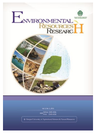

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Analysis of adaptation determinants of domestic rainwater harvesting systems (DRWHs) in Golestan province, Iran

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Abstract

Most residences of the northern parts of Golestan Province, have historically used rooftop rainwater for drinking. Its adoption rate and continued use have declined in recent years for various reasons. Based on a survey of 380 cases, this research attempted to identify what factors are contributing to the adoption of these systems. The results demonstrated that the adoption changes in response to five factors: access to water, existence of specialized organizational sector, previous experience, direct observation and integration into the domestic distribution system, with the odds ratios of 10.5, 2.16, 0.12, 2.7, and 4 respectively ($P<0.01$). One of the factors that is likely to intensify in the region is reduced access to safe drinking water (every unit increase in this factor would increase the adoption by a factor of 10). It seems necessary to develop a governmental sector, specialized in the field of domestic rainwater harvesting, to not only help technically and financially to the construction of these systems, but to offer consultations and hygienic safety packages, such as chlorine stock solutions or modernization of equipment. Modernization of these systems could also help remove the concern over the integration of these systems into the domestic water distribution piping. Lack of experience and less frequent contact with these systems have also resulted in low level DRWHs adoption. It appears mass media and non-governmental organizations could also facilitate improving these two factors. Results of this study could inform decision making to better encourage the use of DRWHs in Golestan Province.

Keywords: Domestic rainwater harvesting, Adoption, Logistic regression, Golestan, Diffusion of innovations

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1. Introduction

Rainwater harvesting defined as "the gathering and storage of water running off surfaces on which rain has directly fallen", could be a potential alternative in small communities that cannot be served by more centralized water supply schemes (Pacey and Cullis, 1986). Rainwater harvesting is an excellent, low cost and simple technique in combating water related poverty (Pattberg, 2012). Notwithstanding these advantages offered by the adoption of rainwater harvesting systems the adoption of these systems seems to be dissatisfactory in most areas which endures severe water scarcity (Handia *et al.,* 2003; He *et al.,* 2007; Murgor *et al.,* 2013). Adoption of these systems is slow because of these factors: 1) current water price for domestic supply both in urban and rural areas is low, 2) the low price of water supply has created a negative attitude towards the value of rainwater, 3) low water price discourages efficient utilization of water (opportunity cost of water), 4) low price of water discourages the adoption of new rainwater harvesting techniques, and 5) the low price of water reduces the incentive for private sector to involve in the supply of the different services of water for users including rainwater harvesting (Awulachew *et al.,* 2006). Despite the undeniable role of low price of water, it seems that other factors could play an equal, even more important role in the adoption of domestic rainwater harvesting systems (hereafter abbreviated as DRWHs). *Inter alia,* Ryan *et al.* (2009), on an internet survey completed by 354 households residing in the Australian Capital Territory, showed that income, gender, age, education, concerns about water collection and reuse risks could not differentiate residents in terms of adopting or rejecting integrated rainwater harvesting and grey-water system. It seems this study has failed to clearly establish which aspects determine adoption of these systems. One major implication of this study is that conceptual understanding and practical implementation of such systems are two separate contexts. Using a binary logistic regression model, He *et al.* (2007) evaluated the determinants of farmers' decisions to adopt rainwater harvesting and supplementary irrigation technology and its elasticity of adoption in the rain-fed farming systems, based on a survey of 218 farmers in the semiarid areas of Loess Plateau. This study demonstrated that 12 variables are significant in explaining farmers' adoption decision. Farmers' educational background, active labor force size, contact with extension, participation in the Grain-for-Green project, and positive attitudes towards RHSIT (Rainwater Harvesting Systems) are some of the variables that have significantly positive effects on adoption of RHSIT, while farmer's age and distance from water storage tanks to farmer's dwellings have significantly negative correlation with adoption. Baguma *et al.* (2010) conducted a study in Uganda to examine the relationships between the dependent variable (rural domestic rainwater management) and the independent predictive variables (personal characteristics, tank size, years of water harvest, rainwater harvesting associations, usage instructions including water borne health risk, and tank operation and maintenance). Logistic regression techniques were used on a random sample of 301 participants to ascertain the influence of predictive variables on rural domestic rainwater management. Analyses of the hypothesized relationship revealed three statistically significant factors: number of years from the first utilization of rainwater, rainwater harvesting associations, and usage instructions. Liang and van Dijk (2015) attempted to identify the decisive factors involved in the use of RWHs for agriculture irrigation in Beijing, and found two non-technological factors, “doubts about rainwater quality” and “the availability of groundwater” to continue or cease RWH operation. Fielding *et al.* (2015), based on a survey of 1200 Australian participants, evaluated the level of comfort in using different water sources. Their results showed that comfort was always highest for drinking rainwater and lowest for drinking recycled water, with comfort with drinking treated storm water and desalinated water sitting between these two. In general, demographic variables were less important predictors of comfort with alternative water sources than psychological variables, and only age and gender emerged as relatively consistent predictors for recycled water. Of the psychological variables, participants’ comfort with technology in general, trust in science and trust in government emerged consistently as significant positive predictors of comfort with drinking recycled water, storm water, and desalinated water. Hurlimann and Dolnicar (2016) based on an online survey of 200 participants, found that public perception of different water sources, including rainwater harvesting changes drastically, based on the intended use and location. Neibaur and Anderson (2016) evaluated the factors affecting public perception of rainwater harvesting in San Jose, Mexico. Their results showed that the existing skills in utilizing rainwater and lack of means to provide safe drinking water are the major determinant of rainwater harvesting acceptance. Taffere *et al.* (2016) argue that inefficient design (without considering deterministically the stochastic nature of rainfall), family size, water demand, rooftop area and storage tank size are the major causes of unreliability in domestic rainwater harvesting systems in Maleke village in Ethiopia.

