Domestic rainwater harvesting, a potential tool for socio-economic development in salinity affected coastal Bangladesh

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Abstract- Salinity intrusion is causing acute drinking water crisis in Southern and coastal part of Bangladesh. During dry season major portion of rural people use pond water for drinking which is unhygienic and also becoming saline gradually. This problem has been even more severe since the cyclone SIDR in 2008. Rainwater harvesting is a laboratory proven sustainable drinking water supply solution. Taking Paikgacha Upazilla in Sathkhira district of coastal Bangladesh the study seeks to analyze the way how rain water harvesting can accelerate the access of coastal people to safe drinking water and to what extent they have willingness to accept and pay for the service. After assessing the current condition of access to drinking water, the opinion of rural people about their willingness to install domestic rain water harvesting system in their houses has been assessed. It has been found that more the 50% of respondents drink the water collected from pond and a good number from the rest buy it from sources outside the village at taka three per liter. This research has revealed that major portion of the rural people has willingness to pay at least two taka per liter; higher income people are even willing to pay taka five for the same. Plus, a section of people have expressed their willingness to take this as a small social entrepreneurship opportunity. They are willing to install rainwater harvesting plant for their own and have expressed their willingness to sell the extra water to their neighbor at the price at which they buy and fetch water from sources outside the village.

Index Terms- Domestic Rainwater harvesting, Social entrepreneurship, Salinity.

I. Introduction

1.1 Background of the study

In the southern part of Bangladesh especially Paikgacha, Shatkhira, Khulna etc. are facing an acute scarcity of safe drinking water due to the adjacency of the Bay of Bengal. This problem has been even more severe after the dreadful attack of SIDR (Coastal Cyclone, attacked in the year 2008). During dry season rural people have no way other than drinking pond, ditch water which is unhygienic and getting saline continuously.

Now-a-days the idea of rain water harvesting system has gained popularity all over the world. So the initialization of rain water harvesting system in these affected areas is necessary to minimize the problem of water scarcity. The objective of the study is to supply rain water in the affected areas after the rainy season when water problems is acute. So the opinion of rural people about their willingness to install the system in their house is assessed.

II. Review of Literature & Case Studies

2.1. Concept of Rainwater Harvesting: Rainwater is an open source of pure drinking water and rainwater harvesting refers to collection and storage of rainwater and other activities aimed at harvesting surface and ground water. It also includes prevention of losses through evaporation and seepage and all other hydrological and engineering interventions and efficient utilization of the limited water endowment of physiographic unit such as watershed (S.Vishwanath, n.d.). The rainwater can be stored for direct use or can be recharged.

2.2 Rain water harvesting project in different countries

2.2.1 Rain water harvesting in Rajasthan, India: Akash Ganga Rain water harvesting, Rajasthan, India has been a successful project mitigating water crisis problem had been faced by a lot of people in the past years. During the dry season, households have to buy water from water vendors at a cost of $2 per camel cart (which on the average is the minimum daily consumption of a family). With support from Akash Ganga, families now have a secure supply source of drinking water enough for 10-12 months of the year. The Akash Ganga project was selected as one of 30 winning proposals from more than 2,600 applicants for the 2006 competition. The big boost to the project came in 2006, when Akash Ganga won the World Bank's Development Marketplace Award. A $200,000 grant allowed the project to expand operations to other villages. (Anon., 2009)

The project has the capacity to collect and store rainwater (with average rainfall) sufficient for an entire year. Each village needed an investment of $100,000. The materials account for 60% to 65% of the total costs and labor expenses constitute 20% to 25%. Some 10% to 15% is absorbed by general and administrative costs. According to the extension proposal, the government will contribute 70% of the funds. The community will pay 15% and the other 15% will be raised from private sources. Revenues will be generated from the fees charged to the villagers for water, and horticulture. A total of 119 household tanks were constructed in three villages in the Alwar district in Rajasthan and an intermediate tank and a recharge well were built. The network stores rainwater sufficient to meet the drinking water needs of these villages. As a community-driven initiative, the project was very careful in its design to develop a scheme that was culturally appropriate and attentive to important issues surrounding social caste, class and gender. (Anon., 2009)

