm plots managed by sample households 295 (40.5%), 331(45.6%) and 101(13.9%) farm plots were classified as red, black and brown, respectively. Red soil categories are more suitable to construct underground structure groups while ponds are usually built in black soil categories. The average size of livestock in TLU was found to be 5.38, with a standard deviation of 3.08, About 51% of total sample household heads has more than 5 TLU sizes of livestock.

Slope is one of the physical characteristics of farm plots which affect the decision to use water harvesting practices. Thus, Sample household heads were asked to classify their farm plots as flat, medium and steep based on their judgment. According to their classification from a total of 727 farm plots managed by sample household heads, 204(28.1%), 338(46.5%) and185 (25.4%) farm plots were classified as flat, medium and steep respectively.

The maximum plot area was 1.25 hectares while the minimum was 0.03 hectare. The mean plot size is found to be 0.3 hectare with a standard deviation of 0.17. The distance of a plot from homestead is estimated to range from a minimum of 1 to a maximum of 90 minutes far from their residence. The mean distance of farm plot from residence is 21.5 minutes with a standard deviation of 16.2.

Plot ownership shows the status of ownership or holding of a specific plot. From the total 727 sample plots, sample household farmers owned 588 plots or 80.8% and the rest 139 plots or 19.2% were obtained by other means like hiring, share cropping from other farmers.

Table: 2 Multiple mean comparison of continuous variables

| Independent Variable | (I) STRUCTURE | (J) STRUCTURE | Mean Difference(I-J) | Std. Error | Sig. |
|---|---|---|---|---|---|
| PLOAREA | 1 | 2 | -0.0002 | 0.034 | 0.995 |
| | 1 | 3 | -0.108 | 0.042 | 0.013** |
| | 2 | 3 | -0.108 | 0.052 | 0.044** |
| DISTPLO | 1 | 2 | 2.04 | 3.94 | 0.606 |
| | 1 | 3 | 4.98 | 3.4 | 0.157 |
| | 2 | 3 | 2.94 | 2.70 | 0.284 |
| TTLU | 1 | 2 | -1.07 | 0.95 | 0.266 |
| | 1 | 3 | 0.09 | 0.93 | 0.923 |
| | 2 | 3 | 1.16 | 0.95 | 0.230 |
| LABORAVA | 1 | 2 | -0.26 | 0.40 | 0.520 |
| | 1 | 3 | -0.05 | 0.39 | 0.900 |
| | 2 | 3 | 0.215 | 0.45 | 0.634 |

**The mean difference is significant at the .05 levels.
Source: results of mean comparison

As shown in Table 3 above the mean difference between underground and surface pond as well as aboveground and surface pond structure groups with respect to a variable of area of the plot is significant at 5% probability level.

Preference decisions for the three groups of water storage technology groups are not only dependent on mean differences of continuous variables. It is also highly affected by frequency differences of discrete variables. For this frequency differences of discrete variables were tested using chi-square test. The result is presented in Table 4 below.

Table 3. Results of chi-square tests for discrete variable

| Variables | Score | No Choice | Under Ground | Above Ground | Surface Pond | Total | Chi- Square |
|---|---|---|---|---|---|---|---|
| **FERTILIT** | 1 | 54 | 33 | 18 | 4 | 109 | **52.12*** ** |
| | 2 | 233 | 98 | 29 | 47 | 407 | |
| | 3 | 156 | 18 | 15 | 22 | 211 | |
| **SOILTYP** | 1 | 131 | 80 | 44 | 40 | 295 | **34.39*** ** |
| | 2 | 225 | 65 | 15 | 26 | 331 | |
| | 3 | 86 | 3 | 4 | 8 | 101 | |
| **SLOP** | 1 | 116 | 43 | 4 | 22 | 185 | **15.79*** ** |
| | 2 | 200 | 62 | 40 | 36 | 338 | |
| | 3 | 127 | 43 | 18 | 16 | 204 | |
| **OWNPLO** | 1 | 321 | 132 | 62 | 73 | 588 | **74.42*** ** |
| | 0 | 121 | 17 | 1 | 0 | 139 | |

*** Significant at 1% probability level
Source: results of Chi-square test

As shown in the table 3 above the results of the Chi-square test indicates that all variables are significant at 1% probability level.