Currently, substantial body of literature exists on factors contributing to the adoption and rejection of water harvesting measures. Results of these studies are mostly reported on the local issue investigated in the corresponding study. In view of the importance of the subject and the lack of knowledge on underlying causes of low level of adoption, or in severe cases abandonment of these systems in Golestan Province which has a long and rich history and culture of using rainwater, it is beneficial to carry out a study to determine why adopters has decided to use the systems and non-adopters have decided not-to do so, or even abandon the use of these systems. Results of this study could inform decision making in this context and help develop policy and institutional interventions to encourage the use of DRWHs in Golestan Province.

2. Materials and methods

2.1. Study Area

Golestan Province with a population of 1.7 million (Statistical Centre of Iran, census of the year 2011), is located in the north-east of Iran. It has a total area of exceeding 20,000 Km^2. Golestan enjoys mild weather and a temperate climate, in the southern part, most of the year. Geographically, it is divided into two sections: the plains and the mountains of the Alborz range. However, there is quite an evident trend in precipitation and vegetation cover in the south-north and west-east directions.

Some villages of the province, located mainly in the central and northern parts, are still deprived of water supply network, and they traditionally harvest rainwater from the roofs of their dwellings into a cubic, and sometimes cylindrical, water reservoir locally called Lari. Some villages could be found having traces of rooftop rainwater harvesting even though they have access to main water supply network. Even in some extreme examples, some villagers in the southern part of the province are happy with collecting pure rainwater into small barrels for domestic uses, such as making tea and cooking. Location of the villages visited during the study and the cases in which DRWH systems are still in use is provided in Figure 1.

