Vol. 14(3), pp. 55-65, July-September, 2022
DOI: 10.5897/IJWREE2022.1031
Article Number: 5D37BCB69469
ISSN: 2141-6613

http://www.academicjournals.org/IJWREE

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International Journal of Water Resources and Environmental Engineering

Full Length Research Paper

Determinants of the adoption of rainwater harvesting technologies in Kebri-Beyah District, Somali Region, Ethiopia

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Received 10 March, 2022; Accepted 5 July, 2022

The study was conducted in 2019 in the Eastern Ethiopia Somali region Kebri-beyah district to identify the determinants of the adoption of rainwater harvesting technologies (RWHT) in the district. The study revealed several determinants for the adoption of RWHT in Kebri-Beyah district, among the factors include a level of education, access to finance, training, extension service and approaches which are major determinants for the adoption of RWHT. In addition to this lack of awareness about the RWHT, poor design and site selection for storage structure were also found to be key factors hindering the adoption of RWHT in the district. An understanding of the factors influencing the adoption of RWHT is therefore critical to a successful implementation of the project Therefore, in the future for the success of RWHT adoption in Kibri-Beyah and other similar areas determinants mentioned in this study must be considered and addressed properly.

Key words: Socioeconomic, institutional, factors, determinant, adoption, rainwater harvesting technologies (RWHT).

INTRODUCTION

Rainwater is the major source of agricultural water supply for most of the subsistence farming system in sub-Saharan Africa (Getachew et al., 2016). However, its distribution is unreliable particularly for the semi-arid and dry sub humid area. Therefore, crop farming and livestock husbandry practice become more difficult putting the lives of many pastoralist and farmers in great danger (Paolo et al., 2020). According to Welteji (2018), over 90% of Ethiopia's food supply comes from rainfed and small-holder agriculture, and rainfall failure means loss of major food supply which always results in massive food deficit. To mitigate this problem, government of Ethiopia developed national strategy based on implementation of different rainwater harvesting technologies (Zenebe et al., 2020).

After the strategy developed, different types of rain

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water harvesting technologies (RWHT) were introduced and implemented in different part of the country (Tasisa et al., 2020; Zenebe et al., 2020). The main rain water harvesting structures widely adopted in Ethiopia is traditional ponds known as *Birka*; this pond RWHT is widely used for livestock and household use in dry land areas such of Somali region and other pastoral agro-pastoral dominated areas of Ethiopia (Nasir and Fekadu, 2017). Despite government effort for the adoption of RWHT, there are different rates of adoption of RWHT among the regions. This adoption differences might have resulted from different socio economic and other factors.

Previous research on adoption of RWHT in different parts of Ethiopia and other similar areas provided several clues to the relationship between the RWHT and socio economic and other factors, and their influence to adopt or not adopt the RWHT. Nasir and Fekadu (2017) reported that socio economic and institutional factors are major determinate for adoption of RWHT in Eastern Ethiopia. Similarly, Samia et al. (2017) reported that socio-economic and institutional factors affect the three adoption stages of SWC differently. Therefore, both household socio-demographic economic and institutional characteristics should be considered in the dissemination of and widespread adoption of water harvesting structures at household level (Lutta et al., 2020).

In areas with extreme weather conditions, especially if the rainfall is unreliable RWHT is regarded as the only viable way to support life and livelihood of the community (Nicholas et al., 2018; Paolo et al., 2020; Zenebe et al., 2020). In Ethiopia, particularly in Somali region in Kebri-Beyah district, there have been efforts of introduction and popularization of different RWHT with variable success. Despite the importance and implementation effort of RWHT, there is very limited information available on factors determining RWHT adoption in Somali region (Keberi-Beyah) and other similar districts in the region. This is because the adoption of RWHT in Somali region is found to be low compared to other districts in other regions of Ethiopia and this might have happened due to several unidentified problems. Therefore, identifying determinant factors will help to overcome the challenges during the adoption of the RWHT. Therefore, this study was performed to find out the socio-economic, institutional and physical factors that affecting the adoption of storage-based rainwater harvesting technologies in Kebri-Beyeha district of Somali region, eastern Ethiopia.