2.2.2 Rain water harvesting in Uganda

Water crisis problem is very severe in Africa especially in Uganda. The field studies confirmed that there is a widespread latent demand for low-cost water storage, especially in Africa, where people are paying US $18- $30 for a 200 liter barrel to store water at the household level. EW (Enterprise Works) contracted an international promotion firm Saatchi & Saatchi to develop a promotional campaign highlighting the advantages of *bob* in posters, billboards, brochures, wall paintings and through radio shows. The campaign combines promotional and educational themes to inform potential clients and stimulate demand. In order to understand how price affects the uptake for the product and the impact at the household level, EW is partnering with Innovations for Poverty Action to conduct an in-depth study. A baseline survey has been undertaken in 3,240 households across 81villages in one district in Uganda. The partnerships formed at the start of the project, and a strong communication strategy ensures that information reaches key organizations (private enterprises, non-governmental organizations, governments, donors, and other interested parties). This project can directly contribute to poverty reduction by improving access to safe water in the home, relieving women and children from the drudgery of fetching water, while improving health and the quality of life of household members. Moreover, reduced medical expenses will directly increase the disposable income in the household.(Naugle, 2011)

III. Study Area Profile & Methodology

3.1.Study Area Profile:

Name of the study Area: Goroykhali of Paikgacha Upazila, Khulna district

Annual Rainfall: 1710m.m.(UNICEF, 2014)

Salinity level: 1000 ppm. (Hasan, 2012)

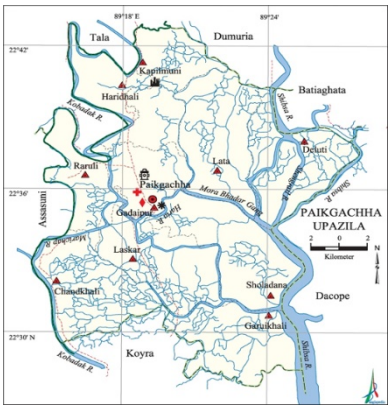


Fig 3.1: Map of Paikgacha Upazilla Source:Banglapedia,n.d.

3.2 Methodology

3.2.1. Selection of Study Area:

Analyzing the opinions of the experts of ITN (BUET) and various information's about geography and salinity problems of the coastal areas,Garaikhali village ofPaikgachchaUpazilla under Khulna district has been selected as our study area.

3.2.2. Selection of target group:

The researchers have selected local village people as the target group.

3.2.3. Reconnaissance Survey

Reconnaissance survey has been conducted to gain the general impression regarding the study area and the people of the study area.

3.2.4. Pilot Survey:

A pilot survey has been conducted on every household to get our necessary information.

3.2.5. Correction of Questionnaire:

Some corrections has been made in the questionnaire after pilot survey on this day.

3.2.6. Final Survey*:*After the correction of questionnaire, final survey has been conducted.

3.2.7. Data Collection

3.2.7.1 Primary Data Collection: The primary data has been collected through questionnaire survey. This data will be collected through following steps-

Sample Selection: The population of village around 15000. Simple random sampling method has been used.The following formulas have been used for sample calculation

$$x=Z(c/100)2r\ (100-r)\ n=N\ x/\ ((N-1)\ E2\ ;$$
$$E=Sqrt[(N-n)x/n(N-1)];$$ Source: (Anon., n.d.)

The researchers have applied a random sample of 30 household surveys which will help to understand the acceptability and participation of the whole village people in the project.

Collected Data type: The researchers have collected informative data such as project participation, willingness to invest on the project, water scarcity problem, source of pure drinking water, type of rooftop area etc. through household survey.

3.2.7.2. Secondary Data collection:

Physical features of the study and various demographic, geographic information's and rainfall data has been collected through analyzing various journals, reports..