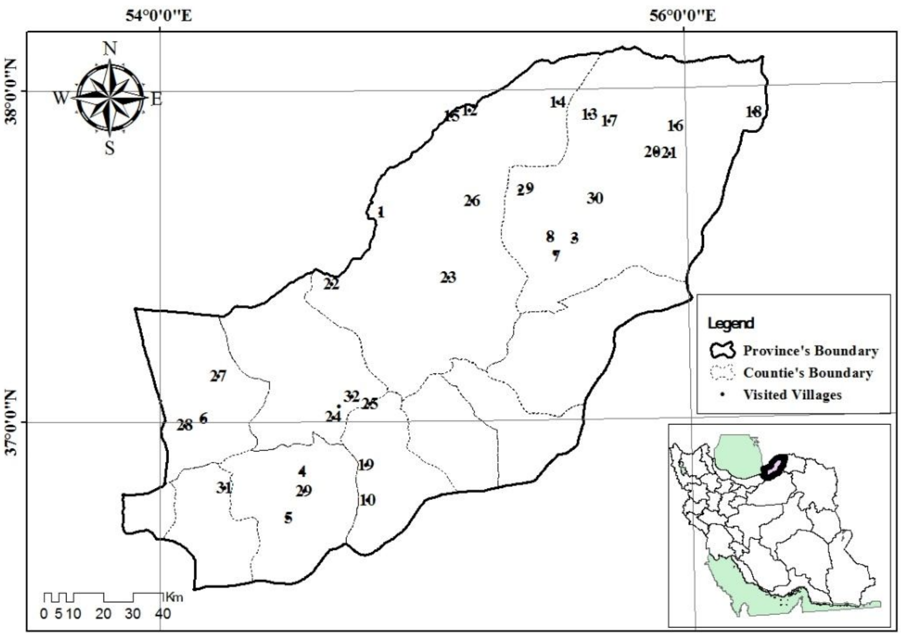

Figure 1. Location of villages surveyed in the current study based on being adopters and non-adopters of DRWH systems.

Table 1. Names and numerical identifiers of the villages in Figure 1

FID	Name	FID	Name	FID	Name
0	Dashli Boroun	11	Qelaq Burteh	22	Cheper Ghoymeh
1	Ughchi Bozorg	12	Qarahgol Sharghi	23	Kord
2	Sheikh La	13	Korand	24	Bahalke Dashli
3	Jelin	14	Kollijeh	25	Aq Band
4	Ziarat	15	Ghar Qijigh	26	Kelleh Post
5	Basir Abad	16	Hemat Abad	27	Khaje Nafas
6	Tamar Ghaghoozi	17	Ghazan Ghayeh	28	Nowmal
7	Yali Bodagh	18	Mohammad Abad	29	Aq Chatal
8	Gachisoo	19	Baba Shemlek	30	Eslam Abad
9	Mahian	20	Chenaran	31	Gerey Davaji
10	Uch Tappeh	21	Tengli		

2.2. Theoretical background

Diffusion of innovations is a theory that seeks to explain how, why, and at what rate new ideas and technologies spread through cultures. In this theory, innovation-decision process is the process through which an individual passes 1) from the first knowledge of an innovation 2) to forming an attitude toward the innovation, 3) to a decision to adopt or reject, 4) to implementation of the new idea, and 5) to confirmation of this decision. This process consists of a series of actions and choices over time through which an individual evaluate a new idea and decides whether or not to incorporate the innovation into ongoing practice (Rogers 2010). Rogers and Shoemaker (1983) believe potential adopters evaluate an innovation on the basis of five attributes. This evaluation includes its relative advantage (the perceived efficiencies gained by the innovation relative to current tools or procedures), its compatibility with the pre-existing system, its complexity or difficulty to learn, its trialability or testability, its potential for reinvention (using the tool for initially unintended purposes), and its observed effects.

However, dwelling on the innovation-decision process of Rogers (2010), the most influential of existing instruments is that developed by Moore and Benbasat (1991). In the study entitle" Development of an instrument to measure the perceptions of adopting an information technology innovation", they concluded eight dimensions in accounting for how the attributes of an innovation contribute to the proliferation of its adoption. The term 'voluntariness' refers to the degree to which the use of the adoption is perceived as being voluntary. 'Relative advantage' means the degree to which the use of the adoption is a benefit in one's job. 'Image' denotes the degree to which the use of the adoption enhances one's image or status within the organization. The term 'compatibility' means the degree to which use of the adoption is compatible with, or requires change, in one's job. 'Ease of use' is used to refer to the degree to which the adoption is easy to learn and use. 'Result demonstrability' complies the confidence with which the effect of adoption may be communicated. 'Visibility' can be defined as the ability to observe the impact of the adoption elsewhere. 'Triability' tries to reflect the degree to which it is possible to try using the adoption. White (2009) by integrating three approaches of diffusion of innovations, environmental modernization and that of Moore and Benbasat (1991), provided a comprehensive set of criteria and indicators for the assessment of the adoption of domestic rainwater harvesting. The scales and definitions are shortly provided in Table 2.