RESEARCH METHODOLOGY

Description of the study area

The study was conducted in Kebri-Beyha district of Somali region of eastern Ethiopia. The district had a total population of 203,304 in 2015, of which 107,287 were men and 96,017 were women (CSA Projection, 2015). Geographically, the district is located between 8°42’00” N to 9°18'00” N and 42°54’00’’ E to 43°30'00”E (Figure 1). The soils of the study area predominantly are Vertisols, Luvisols, Fluvisols, Leptosols, and Cambisols (OWWDSE, 2012).

The district has two rainy seasons with high variability with uneven distribution, these rainy seasons are known locally as the *Gu* (early March to May) and *Karan* (late July to early October). The rainy seasons are alternated by two dry seasons locally known as *Jilal* (late October to March) and *Hagaa* (late May to early July) (Figures 2 and 3). The mean annual rainfall of the area is 582.4 mm with the mean annual potential evapo-transpiration of 1780 mm (Figure 2).

Sampling technique and sample size

A multi-stage sampling technique was employed in this study. At the outset, the Kebri-Beyah district was purposively selected out of several districts in the Somali region based on the problem of water scarcity and the availability of RWHT structures. In the second stage, out of 19 villages in the Kebri-Beyah district, 3 villages were purposively selected. Finally, households were selected for a detailed household survey using the formula (Yemane, 1967).

$$n = \frac{N}{1+N(e)^2} = 120 \quad (1)$$

where n is the sample size, N is the population size (total household size), and e (9%) is the level of precision at 95% level of confidence. To determine sample size in each village, proportional sampling technique was employed. Then the respondents were classified as adopters and non-adopters of RWHT.

Method of data collection and analysis

The data was collected through questionnaires, key informant interviews, focus group discussions, household surveys, and field observation. The focus group discussions were carried out to get detailed and agreed-upon information regarding community attitudes towards SBRWH technologies. Hence, one FGD with adopters and another with non-adopters of storage-based RWH technologies were undertaken with selected 9 households’ heads in the three selected Kebeles. Key informants (KI) were purposively selected based on their knowledge and experiences in SBRWH technologies, and who have lived in the area for a long time, hence, Woreda water resource development experts, soil and water conservation expert, Kebele level development agents, religious leaders, Kebele leaders, and knowledgeable farmers in the study area. Therefore, a total of nine key informants have been selected and interviewed. Close-ended and open-ended questions were combined to develop a well though-out questionnaire. Hence, 120 households filled out the questionnaire. In addition to that field, observation was made to have a general overview of the environmental situation, the types of existing indigenous, and introduced RWH structures.

Selected appropriate econometric analysis

To perform an economic analysis, the Probit model was selected for this study. The main purpose of this model was to analyze determinant of SBRWH technologies adoption. The dependent variable in this case is dummy variable, which takes the value of one or zero depending on the SBRWH technology, (*Birka*) adoption. The explanatory variables are either continuous or dummy variables.