3.2.7.3. Data Analysis: The analysis of the data will be performed based on primary and secondary data

IV. Data Analysis

4.1-Number of Family member and water consumption rate*:*

From the (Fig: 4.1) it has been found that that quantity of consumption of water increases as family member increases. As a result they have to find several alternative sources of drinking water like pond, tube well, buying from external suppliers and rainwater.

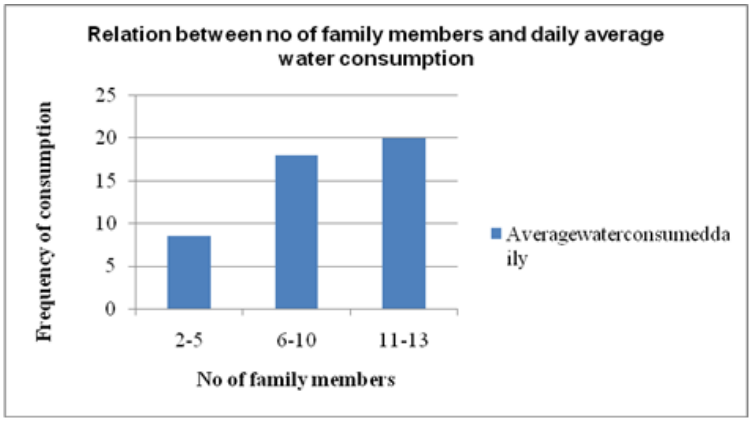


Fig 4.1- Relation between no of family members and daily average water consumption
Source-Field Survey, (2014)

4.2-Sources of drinking water of the study area

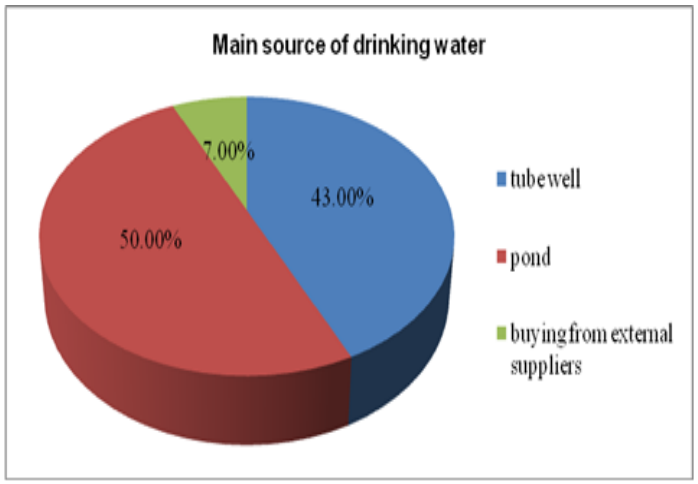


Fig 4.2-Main sources of drinking water
Source-Field Survey, (2014)

The local people collect drinking water from different sources like pond, tube well, buying from external suppliers and rainwater. From the analysis (Fig: 4.2) it has been found that the local people have to depend heavily on the pond as their main source of drinking water.

From the (Fig: 4.3) it has been found that the people prefer buying water from external suppliers as their secondary source of drinking water. These suppliers collect the pond water and sell it to the people in jars. The price of their product is 3 tk per liter.

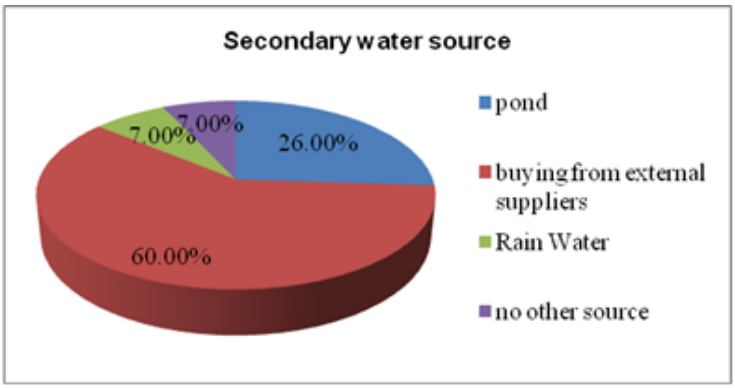


Fig 4.3: Water collection from secondary water source

Source-Field Survey (2014)

4.3-Satisfaction level with the drinking water quality

From the data analysis (Fig: 4.4) it has been found that 93% of the people are not satisfied with the quality of the water they drink.