Regarding the cost evaluation of water harvesting technologies the majority about 63 percent of respondents assumed that the cost is very high. This might have an influence to decide to participate on use of WHT. From the total respondents 61.5% and 23.5% of respondents reported that the financial problem & lack of technical skills are the main problems they expect if a person wants to construct WHT respectively

Table 4: Distribution of respondents by their evaluation on cost of water harvesting matters

| s/n | Evaluation on cost | Number | % |
|---|---|---|---|
| 1 | Very high | 125 | 62.5 |
| 2 | High | 37 | 18.5 |
| 3 | Medium | 27 | 13.5 |
| 4 | Low | 6 | 3 |
| 5 | No response | 5 | 2.5 |
| | Total | 200 | 100 |

## 3.2. Econometrics Analysis

### 3.2.1. Determinants of the choice preference of different water storage structure groups

The major objective of this section is to identify the determinants for the choice decision of sample households among different water storage structure groups. Before estimating the model using hypothesized variables, it is crucial to check the problem of multicollinearity or association among potential explanatory variables. Towards this, multicollinearity problem for continuous explanatory variables was assessed using a technique of variance inflation factor (VIF) and the degree of association between each dummy/discrete variable was also assessed using contingency coefficient. Finally, the variables were considered for further analysis after verifying that multicollinearity is not a problem.

Multinomial logit-model was used to analyze the determinants of choice of Water Harvesting Technologies and SPSS-20 Econometric software was also employed to run the model. The unit analysis was plot level analysis for multinomial logit-model because of the fact that choice decision behavior of users varies depending on the plot characteristics such as soil type, slope, distance, plot area and other related plot characters.

Generally, ten (10) explanatory variables were included in the model to identify the determinants for the choice decision of sample households among different water storage structure groups. The various goodness of fit of measures was checked and validate that the model fits the data. The chi-square value of a likelihood ratio is significant at less than one percent level of significance. This confirms the joint significance of the explanatory variables included in the model and shows existence of useful information in the estimated model.

The maximum likelihood Econometric Estimation method was used to estimate the coefficients of the explanatory variables. The result of multinomial logit model is presented in table 5.

The results indicated that, among the 10 hypothesized explanatory variables included in the model, only five variables namely educational level of the household head (EDUC), Access to credit (ACCR), area of a farm plot (AREIM), distance of the plot from residence (DISTPLO), fertility of a farm plot (FERTILIT) and type of soil (SOILTYP) were found to be significantly affecting the choice decision for underground at the conventional probability levels in the study area. Two variables Access to credit (ACCR) and type of soil (SOILTYP) were also affect the choice decision aboveground structures. Similarly; three variables namely; area of a farm plot (AREIM), distance of the plot from residence (DISTPLO) and slope of the plot (SLOP) were found to be affecting the choice decision of surface pond. The effect of some significant variables is not similar for the three structure groups. Some may be highly significant to affect the choice decision for a particular group and may be insignificant for the other groups. The coefficients of other variables which were not statistically significant at the conventional probability levels implying that they were less important in effecting the choice decisions of a farmer.

Education level is significant to affect the decision for underground structure groups at 10% probability level but insignificant to affect the choice decision for aboveground and surface pond structure groups. The coefficients in all the three groups were found to be positive. The result shows that literacy of the head of the household enables him to identify and to select convenient structure group. The odds ratio 0.419 for the underground structure group indicate that keeping the other things being constant, the decision to choose underground structure groups gets increasing by 0.419 as a household head is literate.

Access to credit is significant at 10% and 5% significant level to affect the choice decision for underground and above ground structure group respectively. The coefficients capture the sign of negative for underground and positive sign for above ground structures. As responded by respondents aboveground structure groups generally require large amount of money when compared with the other two groups .The odds ratio 0.245 for underground structure indicate keeping the other things being constant, the decision to choose underground structure groups decreases by a factor of 0.245 as a household gets access to credit. Similarly, the odds ratio 0.103 for above ground structure indicates that the choice decision in favor of aboveground structure group gets increasing by a factor of 0.103 as a household gets access to credit.