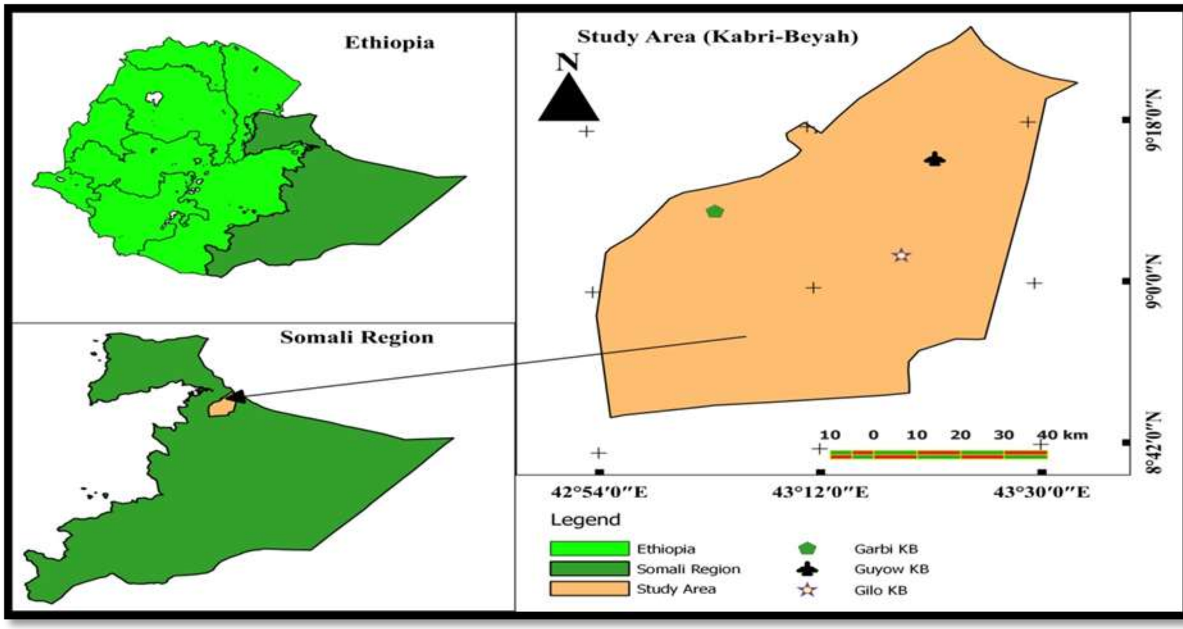

Figure 1. Location map of the study area.
Source: Own Survey (2019)

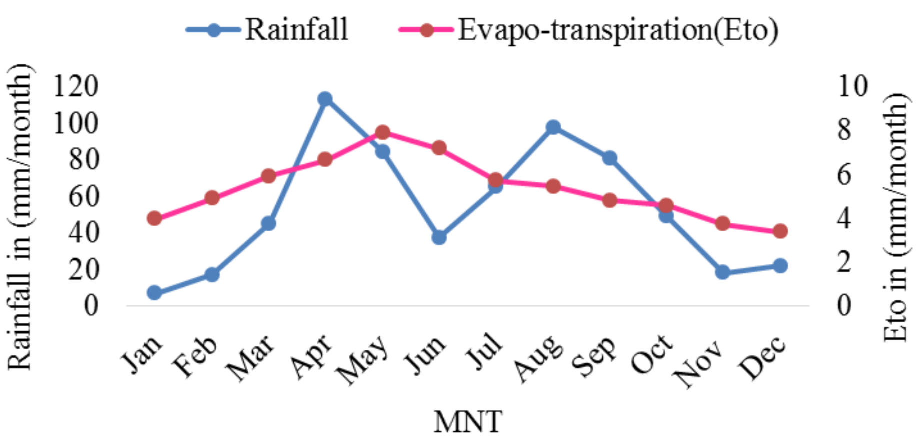

Figure 2. Monthly average rainfall and potential evapo-transpiration in Kabri-Bayeh district Somali region, Ethiopia.
Source: Ethiopia Meteorology agency (2019)

Suppose response variable Y is binary, thus it can have only two possible outcomes which are denoted as 1 and 0. For example, *Y* may represent RWHT adopter or storage-based RWH non-adopter. There is also a vector of repressors *X*, which were assumed to influence the outcome *Y*. Mathematically, it is explained as follows:

$$Yi = \beta^1 X_i + \varepsilon_{i,} Yio \quad (2)$$
$$(\varepsilon_i) \sim normal\ (0, \sigma_\varepsilon \sigma)$$

where Y_i is a dummy variable that takes a value of 1 if the household head adopts Birka technology and 0 otherwise. X_i and β^1 are parameters of the models and ε_i is error terms of the regression.

Yio is the respondent value of a given parameter for a respondent Yi.

$$Pr(Y = 1|X) = \Phi\ (X'\ \beta) \quad (3)$$

where Pr denotes probability and **Φ** is the Cumulative Distribution Function (CDF) of the standard normal distribution. The parameter '***β'*** is typically estimated by outcome. It is also possible to motivate the Probit model as a latent variable model supposing the existence of an auxiliary random variable. The use of the standard normal