The water they drink is unhygienic full of debris and some said that there is arsenic in their water.

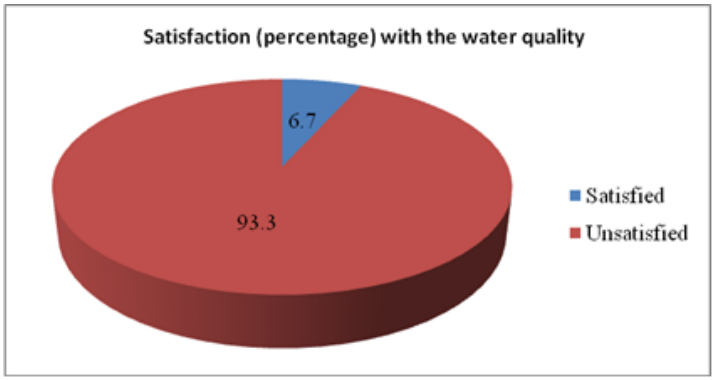


Fig-4.4: Satisfaction level with the water quality Source-Field survey (2014)

4.4-Distance from water collection point and transportation cost

From field survey it has been found that people on an average living 3-5 km away from water collection point use van and other living adjacent to it depends on foot. So the people have to pay additional transportation cost whether they use various mode like van, rickshaws for collecting water or they buy from external suppliers. They have to pay to the external suppliers 2 tk or 3 tk depending on the distance. From the field survey it has been found that the people have to pay a good amount of money as transportation cost for the collection of drinking water. From the (Fig: 4.5) the linear relationship between distance and transportation cost has been shown and it is apparent that the transportation cost is increasing with the distance.

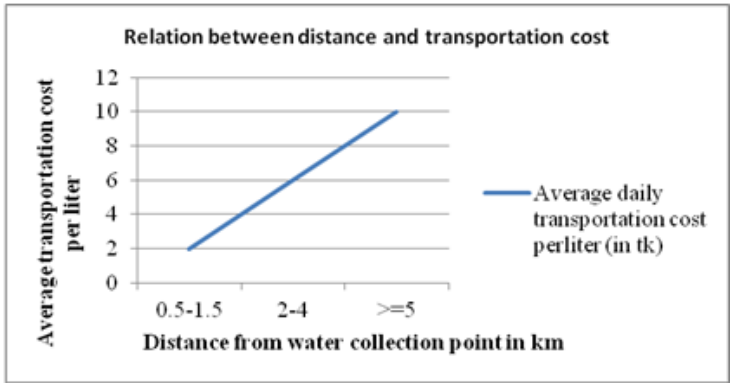


Fig 4.5: Relation between distance and average transportation cost per liter
Source-Field Survey (2014)

4.5: Problems while water collection

The people have to face various problems while collecting water. From the (Fig: 4.6) it has been found that 67% respondent identified time consuming as their major problems.

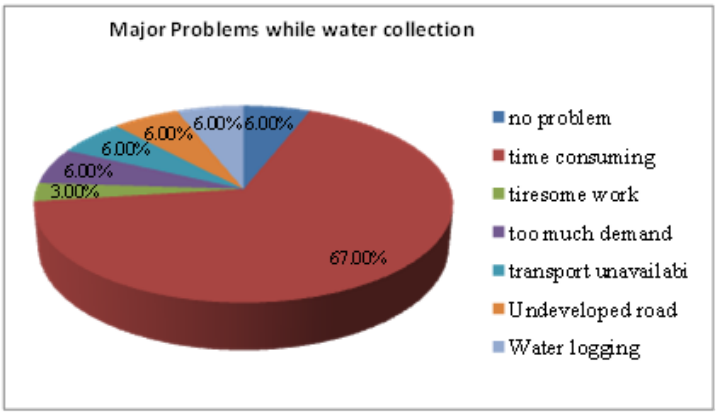


Fig 4.6: Major problems while water collection
Source-Field Survey (2014)