Table 5: Parameter estimates of the multinomial logistic regression

| Variables | | B | Wald | Sig. | Exp(B) (odds ratio) |
|---|---|---|---|---|---|
| Underground Water | Intercept | 0.517 | 0.127 | 0.722 | |
| | EDUC | 0.870 | 3.782 | 0.052* | 0.419 |
| | LABORAV | 0.113 | 0.507 | 0.476 | 1.120 |
| | ACCR | -1.407 | 3.626 | 0.057* | 0.245 |
| | TLU | -0.032 | 0.213 | 0.645 | 1.033 |
| | AREIM | -1.995 | 1.768 | 0.184 | 0.136 |
| | DISTPLOT | -0.030 | 3.601 | 0.058* | 0.970 |
| | FERTILIT | -0.914 | 7.044 | 0.008*** | 2.494 |
| | OWNPLO | 0.639 | 1.015 | 0.314 | 1.894 |
| | SOILTYP | -0.883 | 7.024 | 0.008*** | 0.414 |
| | SLOP | 0.029 | 0.009 | 0.925 | 1.029 |
| Above ground | Intercept | -16.848 | 0.000 | 0.995 | |
| | EDUC | 0.012 | 0.000 | 0.986 | 1.013 |
| | LABORAV | -0.248 | 1.369 | 0.242 | 1.282 |
| | ACCR | 2.271 | 6.014 | 0.014** | 0.103 |
| | TLU | 0.088 | 1.025 | 0.311 | 1.091 |
| | AREIM | 2.590 | 1.387 | 0.239 | 0.075 |
| | DISTPLOT | -0.023 | 0.887 | 0.346 | 0.977 |
| | FERTILIT | 0.778 | 2.522 | 0.112 | 2.178 |
| | OWNPLO | 17.018 | 0.000 | 0.995 | 24586362.898 |
| | SOILTYP | 1.382 | 6.497 | 0.011** | .251 |
| | SLOP | 0.297 | 0.444 | 0.505 | 1.345 |
| **Surface Pond** | Intercept | -32.024 | 0.000 | 0.989 | |
| | EDUC | .837 | 1.273 | 0.259 | 2.310 |
| | LABORAV | 0.035 | 0.025 | 0.874 | 1.036 |
| | ACCR | -16.543 | 0.000 | 0.976 | 15300594.137 |
| | TLU | -0.117 | 1.094 | 0.296 | 0.889 |
| | AREIM | 3.343 | 4.929 | 0.026** | 28.312 |
| | DISTPLOT | 0.083 | 7.229 | 0.007*** | 0.921 |
| | FERTILIT | 0.555 | 1.308 | 0.253 | 0.574 |
| | OWNPLO | 17.579 | 0.000 | 0.994 | 43092307.721 |
| | SOILTYP | 0.406 | 0.952 | 0.329 | 0.666 |
| | SLOP | 0.858 | 4.188 | 0.041** | 0.424 |

***;** & * Significant at 1%; 5% and 10% probability level respectively; -2 Log Likelihood = 331.51

Area of the plot affects the choice decision for surface pond structure group positively and significantly at 5% significant level. It indicates that surface pond structure require relatively larger area as compared others. The odds ratio 28.312 for this variable in surface pond structure group indicate that keeping the influences of other factors constant, the decision in favor of the surface pond structure group increases by a factor of 28.312 as plot size increases by one unit.

Distance of the plot from homestead is significant at 10% and 1% significant level to affect the choice decision for underground and surface pond structure groups respectively but insignificant for above ground structure group. The parameter gets negative in underground and positive in surface pond structure groups. The result fits with the idea in the hypothesis. The negative sign of the coefficients for underground structure indicating that as the distance of a plot from the residence is far, users are not interested to construct underground structure groups.

The odds ratios 0.970 for the underground indicate that keeping the influences of other factors constant, the choice for underground structure group's decrease by the rate of 0.970 as distance of the plot far from the residence by one additional minute. While, the odds ratio 0.921 for the surface pond structure groups indicates that the choice decision in favor of surface pond structure group gets increasing by a factor of 0.921 as distance of the plot far from the residence by one additional minute.

Fertility of the plot refers to the fertility status of the plot on which water harvesting structure is to be constructed. This variable affects the choice decision of underground structure groups negatively and significantly 1% probability level. The negative sign shows that underground water harvesting structure is mostly constructed in fertile plots for the purpose of crop production. While; aboveground and surface pond types can be built in both fertile and infertile plots for different purposes (crop production, drinking water). That is why fertility of plots is not so much concerns of respondents to construct the two structure groups. The odds ratio 2.494 shows that the decision to construct the underground structure groups gets decreasing by a factor of 2.494 as fertility level decreases by a unit category.