Table 2.Integration of ecological modernization and diffusion of innovation constructs. After White (2009)

Construct	Summary Description
Cost and Economy	The cost benefit of an innovation influences its adoption, with lower initial outlay and conducive to adoption and ongoing financial benefit conducive to continuity.
Environment	Environmental awareness facilitates adoption of pro-environmental technologies and behaviors so that households ceteris paribus, seek to reduce their ecological footprint
Governance and regulation	Pro-environmental policy initiatives including mandates and rebates indirectly facilitate RH adoption
System Sophistication	RH systems vary in their capabilities and end-use. It is appropriate to discriminate among RH system sophistical.
Technological innovation	Innovation of RH system component technologies facilitates adoption by providing access to better (more efficient and effective) technologies.
Community	If normative societal values support an innovation it is more likely to be adopted. The value attached by the household to societal system norms is also considered.
Compatibility	Innovations that are compatible with the physical parameters and values of the household are more likely to be adopted.
Ease of use	Difficulties experienced or perceived in understanding, installing, use and maintenance of RH inhibit its adoption.
Experience	Past experience and/or the ability to trial and innovation facilitates adoption.
Image	Many adoptions of innovations are facilitated by a status or other image component.
Independence	One of the principle advantages gained by household RH installation is at least partial independence from the mains water supply. This has volumetric and temporal dimensions.
Relative advantage	The perceived advantages conferred by adoption of RH directly facilitate household adoption. This construct has been modified to concern RH relative to other water supply technologies.
Visibility	Visible innovations are more likely to be adopted than those that are unseen.
Voluntariness	Objective and subjective freedoms in making the adoption decision influence adoption and continuity

2.3. Variable selection

The description of the dependent and explanatory variables and hypothesis are given in Table 3. The profile of respondents of this study is provided in Table 4.

2.3.1 Dependent variable

Adoption (as the dependent variable) is defined in terms of a binary variable, taking either 0 (those who have not adopted the DRWHs) or 1 (those who have adopted, and are still utilizing DRWHs).

2.3.2 Explanatory variables

In this study, according to the methodology provided by Rogers (1983), Moore and Benbasat (1991), and White (2009) eight factors were considered; yet, with analogous definitions. These factors included cost and economy, environmental conservation, law and regulations, social effects, compatibility with daily requirements, triability (ability to experience water harvesting directly), image (reflectance of the person's decision in the eyes of the public), providence, and risk preference. Providence is broadly defined as how the respondents think of themselves to be timely prepared for future eventualities. Risk preference refers to the strength and direction of risk attitudes of the respondents. As argued by Marra*et al.,* (2003), risk, uncertainty and learning play a number of distinct roles in the process of adopting new technologies.

A large and growing body of literature has investigated the role of different explanatory variables on the adoption or rejection of innovations (Sterne *et al.,* 2009; Bekele and Drake 2003; Amsalu and De Graaff, 2007; Jara-Rojas *et al.,* 2012; He *et al.,* 2007; Murgor *et al.* 2013) *inter alia*. The literature was searched for the indicators to be included in the final assessment tool. The elicited indicators were then grouped under their relative dimensions and final adjustments were applied.

Table 3. Description of the variables specified in the empirical binary logistic model

Acronym	No	Description	Type of measure	ES*
		Dependent variable		
Adopt		Whether a household head has adopted or not	Dummy (1 if yes, 0 if no)	
		Explanatory variable		
Age	1	Household head's age	years	-
Education	2	Educational background of the household head	Illiterate 0; Primary; education 1; High school 2; Associate degree 3; Bachelor 4; Master 5	+
Access to water is. (month)	3	Months with interruptions in water access	Number of months per year	+
Acc. Prob.	4	Difficulty in accessing water	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
RWH aware	5	Whether a household head is aware of DRWH or not	Dummy (1 if yes, 0 if no)	+
Const	6	Importance of construction cost in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	-