4.6-Total time needed for water collection:

It has been found from the (Fig- 4.7) that time they waste to collect water can be utilized in various productive sectors like fishing, farming, small business etc. If we convert this time in monetary value, it will be observed that they have to spend a good amount of money for water collection.

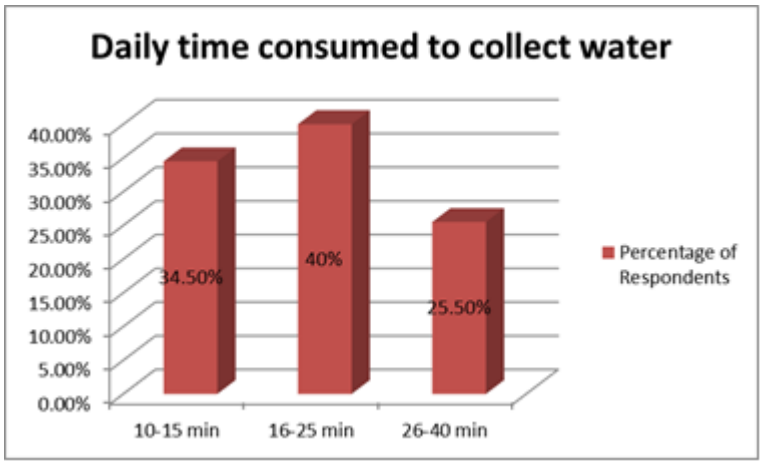


Fig 4.7: Daily time consumption to collect water
Source-Field Survey (2014)

4.7. Monthly income and total cost for drinking water purpose (including transportation cost): From the Fig:4.8 it has been found that people of the study area spend a significant amount of money from their monthly income for drinking water purpose.

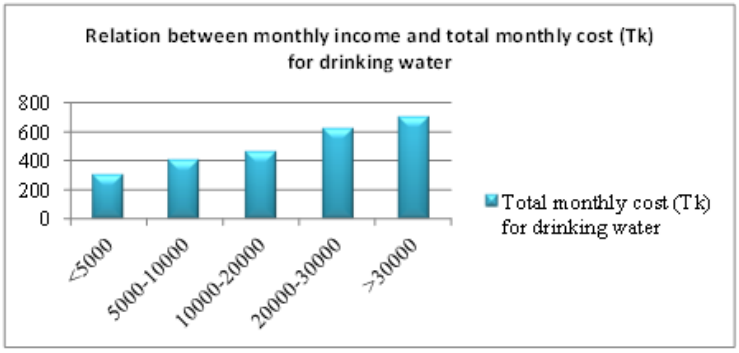


Fig 4.8: Monthly income and total monthly cost for drinking water
Source-Field Survey (2014)

From the (Table-4.1) it has been found that monthly income and total cost for drinking water purpose is positively co-related. People of relatively higher income group spend more in this purpose.

Table 4.1: Statistics measures of income distribution and cost for drinking water

Correlation	Co-efficient of correlation
Pearson's R	.506

Source- Researchers calculation, (2014)

4.8: Educational qualification and willingness to participate in the project: From the (Fig:4.9) it has been found that educated people specially Secondary and above who are conscious about health problems and the need of pure drinking water have agreed to participate in our project.