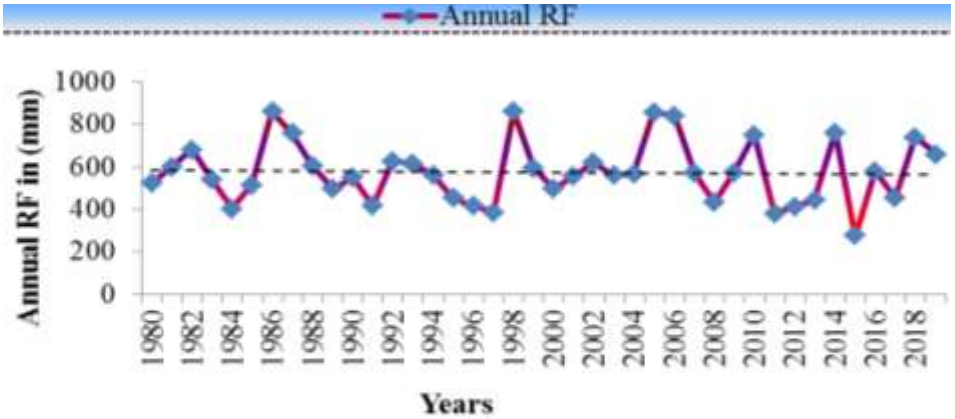

Figure 3. Annual rainfall pattern of Kebri-Beyah district Somali region, Ethiopia.
Source: Ethiopia Meteorology agency (2019)

distribution causes no loss of generality compared with using an arbitrary mean and standard deviation because adding a fixed amount to the mean can be compensated by subtracting the same amount from the intercept, and multiplying the standard deviation by a fixed amount can be compensated by multiplying the weights by the same amount.

To see that the two models are equivalent, note that:

$$\Pr(Y = 1|X) = \Pr(Y^* > 0) = \Pr(X^* \beta + > 0) \quad (4)$$
$$= \Pr(\varepsilon > -X'\beta)$$
$$= \Pr(\varepsilon < X'\beta) \quad \text{(by symmetry of the normal distribution)}$$
$$= \Phi(X'\beta)$$

The probit selection model is given by:

$$Y_i = ß_0 + \beta X_i + \varepsilon_i \quad (5)$$
$$I = 1 \quad \text{if } Y_i \geq t_i, \quad I = 0 \quad \text{if } Yi < t_i$$

where Y_i = i^{th} respondent's true unobserved point valuation for the Birka adoption in question, $ß$ = a coefficient for X, t_i= the offered threshold, assigned arbitrarily to the i^{th} respondent, I = discrete response of a respondent for the Birka adoption question (1=Yes or 0= No), εi = unobservable random component distributed N (0, σ) and X_i= observable attributes of the respondent.

The empirical Probit model for this study is as follows:

$$\text{Respondent's SBRWHTA} = ß_0 + ß_1\text{SEX} + ß_2\text{AGE} + ß_3\text{EDU} + ß_4\text{ FARSIZE} + ß_5\text{ FAMILY SIZE} + ß_6\text{OFFARM} + ß_7\text{MARKET DIST} + ß_8\text{EXTENAPPRO} + ß_9\text{EXTENSER}ß_{10} + ß11\text{ TRAINI} + ß_{12}\text{ SLOPE} + ß_{12}\text{ TECHNICAL} + \varepsilon \quad (6)$$

In addition, the marginal probabilities were computed for the variables to show the magnitude of their effect on adoption of storage-based SBRWH technologies.

Definition of variables and working hypothesis

There are various factors determining a household's decision to adopt or not to adopt new technologies. These include socio-economic, institutional, and biophysical factors. It was represented in the Probit model by (1) for those households who are adopters of storage-based rainwater harvesting technologies practiced and (0) otherwise. Based on the previous study done on the adoption of RWHT and the experience of the farming system of the study area, Table 1 shows the listed explanatory variables were selected for this study.

RESULTS AND DISCUSSION

Description of SBRWH structures in Kabri-Beyah district

During the last three decades, 224 storage-based rainwater harvesting structures (Birka and community earthen ponds) were constructed in the nineteen kebeles of Kabri-Bayeh district by governmental organizations, and non-governmental organizations (NGO), the individual households, and community participation (Table 2). The two most important storage-based macro-catchment RWH structures are Birkas and earthen ponds. The majority of the storage structures were constructed mainly by individual efforts. The community participated either on a food-for-work basis or provision of free labor during the construction of the structures (KWWRDO, 2009).