Main	7	Importance of maintenance cost in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	-
Saving	8	Importance of saving money in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
Acc. Loan	9	Importance of having access to loans and credit in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
R. Return	10	Importance of rate of initial investment’s return in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	-
Env. Pro.	11	Importance of environmental protection in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
Cur. Dro.	12	Importance of recent droughts in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
Fut. Drou.	13	Importance of anticipated droughts in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
R. Qual.	14	Attitude towards rainwater quality	1 not satisfied; 2 not very satisfied; 3 somewhat satisfied; 4 very satisfied; 5 extremely satisfied	+
Dam C.	15	Importance of dam construction and thus environmental degradation in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
G. Sup.	16	Importance of governmental support in decision making	1 unimportant; 2 less important; 3 somewhat important; 4 important; 5 extremely important	+
Trust Ex	17	Trusting extension officers	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Es. G. Or.	18	Effect of existing especial governmental RWH organization	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Acc. Exp.	19	Importance of having access to RWH experts	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Mand	20	Effect of mandating DRWH systems	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Talk. Rain	21	Willingness to communicate about DRWH	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Fam. Eff.	22	Family’s impact on decision making	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Neig. Eff.	23	Neighbor’s impact on decision making	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Frien. Eff.	24	Friends’ impact on decision making	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Coll. Eff.	25	Colleagues’ impact on decision making	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Med. Eff.	26	Media’s impact on decision making	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+

Cont. Adopt.	27	Contacts with the adopters of DRWHs	1 never; 2 seldom; 3 sometimes; 4 very often; 5 always	+
Cur. W. Qu.	28	Current water quality	Dummy (1 if suitable, 0 if impaired)	-
RWH W. S.	29	Attitude towards DRWHs suitability for water scarce situations	1 strongly disagree; 2 disagree; 3 neutral;4 agree; 5 strongly agree	+
RWH Poss.	30	Attitude towards RWH potential in the area	1 strongly disagree; 2 disagree; 3 neutral;4 agree; 5 strongly agree	+
RW Rel.	31	DRWHs stored water reliability for water scarce situations	1 poor; 2 fair; good; very good; excellent	+
Suit. Reg.	32	Attitude towards DRWHs suitability for the region	1 strongly disagree; 2 disagree; 3 neutral;4 agree; 5 strongly agree	+
Hyg. RWH.	33	Attitudes towards stored water health safety	1 strongly disagree; 2 disagree; 3 neutral;4 agree; 5 strongly agree	+
Integ. Issues.	34	Issues integrating water reservoirs into domestic piping	Dummy (1 if yes, 0 if no)	-
Suf. Know.	35	knowledge about DRWHs	1 very little; 2 little; 3 somewhat; 4 much; 5 very much	+
En. Bud.	36	Budget availability for DRWHs construction	1 very little; 2 little; 3 somewhat; 4 much; 5 very much	+
En. Space	37	space availability for DRWHs construction	1 very little; 2 little; 3 somewhat; 4 much; 5 very much	+
S. Comple	38	Attitude towards system complexity	1 very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Indep.	39	Independence gained by using DRWHs	1 very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Eas.	40	DRWHs ease of use	1 very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Cons. Ti.	41	Importance of construction duration	1very little; 2 little; 3 somewhat; 4 much; 5 very much	-
P. Exp.	42	Level of past experience (direct – indirect)	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Dir. Obs.	43	direct observation	1 never; 2 seldom; 3 sometimes; 4 very often; 5 always	+
R. Mo.	44	Willingness to become a role model for others	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Prov. Pride.	45	Provoking a sense of pride by adopting DRWHs	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Cult. Her.	46	Believing DRWHs to be a cultural heritance	1 strongly disagree; 2 disagree; 3 neutral;4 agree; 5 strongly agree	+
Reg. Aest.	47	Impact on regional aesthetics	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
R. P.	48	Attitude toward risk preference	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+
Antic.	49	Attitude toward being futuristic	1very little; 2 little; 3 somewhat; 4 much; 5 very much	+