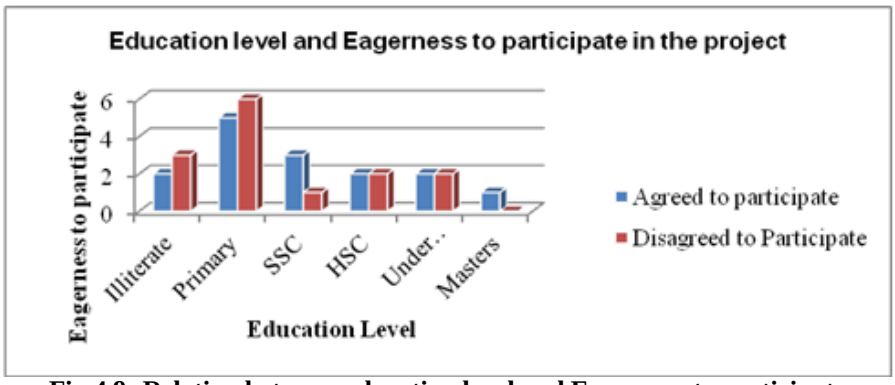
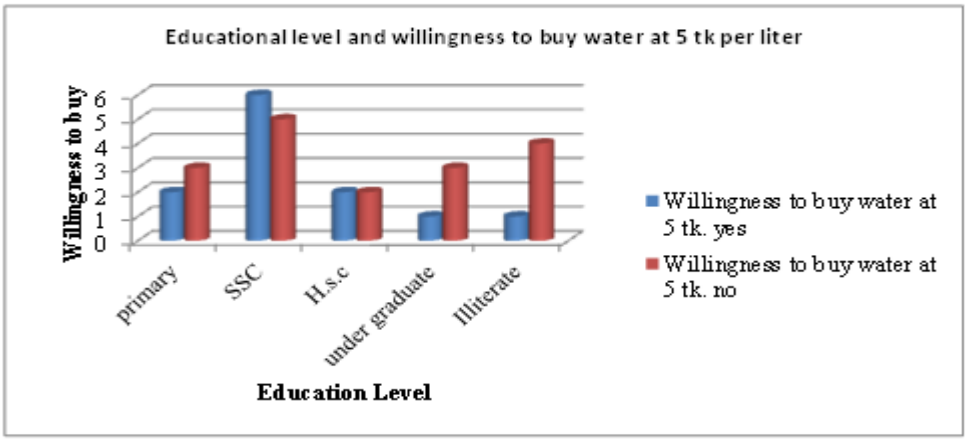


Fig 4.9: Relation between education level and Eagerness to participate
Source-Field Survey (2014)

4.9: Educational qualification and willingness to buy our product at 5 tk per liter: From the (Fig: 4.10) it has been found that majority of people have shown unwillingness to buy water 5 tk per liter.



Source-Field Survey (2014)
Fig 4.10: Educational level and willingness to buy water at 5 tk per liter

4.10: Variability in the level of income of the local people

From the (Table-4.2) and the (Fig-4.11) it has been found that the value of skewness of the income data of the respondents is 0.076.It denotes that the income data is symmetrical. So there is no major disproportion of income group in this area. So the number of different income groups (high, middle and low) are in equal proportion. Again from the below Fig: 4.12, it can be said that the Kurtosis of income data is platykurtic (as negative). Most of the income value is spread from mode income of the income database.

Number of cases (N)	Mean Income	Skewness		Kurtosis	
		Statistic	Std. Error	Statistic	Std. Error
30	16700	0,076	.427	-.118	.833

Table 4.2: Statistical measures of income distribution
Source: Researchers calculation, 2014

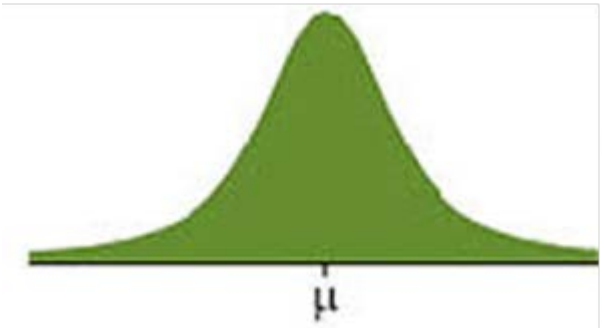


Fig 4.11: Symmetrical Skewness of Income data (Anon., n.d.)