Socio-economic and demographic characteristics of Kebri-beya district

The socio-economic characteristics of the respondents in the Kebri-Beyah district are presented in Table 3. The result indicated that the majority of the respondents (81.6%) livelihood was found to be semi-pastoral farming

Table 1. Explanatory variables and their hypothesized effect

Variable code	Variable type	Description & measurements	Expected sign
SEXHH	Dummy	Gender of the household head(male 1, female 0)	±
AGEHH	Continuous	Age of household head (in year)	±
FAMSIZE	Continuous	Household size (total numbers of family in household)	±
EDUHH	Dummy	Formal & informal education of household head	+
TLANDSIZE	Continuous	Total land size held by household (in hectare)	+
OFFARM	Dummy	Household engaged in off-farm (1 = yes and 0= otherwise	+
EXTSER	Dummy	Extension service	+
TECHAVA	Dummy	Availability of technical support services	+
EXSTAPRO	Dummy	Extension approach	+
TRAINI	Dummy	HH head's participation on RWH structures training	+
SLOP	Continuous	Slope of the location of the storage	+
MKTDIS	Continuous	Market distance	±

Source: Own Survey (2019)

Table 2. Types and status of SBRWH structures in Kebri-Beyah district of Somali region in Ethiopia

No.	Type of structure	Mean water holding capacity (m^3)	Wall and top cover conditions of the structures			
			Plastered uncovered	Plastered covered	Un plastered uncovered	Total
1	Birka	460	90	67	15	172
2	Earthen pond	1875	0	0	52	52
3	Total SBRWH structures in Kebri-Beyah district					224

Source: Own Survey (2019). *Birka* refers to a concrete made rainwater storage structure which is locally named Birka.

system. Hence, the community livelihood means are livestock including sheep, goats, cattle, and camels, while the major crops practiced in the area are maize and sorghum. A small proportion of the respondent (6.7%) engaged in pure pastoralism and 11.62% of respondents engaged in non-farming forms of livelihood. The results in Table 3 indicated that the majority of respondents fall in the age group of 30 to 45. The family size of the respondents was between 6 and 7 individuals per household for about 41.1% of the respondents with large family sizes up to above 12 individuals per household recorded from 11.23% of respondents.

The land holding was between 5.25 and 7 ha/ household while livestock holding was between 7 and 10 livestock per household. The majority of respondents (49.6%) never had any form of education while nearly 35% of the respondent can read and write very few of the respondents 15.85% attended up to elementary school (Table 3).

Determinant factors of adoption of SBRWH technologies

Socio-economic determinant factors for adoption of SBRWH

According to the result of this study, adoption of RWHT is found to be determined by different factors in the society. Accordingly age, family size, level of education and land holding positively affected the adoption of RWHT and the result was also showed statistically highly significant difference (α< 0.05). According to the result in Table 4, majority of respondents (72.5%) in the Kebri-Beyah district never adopted RWHT while small 27.5% respondents adopted RWHT mainly handmade water storage locally known as *Birk*a. Accordingly, the proportion pastoralist livelihood is higher in non adopters while the proportion of semi pastoralist was found to be higher in adopters group. However, the proportion of off farm livelihood group was relatively constant despite slight increment in non adopting group. The variation in adoption of RWHT based on the livelihood difference implies that livelihood plays a vital role in adopting RWHT.

The result in Table 5 revealed that, a household characteristic such as age, family size, land and livestock holding affect adoption of RWHT. The mean age of RWHT adopters was greater than the mean age of non-adopters. The age mean age of adopters was around 45 which was younger than the mean age of non adapters which was 60. This implies that younger and active working age groups are positively associated with RWHT adoption than older age groups. The current finding corroborates with Baiyegunhi (2015) who reported age

Table 3. Some socio-economic characteristics of Kebri-Beya district.