[*] ES = Expected sign, expected effect on the outcome variable

Table 4. Statistics of variables used in the binary logistic regression

Variable	Mini	Max	Mean	SD	Variable	Mini	Max	Mean	SD
Age	20	65	41.0	11.94	Med. Eff.	1	5	2.43	1.13
Education	0	5	2.03	1.10	Cont. Adopt.	1	5	2.78	1.28
Access to water is. (month)	1	8	4.03	2.04	Cur. W. Qu.	0	1	0.66	0.47
Acc. Prob.	1	5	2.72	1.34	RWH W. S.	1	5	3.21	1.23
RWH aware	0	1	0.68	0.46	RWH Poss.	1	5	3.21	1.05
Const	1	5	3.11	1.04	RW Rel.	1	5	3.41	0.99
Main	1	5	2.99	1.01	Suit. Reg.	1	5	3.26	1.24
Saving	1	5	3.02	1.15	Hyg. RWH.	1	5	3.29	1.27
Acc. Loan	1	5	3.08	1.18	Integ. Issues.	0	1	0.65	0.47
R. Return	1	5	2.82	1.24	Suf. Know.	1	5	3.06	1.24
Env. Pro.	1	5	4.22	0.79	En. Bud.	1	5	2.88	1.05
Cur. Dro.	1	5	2.40	1.09	En. Space	1	5	3.36	1.18
Fut. Drou.	1	5	2.80	1.22	S. Comple	1	5	2.53	1.09
R. Qual.	1	5	2.76	1.23	Indep.	1	5	2.92	1.13
Dam C.	1	5	2.99	1.01	Eas.	1	5	2.89	1.09
G. Sup.	1	5	3.22	1.17	Cons. Ti.	1	4	2.33	1.00
Trust Ex	1	5	2.48	1.02	P. Exp.	1	5	2.77	1.40
Es. G. Or.	1	5	2.72	1.13	Dir. Obs.	1	5	2.71	1.29
Acc. Exp.	1	5	2.73	1.21	R. Mo.	1	5	2.5	1.25
Mand	1	5	3.41	1.10	Prov. Pride.	1	5	2.46	1.24
Talk. Rain	1	5	2.87	1.06	Cult. Her.	1	5	2.19	1.13
Fam. Eff.	1	5	3.12	1.03	Reg. Aest.	1	5	2.24	1.17
Neig. Eff.	1	5	3.2	0.99	R. P.	1	5	4.01	0.32
Frien. Eff.	1	5	3.14	0.94	Antic.	1	5	3.57	0.25
Coll. Eff.	1	5	2.91	1.13					

2.4 Modelling DRWHs adoption

In statistics, logistic regression is a regression model where dependent variable is categorical, but the predictors may be categorical and/or continuous. Logistic regression has been widely applied in adoption studies (He *et al.,* 2007; Aladenola and Adeboye, 2010; Amsalu and De Graaff, 2007; Bekele and Drake, 2003). Logistic regression is divided into binary logistic regression and multinomial logistic regression. In binary logistic regression analysis, the same logics as multiple regression is held, but the outcome variable is categorical and binary. Equation 1 shows the formula for multiple regressions.

$$\hat{Y} = B_0 + \sum(B_k X_k) \qquad (1)$$

Where, $\hat{Y}$ represents predicted value n the outcome variable Y, B_0 predicted value on Y when all X=0, X_k predictor variable, B_k the unstandardized regression coefficients, and k the number of predictor variables. By substituting $\hat{Y}$ in eq. 2 with $\ln(\hat{Y}/1-\hat{Y})$, the multiple regression formula is adjusted for binary outcomes. Taking the natural log of the outcome variable satisfy the need that predicted score must fall between zero and one.

$$ln(\hat{Y}/1-\hat{Y}) = B_0 + \sum(B_k X_k) \quad (2)$$

The probability of the outcome could be thought of as the odds of the outcome, or odds ratio. Odds ratio is calculated as:

$$Odds = P(\hat{Y})/1 - P(\hat{Y}) \quad (3)$$

The natural log of the odds ratio is called log-odds, which is abbreviated as logit. Logit actually implies the magnitude of change in the outcome variable based on one unite increase in the predictor variable. Logit is calculated as follows:

$$Logit = ln(P(\hat{Y})/1 - P(\hat{Y})) \quad (4)$$

In terms of binary logistic regression analysis in this study, the respondent's behavior towards DRWHs is described by the following equations.

$$Prob(event) = Prob(Y, 1\ represents\ i^{th} respondent\ adopted, and\ 0, otherwise)(5)$$