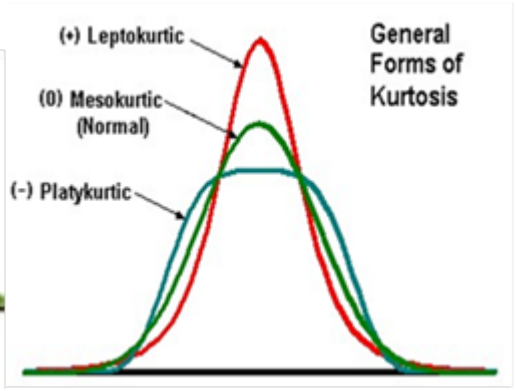


Fig 4.12: Kurtosis of Income data (Anon., 2012)

4.11- Monthly Income and Willingness to participate in our project*:*

From the (Fig 4.13) it has been found that middle income group (10000-20000) has agreed to participate in our project.

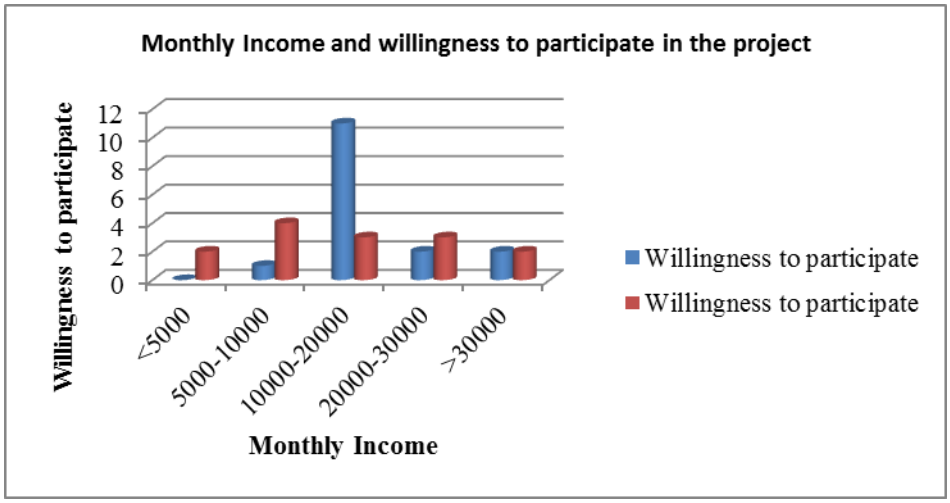


Fig 4.13: Column chart showing monthly income and willingness to participate in the project
Source-Field Survey, 2014

4.12: Hypothesis testing whether people are willing to pay 5 tk per liter

Hypothesis: Most of the respondents willing to pay 5 tk per liter

Alternate hypothesis: Most of the respondents are not willing to pay 5 tk per liter

Level of Significance: .05

From the analysis of one sample t-test it is found that there is mean difference (See table:4.4) between of test hypothesis and actual mean. As the t value is -14.470 (See table:4.4) which is greater than 0.05. So the null hypothesis (Most of the respondents willing to pay 5 tk per liter) is rejected. Again as the "t" value is negative, the calculated mean of the sample is less than the test value (here 5 tk.).

From this it can be concluded that, Most of the respondents are not willing to pay 5 tk per liter. Most of the people are willing to pay 2 tk per liter.

