Rain water harvesting for drinking in rural area
(A case study on three villages of Paikgacha Thana in Khulna District)

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Rainwater harvesting is an accepted freshwater augmentation technology. While the bacteriological quality of rainwater collected from ground catchments is poor, that from properly maintained rooftop catchment systems, equipped with storage tanks having good covers and taps, is generally suitable for drinking, and frequently meets WHO drinking water standards. Notwithstanding, such water generally is of higher quality than most traditional, and many of improved, water sources found in the developing world. Contrary to popular beliefs, rather than becoming stale with extended storage, rainwater quality often improves as bacteria and pathogens gradually die off .Rooftop catchment, rainwater storage tanks can provide good quality water, clean enough for drinking, as long as the rooftop is clean, impervious, and made from non-toxic materials and located away from over-hanging trees. Rainwater harvesting will make an important contribution to resolving water shortages in the future. For at least three millennia, people across the world have harvested rainwater for household, livestock and agricultural uses, but rainwater harvesting has become more and more neglected since the advent of large centralized water supply systems, in spite of their high energy input and serious environmental problems. Rainwater harvesting can be as simple as a small dam to stop water flooding off a slope or as technically advanced as a reservoir that catch rainwater for drinking and agriculture. It offers a wealth of promising possibilities for the salinity affected areas like coastal region of Bangladesh. In this paper there is outlined the use of rainwater harvesting for drinking and domestic purposes especially in costal region of Bangladesh where there is serious scarcity of pure water exist. The paper also describe the collection, operation and management of harvested of rainwater in Garuikhali Union at Paikgacha Thana, a remote salinity affected area of South-west costal region of Bangladesh. This paper also tried to give some guide lines for modifications of rainwater harvesting system from planning perspective in Garuikhali union.

Key words: *Rainwater Harvesting, South-west Coastal region, Rooftop catchment*

Background: Access to safe water has been recognized as the basic human needs. Significance of safe water has been recognized in the World Summit held at Johannesburg, South Africa in 2002 and later in the 3rd World water Forum held at Kyoto, Japan by mentioning that without safe water; sustainable poverty reduction in the third countries is not possible.

Rain water is an option, which has been adopted in many areas of the world where conventional water supply systems are not available or have failed to meet the needs and expectations of the people. It is a technique of water collection, which has been used since antiquity. Rain water harvesting refers to both large and small scale. A simple affordable, technically feasible and socially acceptable safe drinking water supply system in the geo-hydrological areas (rural/urban) is very much in demand. In this context, rain water harvesting system can be considered as a probable solution of the drinking water problem in the arsenic and salinity affected areas. The rain water is free from arsenic contamination, salinity and other harmful infectious organisms

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and pathogens. Beside this the physical, chemical and bacteriological characteristics of harvested rainwater represent a suitable and acceptable means of potable water.

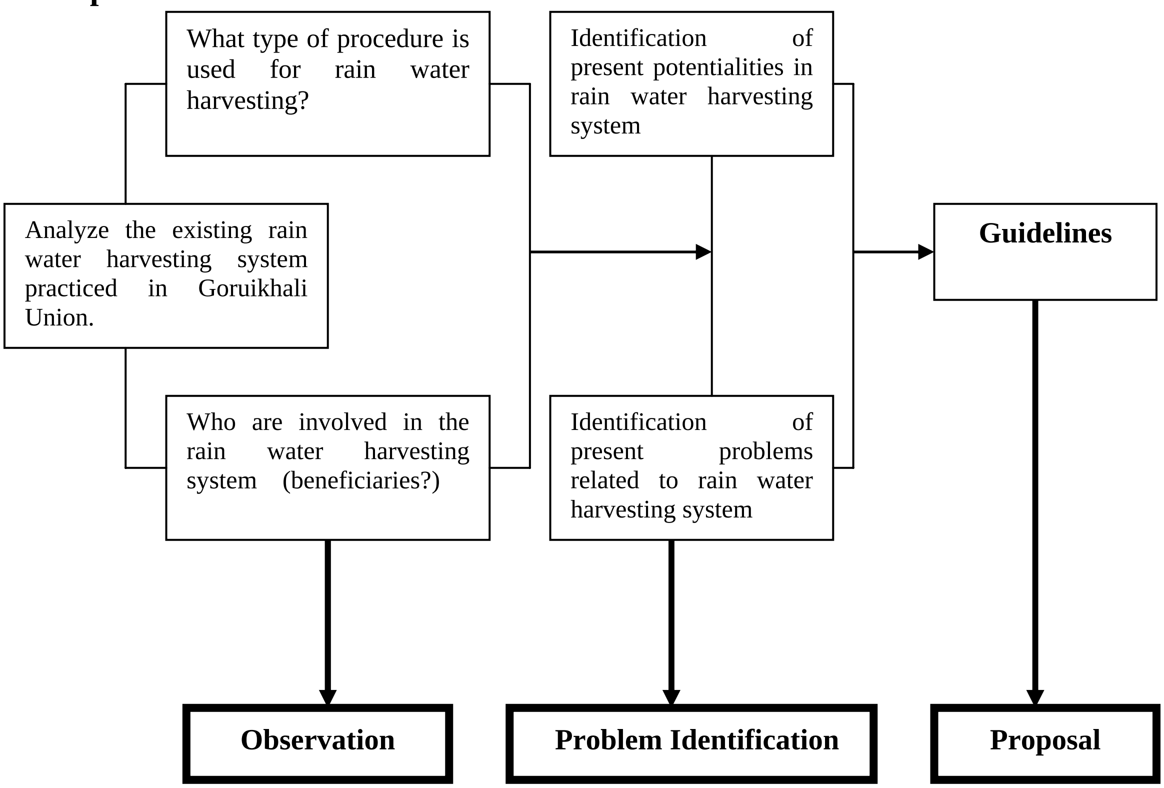
Objective: For the present study the following two objectives have been selected:

- To explore and analyze the existing rain water harvesting system in the study area.
- To suggest some modifications for better rain water harvesting in the study area.