Demographic characteristics		Percent	Frequency	N
Age range	18-29	34.7	41	120
	30-45	52.8	63	
	46-65	13.3	16	
Education	Can't read and write	49.16	59	120
	Informal education	35.00	42	
	Elementary	15.83	19	
Livelihood	Pastoral	6.72	8	120
	Semi pastoral	81.66	98	
	Off farm	11.62	21	
Average Family size	2-4	9.16	10	120
	5-6	41.4	50	
	7-9	39.17	47	
	10-15	11.23		
Average Land holding (ha)	0.5-1	2.5	3	120
	1.25-5	21.66	26	
	5.25-7	32.5	39	
	7.25-9	27.5	33	
	9.25-11	10	12	
	11.25-15	5.83	7	
Livestock holding	3-6	10.83	13	120
	7-10	51.66	62	
	11-15	26.66	32	
	16-20	10	12	
	Above 20	4.16	5	

Source: Own Survey (2019).

Table 4. Major means of livelihood for the respondents in Kebri-Beyah district.

Type of major means of livelihoods	Adopter (N=33)	Non-adopter (N=87)	Total (N=120)
	%	%	%
Pastoral	6.12	69	75
Semi pastoral	81.8	11.5	93.5
Off farm	12.1	19.5	17.5

Source: Own Survey (2019).

has a statistically significant negative effect on adoption of RWHT, that is, older farmers are less likely to adopt RWHT. The mean family size of RWHT adopters was greater than the mean family size of non-adopters (Table 5) and the result showed also statistically significant difference (α<0.05) between adopters and non-adopters. This could be due to large family size associated with better farm activity and productivity in subsistence farming (Shalamzari et al., 2016). This tells that households that have larger number of working group members were more likely to engage in RWHT The findings of this study are in agreement with Nasir and Fekadu (2017), who reported family size was positive and statistically significant to influence adoption of RWH technology. The average land holding size of RWHT technology adopters was greater than the average land

Table 5. Selected socio-economic characteristics of adopter and non-adopter households for RWHT in Kebri-Beyah district.

Household characteristics	Adopter				Non-adopter				t-test
	Min	Max	Mean	STD	Min	Max	Mean	STD	
Age	19	67	46.55	12.2	19	60	33.7	10.43	5.74**
Family size	2	14	6.79	3.75	2	13	5.9	2.79	-1.6***
Land holding size (Ha)	1.5	14	6.93	3.36	0.5	14	5.65	2.28	4.79**
Total livestock unit	0	19	11.56	3.41	6	22	8.43	4.44	4.352**

***, **Statistically significant at 1 and 5%, respectively.
Source: Own Survey (2019).

Table 6. Education level and off-activities among adopters and non-adopters of RWHT in Kebri-Beyah district.

Household characteristics		Adopter (N=33)	Non adopter (N=87)	Chi^2-test
		%	%	
Education level	Can't read and write	15.2	60.9	6.42**
	Informal education	60.6	25.3	
	Elementary	24.2	13.8	
Involvement off-farm activities	Yes	75.8	34.5	4.34**
	No	24.2	65.5	

**Statistically significant at 5%.
Source: Own Survey (2019).

holding size of non-adopters in the study area (Table 5). This implies that household with relatively large land holding, positively affected adoption of RWHT (Hayelom, 2016). The result in Table 5 also revealed that adopters had relatively large number of livestock holding compared to non-adopters. This means that households with larger number of livestock tend to use RWHT than those who have smaller number of livestock. The finding is in agreement with Mesfin (2005) and Nasir and Fekadu (2017) reported that adopters of RWHT had relatively large livestock holding compared to non-adopters.

The study also revealed that level of education had significant effect on adoption of RWHT in which adopter had formal education while all non-adopters had only informal education (Table 6). This implies that there is a strong positive relationship between education and RWHT technologies adoption (Baiyegunhi, 2015). Similar results were also reported previously on positive association between farm technology adoption and level of education (Bayissa, 2014; Nasir and Fekadu, 2017; Bekele, 2020). The study revealed that there was a significant association between adopting RWHT and involving off-farm activities (Table 6). The result is in line with previous studies that revealed farmers who are involved off-farm activities tend to adopt new technologies (Mesfin, 2005).

Institutional factors

Market distance

According to the result of the study, there was no statistically significant association between market distance and adoption of RWHT technologies (Table 7). However, the result of this study contradicted that of Melesse (2018) who reported that market distance significantly and negatively affect adoption of improved technologies.