Table 4.3: Statistics for willingness to pay

	N	Mean	Std. Deviation	Std. Error Mean
Willingness to pay	16	2 tk	0.9139	0.2285

Source: Researchers calculation,2014

Table 4.4: One sample "t" test for willingness to pay

Willingness to pay	Test Value = 5 tk		
	t-value	Degree of freedom	Mean difference
	-14.470	15	-3.3063

Source: Researchers calculation, 2014

4.13: Hypothesis testing whether people are willing to share the total implementation cost (5000 tk) of 600 liter tank

Hypothesis: Most of the respondents willing to share the total implementation cost (5000 tk) of 600 liter tank

Alternate hypothesis: Most of the respondents are not willing to share the total implementation cost

Level of Significance: .05

From the analysis of one sample t-test (See Table: 4.6) it is found that there is mean difference between of test hypothesis and actual mean. As the t value is -4.703 which is greater than 0.05. So the null hypothesis is rejected. Again as the "t" value is negative, the calculated mean of the sample is less than the test value (here 3178 tk.). (See Table:4.5)

Table 4.5: Statistics for willingness to share

	N	Mean	Std. Deviation	Std. Error Mean
Willingness to share	14	3178 tk	1449.232	387.324

Source: Researchers calculation, 2014

Table 4.6: One sample "t" test for willingness to share

Willingness to share	Test Value = 5000 tk		
	t-value	Degree of freedom	Mean difference
	-4.703	13	-1821.429

Source: Researchers calculation,2014

4.14: Monthly income and willingness to buy water at 5 tk per liter:

From the Fig: 4.14 it has been found that people of higher income group (20000-30000 & 30000+) are willing to buy our product at 5 tk per liter. Rest of the income group showed unwillingness to buy at this price.

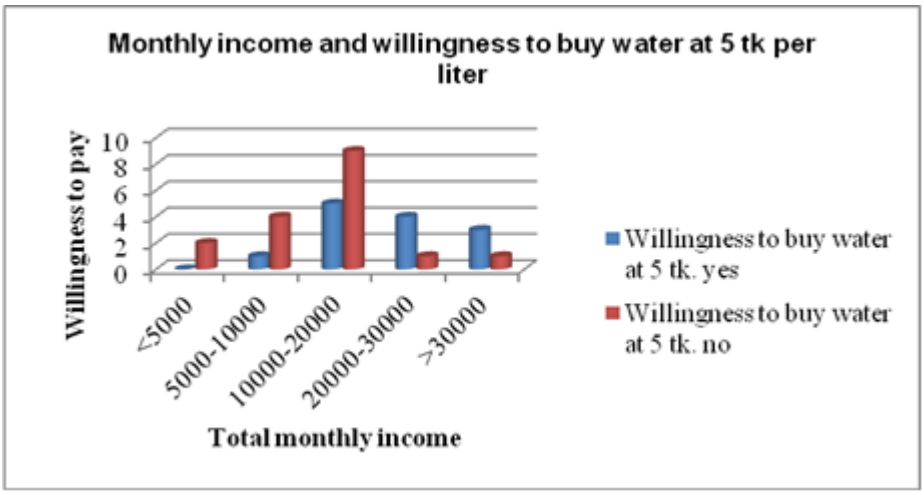


Fig: 4.14: Relation between monthly income and willingness to buy water at 5 tk per liter
Source-Field Survey (2014)

V. Suggestions & Conclusion

Based on field survey and study from the secondary sources, some recommendations are being generated for the successful installation and constant acceleration of the project. They are given below.

- The most prevailing hindrance to this project is lack of consciousness of village people. Effective campaign is recommended to be organized by concerned authorities.
- Government and volunteer organizations have to be convinced to provide adequate financial and institutional support in this regard.
- Incorporating new technologies to minimize initial cost and cost related to purification.
- Proper participation of rural people should be ensured through employment and volunteer activities in the project.

Severe water salinity problem in the coastal area of the country can be better solved through inagurating the idea of rainwater harvesting. The International Water Management Institute (IWMI) estimated that Bangladesh will face economic scarcity of water by 2025. Besides, sea level rise due to climate change phenomenon will further degrade our fresh water resources. This project is a simple triumph to attain that requirement and for further research work it can play a vital role in this regard. Although people are averse to buy water at rated price they expressed their willingness to participate in this project. In future it is hoped that advanced advent of new technology will lower the price to make drinking water within their reach. When participation from all walks of people will be ensured, better continuity will be gained with acceleration. Concerned authorities and NGOs should play a vital role in this regard.

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