Soil type of the plot is significant at 1% and 5% significant level to affect the choice decision for underground and above ground structure groups respectively but insignificant for surface pond structure group. The coefficients get a negative sign for underground structure and the positive sign for aboveground structure groups. This means that red soils are more preferable to construct underground structure groups. This is what mostly done in the study area The odds ratio 0.414 in underground structure group indicates that holding other things being constant, the choice decision in favor of underground structure group decreases by a factor of 0.414 per unit change in the soil category. Similarly, the decision in favor of above ground structure group increases by a factor of 0.251 per unit change in the soil category.

Slope of the plot affects positively and significantly the choice decision for surface pond structure groups at 5% significant level and insignificant to affect the choice decision for underground and aboveground structure group. Users usually prefer to construct underground and surface pond structure groups in plots having flat topography mainly to avoid or to minimize the large earth works required to construct them. The odds ratio 0.424 in the surface pond structure group indicate that holding other factors being constant, the choice decision in favor of the surface pond structure group increases by a factor of 0..424 as the steepness of the slope decreases by one category unit.

## 4. CONCLUSION AND RECOMMENDATIONS

The effect of agriculture in the overall economy of the country is high. Hence a desperate need for increasing productivity of Ethiopian agriculture paramount important. To do this; among others, this requires overcoming the moisture stress problem, which is believed to play a pivotal role in the agricultural development of the country.

Currently, the government of Ethiopia has tried to adopt the household level water harvesting ponds, shallow and deep well development as one strategy of the country's irrigation development in order to alleviate the problem of food security and enhance the overall growth of the rural economy. This is clearly stated in the policy document of Agricultural Development Led Industrialization (ADLI), by saying that in drought-prone areas, agricultural production, among others, can be increased through the development of water harvesting irrigation by providing the necessary farm inputs, credit facilities and extension services.

The finding of this study, therefore, would provide first hand information on the factors determining the choice of preference of farmers among water harvesting technologies for different governmental, nongovernmental organizations, extension agents working in the study area and other similar areas.

The result of the study showed that the perception of the concerned experts and political leaders on the importance of expanding small scale irrigation schemes through water harvesting practices for sustained development of the agricultural sector has been becomes growing. However, the perception of farmers and development agents on its vital importance is very low. Due to this , as observed in the field observation most of constructed water harvesting structures were not used to for crop production, rather they largely used for drinking of animals water.

The results of multinomial logit model analysis based on a sample of 200 farmers selected from three districts of east Gojjam zone namely, Motta district, Enebsiesarmider district and Enarjenawuga district in 2013 showed that among the 10 hypothesized explanatory variables included in the model, educational level of the household head, Access to credit, area of a farm plot, distance of the plot from residence, fertility of a farm plot and type of soil were found to be significantly affecting the choice decision for underground structures whereas only access to credit and type of soil affect the choice decision for aboveground structures. Similarly, area of a farm plot, distance of the plot from residence and slope of the plot were found significantly affecting the choice decision of surface pond. The magnitude and sign of the effect of some significant variables were not similar for the three structure groups. Some may be highly significant to affect the choice decision for a particular group and may be insignificant for the other groups.

Based on the findings of this study the following points need to be considered as possible policy recommendations in order to enhance the use water harvesting practices based on farmers preference;

- Regarding the cost evaluation of water harvesting technologies the majority about 63 percent of respondents perceived that the cost is very high. This might have an influence on the choice preference of farmers. Therefore, designing appropriate credit system is necessary from the concerned bodies to promote the appropriate technologies choice of farmers. In addition, Promotion of water harvesting should be done in conjunction with crops, which can be sold for cash. This can be also supported by improving marketing channels for produced crops.

- Physical characteristics of the plot are also important factors for the preference decision behavior of farm households among alternative water harvesting technology groups. Therefore, concerned bodies should develop and promoting water harvesting structure groups which best fits with physical characteristics of the particular area.

- Education is an important variable which affects the choice decision of farmers. it has positive and significant effect for choosing above ground structures. Participating farmers in training on water harvesting related issues is an essential element to make farmers choice decisions based on the enough knowledge of water harvesting technology group. This also helps to enhance the use of water harvesting technologies at farm household level.

- As observed in the field observation most of constructed water harvesting structures were not used to for crop production, rather they largely used for drinking of animals water. Thus, providing informal trainings, expanding informal education to the farming household and enhance the knowledge of development agents is paramount important. Therefore, the concerned bodies at every stage should strengthen educational opportunities through the established farmers training center for farmers and development agents; who are vital for expansion of the technology.

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