Training and extension service

According to the result, there was a significant association between the extension approach and adoption status (Table 8). This could imply that the extension service helped adopters to get information, internalize it and adopt RWHT. Similarly, majority of adopter got training on construction and management of RWHT may have contributed to its adoption. The current study may corroborate with that of Singh et al. (2011) who reported training programs had resulted in desirable impact on the farmer's knowledge about improved technology and played an important role adoption and productivity

Table 7. Market distance and RWHT adoption in Kebri-Beyah district.

Variable	Categories	Min	Max	Mean	Std.	t-test
Market distance	Adopters	7	28	17.75	7.27	
	Non-adopters	7	28	20.06	7.08	1.567[NS]
Total		7	28	18.38	7.27	

[NS]Statistically not significant.
Source: Own Survey (2019).

Table 8. Extension service, extension approach, and RWH T adoption in Kebri-Beyah district.

Variable	Categories		Adopters (N=33)	Non-adopters(N=87)	Chi^2-test
Extension service	Yes	N	23	30	3.34**
		%	69.7	34.5	
	No	N	10	57	
		%	30.3	65.5	
Extension approach	Participation	N	8	32	2.38*
		%	24.2	36.8	
	Top-down	N	25	55	
		%	75.8	63.2	
Training participation	Yes	N	27	12	2.42**
		%	81.8	13.8	
	No	N	6	75	-
		%	18.2	86.2	

*, **Significant differences at 5 and 1%.
Source: Own Survey (2019).

improvement. Similarly, it was indicated that extension and training service for farmers is the vital way that simplifies the technology adoption problem and increases productivity at farmer's level (Shaibu et al., 2018; Wang et al., 2020).

Physical factors determining adoption of RWHT

The result of the study showed that 12 and 45.8% of adopters and non-adopters plots were located at steep slope areas implying not suitable for construction of RWHT technologies (Table 9). The location of the Birka's slope categories as perceived by sampled respondents showed statistically significant differences (Table 9) indicating that sites of steep slopes are not economical for RWHT, because of high runoff. The result implies that slope is an important factor in the selection and use of Birka water storage structures in the study area. The result of this study is in agreement with that of FAO (1994) recondition where slope >5 % is not suitable for rainwater harvesting. Similarly, other previous studies reported that there were significant associations between flat slope and the use of water harvesting technologies (Molla, 2005; Gaylan et al., 2019).

Soil condition was also studied as it might affect the adoptions of the technology; the result revealed that there was no statistically significant association between adopters and non-adopters with regard to the soil condition (Table 9). Hence, this is an indication that the soil condition with respect to the classes in the study area was not considered as a factor for adoption of RWHT (Table 9). This finding is contrary to Gaylan et al. (2019) who reported that soil condition affected adoption and implementation of rainwater harvesting. Similarly, Mangisoni et al. (2019) reported that soil texture played a key role in the choice of both *in situ* and *ex situ* technologies. Similarly, the result in Table 9 indicated that, location was statistically not significant among adopters and non-adopters. This indicates that location of

Table 9. Physical characteristics of land and adoption of RWHT.

Variable	Categories	Respondents		
		%Adopters (N=33)	%Non-adopters (N=87)	Chi^2-test
Slope	Plain (Suitable)	87.9	55.2	11.809**
	Steep (Not suitable)	12.1	44.8	
Soil type	Crack	18.2	32.2	4.121^{NS}
	Without crack	24.2	14.9	
	Hard to dig	57.6	52.9	
Location	Suitable	75	55.3	9.87^{NS}
	Not Suitable	24.2	43.7	

**, NS Statistically significant differences at 5% and Non-significant
Source: Own Survey (2019).

Table 10. Estimation of the probit model output for RWHT technology adoption status in Kabri-Beyah district.