3. Results

3.1. Model validity

The coefficients of the binary logistic regression model were estimated by maximum likelihood method using SPSS 22. As can be seen in Table 5, the model is correctly classifying 68.3% of the cases. Moreover, the Hosmer and Lemeshow Goodness-of-Fit test with the p-value 0.97 computed from the Chi-square distribution and 8 d.f. shows that there is difference between the observed and predicted values of the dependent variable, implying that the model's estimates very well fit the data at an acceptable level (He *et al.,* 2007). In the interpretation of the logistic regression analysis, R2 values are the most readily understood since if multiplied by 100, they indicate the percentage of variance accounted by the model. Since the R2 value in Table 5 is sufficiently large (91.2% of the variance), the model's performance is considered satisfactory (Foster *et al.,* 2006). In terms of log-likelihood, 74.94 is considered low enough compared with the initial value of 473.2 which shows better performance of the new model.

Table 5. The results of the binary logistic regression model

Step	X^2	*df*	*Sig.*	*Classification*	*Cox and Snell*	*Nagelkerke R*	*-2Log*
5	398.272	5	0.000	68.3	0.650	0.912	74.94

The column EXP(B) in Table 6, shows the logit values which are predicted changes in odds for a unit increase in the corresponding explanatory variable. In sum, five variables in the model were significant in explaining DRWHs adoption in Golestan, as given in eq.6:

$$ln\left(\frac{P(\hat{Y})}{1-P(\hat{Y})}\right) = -20.42 + (10.57 \times Accesstowatermonth) + (2.168 \times Es.G.Or) - (0.122 \times Integ.Issues) + (2.697 \times P.Exp.) + (4.080 \times Dir.Obs) \quad (6)$$

Table 6. Parameter estimates of the binary logistic regression model for factors influencing adoption of DRWHs in Golestan

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 5	Access to water month	2.358	0.443	28.322	1	0.000	10.570
	Es. G. Or	0.774	0.305	6.427	1	0.011	2.168
	Integ. Issues	-2.104	0.670	9.869	1	0.002	0.122
	P. Exp	0.992	0.340	8.500	1	0.004	2.697
	Dir. Obs	1.406	0.382	13.578	1	0.000	4.080
	Constant	-20.427	3.391	36.286	1	0.000	0.000

4.1 Discussion and conclusions

4.1.1 Interpretation of the factors

a) Access to water

Access to water was measured in terms of the number of months with household's restricted access to clean potable water. As Table 3 shows, it was expected that restricted access to have a positive impact on the motivation of households to adopt DRWHs. This hypothesis is accepted by the positive sign of its corresponding logit value. As given in Table 6, one unit increase in the number of months with restricted access to clean potable water (which is mainly provided in the form of water distribution networks or transporting tankers) could increase the chance of households accepting to adopt and use DRWHs ten folds. Lack of access to water is a factor in ongoing poverty for numerous reasons. First, poor families are often forced to purchase water from more expensive sources including water tankers. Poor families are also forced to spend their time and energy collecting water from distant locations (Gleick *et al.,* 2013). In this study, it is clearly identified that lack of access to clean water has had primary implications in the process of adopting DRWHs. Several research projects indicate that DRWHs can provide disadvantage groups with access to water, thereby ensuring food security of the rural population at the household level (Kahinda and Taigbenu, 2011). White (2009) also believes that lack of access to safe drinking water might play a facilitating role in the adoption of other water provision technologies like DRWHs.

b) Specialized governmental authority

Respondents were inquired on the importance of the existence of specialized governmental organizations, regulations, and laws in advancing the adoption of DRWHs. As given in Table 6, one unit increase in the level of importance of specialized governmental organization, reported by the interviewees, may result in 2.1 times more adoption rate in Golestan Province. The expected effect of this factor on the total adoption was considered positive in Table 3, which is hereby proved. Receiving extension services, rebates, funds, equipment and materials from government extension services tend to intensify adoption of different innovative technologies, such as DRWH (Mazvimavi and Twomlow, 2009). Shikur and Besha (2013) reported that 90% of their DRWHs adopters had delivered highly subsidized plastic sheet for rainwater harvesting practice from the governmental and non-governmental sources. This emphasizes the role of government as an easing factor in the process of adoption. Nonetheless, the governmental role could be more pronounced through a specialized governmental organization, as a majority of the respondents (both adopters and non-adopters) stated the effect of this factor on their decision to use DRWHs. This role might be played through the provision of fund, consultation and material to the potential users, or through the provision of drinking water safety measures (such as providing chlorine stock solutions for water treatment or offering consultations) and material to the users of such systems.

c) Integration issues

This factor indicates potential issues experienced in the process of integrating water reservoirs into domestic distribution system. Currently in Golestan, rain water harvesting is mainly conducted via the collection of rooftop runoff and the delivery of harvested water through a very simple piping line to simple underground reservoirs, locally called Lari. The harvested water then is carried to the place of need by hand or simple water pumps connected to a separate pipe. Main water distribution delivers water to most houses through a separate piping line which makes it difficult for both adopters and non-adopters of the DRWHs to integrate the two water sources. Rainwater harvesting system installation can pose challenges to physical compatibility with the existing household in terms of space and siting constraints for tank storages, and for integration with internal fixtures. This study indicated that this integration could negatively affect adoption of DRWHs in Golestan Province (Table 6) (White, 2009).

d) Previous experience

It was hypothesized that past experience of the adopters and non-adopters could facilitate the adoption of DRWHs. Compatibility is a primary mediating factor influencing the adoption of DRWHs. As Rogers and Shoemaker (1983) have stated, compatibility is broadly conceptualized as the degree to which an innovation is perceived as consistent with the existing values, previous experience, and needs of potential adopters. This study has indicated that one unit increase in the level of person’s previous experience could positively intensify the chance that the person adopts the innovation by 2.6 times. White (2009), by studying the factors influencing the adoption of domestic rainwater tanks in Australia, has demonstrated that past experience makes a significant difference between adopters and non-adopters of DRWHs. It was believed for the past experience factor to have positive impact on the adoption and results state the hypothesis as true.

e) Direct Observation

To Rogers (2010), visibility is the degree to which an innovation is visible during its diffusion through a user community. Moore and Benbasat (1991) define result demonstrability as the degree to which the benefit and utility of an innovation are readily apparent to the potential adopter. These two constructs were integrated in this study into the direct observation scale. As provided in Table 6, direct observation (which is closely, but not necessarily, related to the past experience scale), could escalate adoption ratio by four times. Results of this study showed that, individuals who have directly seen or indirectly heard about the benefits and potential of DRWHs, have higher chances of acceptance and continued use of these systems. White (2009) has clearly stated the significant difference between adopters and non-adopters for the overall impact of visibility on the DRWHs adoption decisions.

5. Implications

This study tried to explore the factors contributing to the enhancement of DRWHs adoption and use in Golestan, Iran. As stated by the interviewees and experts in this province, domestic rainwater harvesting holds promise for the obviation of the need for costly water provision measures and for the remediation of water scarcity in this region. Major climate change has been experienced in this region by local people (personal communication) and it seems that extension of rainwater harvesting and other similar water harvesting techniques could result in a remarkable reduction in the costs of water provision and could help improve food security of the local households. However, rate of adopting and/or continued use of these systems have diminished significantly in Golestan and a determined will is required to help this technique stand on its foot or even prosper. To this end and to help extension programs in achieving their goals, this study proposes channeling the focus on five primary factors. Among these factors, difficulty in accessing safe drinking water has resulted from the harsh natural climatic conditions of the area for which nothing can be done except introduction of water conservation techniques. Other four factors include specialized governmental sectors, integration issues, past experience and direct observation. The government through the provision of expertise and financial support could improve the level of rainwater harvesting adoption. Moreover, this organization of institution could provide modern and durable parts for the system to enhance its performance and appearance. Yet, the role of government in this field and the subsequent public perception is still in question and requires further studies since the lack of trust in governmental organizations and officers could neutralize investments and efforts. On the other hand, lack of experience and less frequent contact with these systems has resulted in such a low level of DRWHs adoption. It appears mass media (TV, radio, extension programs etc.) and non-governmental organizations could significantly help improve these two factors. Given the originally and culturally diverse statistical population of this study and extensive areal coverage, the findings may be generalized to other parts of the country as well.

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