Variable	Coeff.	Std. Err.	z	P>z	Marginal effect
Sex	0.4406832	0.4354446	1.01	0.312	0.1522097
Age	0.00366	0.0173156	0.21	0.833	0.0091998
Education level	0.4237928**	0.2774847	1.53	0.027	0.1882661
Farm land size	-0.030676	0.0696183	-0.44	0.659	-0.0317784
Family size	-0.1616174**	0.0706998	-2.29	0.052	-0.0068238
Off-farm	0.3346306	0.4281222	0.78	0.434	0.2035068
Extension approach	0.7789413**	0.3674538	2.12	0.034	0.022603
Extension service	0.178507***	0.365413	3.23	0.001	0.0987747
Training	0.510485***	0.3760237	4.02	0.0013	0.0981982
Slope	0.5746175	0.2627185	2.19	0.69	0.0268098
Technical availability	0.4714914**	0.2392863	1.97	0.038	0.1174328
Market distance	-0.04872	0.0296185	-1.65	0.58	-0.0117627
Constant	-5.880209	2.071725	-2.84	0.000	

***, ** represent the level of significance at 1 and 5% probability level, respectively. “HH”=household head, Number of observation = 120, Log likelihood = -35.068827, LR Chi^2 (11) = 95.38, y = Pr (SBRWH adoption) (predict) = 0.7211295, Prob > Chi^2 = 0.000, Log likelihood square test= 90.7, Pseudo R^2 =0.5763.
Source: Own Survey (2019).

RWHT structures may not affect the adoption of rainwater harvesting in the study area. This result is inconsistent with the previous finding of Molla (2005).

Empirical result and discussion

The result of the econometric analyses indicated that the determinants for the adoption of SBRWHSs were extension approaches, access to extension service and training, education level of household head and technical service (Table 10). The educational level of household heads was found to be positively correlated with the adoption of RWHT (Table 10). The result shows that as the education level of the household head increase, the probability of households to adopt RWHT technology is likely to increase by 18.8% (Table 10).

It was related to the findings of Christian et al. (2012) who revealed that the increase in the education level can increase in the degree of adoption of improved technology. Moreover, previous studies implied the importance of education in the adoption of soil conservation practices (Maurice et al., 2010). The model result indicated that the access to training correlates positively with the adoption of RWHT. The participation of a household head in training is likely to increase RWHT adoption by 9.81%. The result of this study is in conformity with the findings of Singh et al. (2011) and Lutta et al. (2020). Similarly, prior studies indicated that as trainings and on soil erosion problem increases, adoption of soil and water conservation technology also increases (Belachew et al., 2020).

The probit model results (Table 10) indicate that extension service on different RWHT aspects is statistically-significantly positive at p<0.01 probability level on adoption of RWHT, that is, farmers who had extension service from different agents/experts are more likely to adopt RWHT. The probability of one household head having extension service is likely to increase RWHT adoption by 9.87% than those who do not have access to RWHT extension service. Extension service allows farmers greater access to information, training on technology, inputs, credit and the borrowing of agricultural equipment, through increased opportunities to participate in on-farm demonstrations and trials, which thus increase farmers' ability to adopt RWHT technologies (Adesina and Chianu, 2002; Sidibe, 2005).

The result of the model indicated that the extension approach was positively related to the adoption of RWHT. The variable indicated that keeping other influencing factors constant, farmers decision to RWHT increases by 2.26% when the extension approach is participatory than top-down (Table 10). Therefore, it can be safely concluded that the extension approach lacks to combine appropriate methods to promote RWHT in the study area. Similarly, Belachew et al. (2020) pointed out that practically many innovations considered worthwhile by researchers proved their inability to make sense for many farmers due to lack of participation.

CONCLUSION AND RECOMMENDATION

The study revealed several determinants of the adoption of RWHT in Kebri-Beyah district of Somali region eastern Ethiopia. Level of education, training, family size, extension system and approaches are the major factors limiting the adoption of RWHT technologies. In addition to this, lack of awareness about the RWHT for storage structure is also found to be one of the key factors hindering the adoption of RWHT in Kabri-Beyah district. In the future for the success of any RWHT adoption in Kabri-Beyah and other similar areas of Somali regional state, determinant factors mentioned in this study must be addressed. Similarly, to avoid structural physical and capacity failure for the RWHT, site selections, design, quality of construction, accessible finance and collaboration between different actors must be supervised by the trained and skilled worker along with the farmers. Furthermore, accesses for credit and loan should be studied as financial factors that can be determinant of RWHT adoption. Moreover, RWHT implementation and adoption requires the involvement of multiple actors to work in collaborations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors thank the Somali Region Pastoral and Agro-pastoral Research Institute and Jigjiga University for funding this study and facilitating the logistics.

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