Rain water harvesting system:

Rain Water Harvesting as a method of utilizing rain water for domestic and agricultural use is already widely used throughout the world. It is a method which has been used since ancient times and is increasingly being accepted as a practical method of providing potable water in development projects throughout the world.

Conceptual framework:



Study area (Goruikhali Union):

Paikgacha Thana situated at middle portion of Khulna district and south-western direction of Khulna Metropolitan area. Paikgacha is the smallest Thana of Khulna district in respect of population. Garuikhali union is located on the southern part of Paikgacha. Garuikhali union is one another impending part of Paikgacha Thana. Garuikhali union consists of six villages. Some of them are small and some are large. The study area is situated at the Garuikhali union and located at the northwest part of Garuikhali union. The river Shibsha runs over besides the study area. The embankment of water development authority goes along the northeast boundary of the study area. The study area comprises mainly three villages namely Shanta, Kumkhali and Uttar Fakirabad. The distance between the Garuikhali Growth center and the beginning of the study area is only about 1 km. Population growth rate is high due to intensive illiterate rate of the inhabitant. The male female ratio in the study area is 84.91 and average household size is 6.5.

Method of the study:

The study has been completed through some sequential steps. For selecting the study area, some literatures are reviewed. Garuikhali Union at Paikgacha Thana under Khulna district is taken as the study area because the area has extensive scarcity of pure drinking water and all most family is engaged in rain water collection and consumption.

Under primary data collection reconnaissance survey was performed to gain a perspicacious view of the study area and to understand existing rainwater harvesting system and to realize problems associated with rainwater collection and use. Here all necessary information related to the study was collected from only three villages out of six villages in the Union due to time limitation and nearness among those villages. Some Photographs are taken to visualized existing rainwater collection system. During survey period 3 FGD was completed in the study area in three different villages and the same way case study was taken from these three villages. For the study a semi-structured questionnaire survey was performed to collect information related to rainwater collection, consumption and problems associated them. For this purpose 10% sample was taken from each village out of 3 villages for data collection through sample survey by following way:

Table 1: Sampling Techniques

Village name	**No: of household**	**Samplesize (10% OF TOTAL HH)**
Fakirabad	210	20
Kumkhali	190	20
Shanta	105	10
Total	**505**	**50**

Source: BBS Community Series, 1991

Data from various secondary sources are also used for the successful completion of this study. Rainfall data was collected from Weather Forecasting centre, demographic information of the study area was collected from BBS and location map of the study area was collected from LGED. To enrich the study data from different NGOs were also used. Demand; supply and consumption were calculated followed by the standards of Water Aid Bangladesh and some others information were used in different part of this paper from different organizations. After processing, data were analyzed regarding the objectives of the study and analyses were presented through different maps, photographs, chart, graphs and text. With the help of findings and analysis the final paper is prepared.

Components of rainwater harvesting system and its function: The following figure shows different component of rainwater harvesting system locally used in Bangladesh.

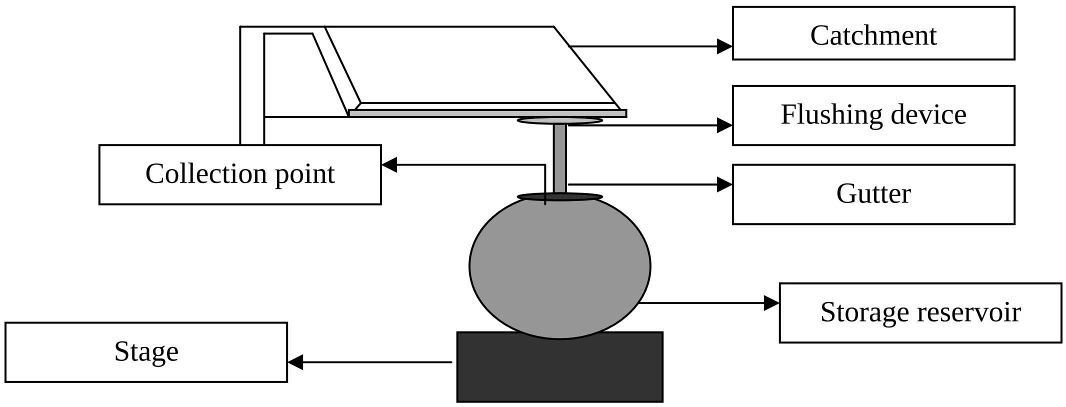


Figure: Different Components of Rainwater Harvesting

Existing different source of water supply: Garuikhali union is located in very remote area of Khulna. It is a matter of regret there is not a single tube-well in this area for water supply. Salinity, water problematic depth of water table and lack of proper initiative to install tube-well is responsible for it. In the study area all most people rain water and pond water for drinking purpose. Rain water is not available around all the year so people also dependent on the pond water for drinking. Beside this about 20% people use river water for domestic and bathing purpose which is large quantity.

Water borne disease and purification practices: People in the study area are not well known with purification practices. The collected rain water may be polluted by dust, dirt, and various types of contaminants which may cause various type of water borne diseases. Due to lack of proper purification practices all most people are suffering by various water borne diseases in each year. In the study area most of the households use rainwater without any purification practices and it is about 66%. About 24% and 8% households purify rainwater by Fitcary mixing and boiling to remove various harmful bacteria and polluting contaminants. Various water borne diseases found here by which suffering the people of the study area due to lack of purified water. Most of the people were suffered by Dysentery and Diahorrea in the last year and it is about 46% and 36% respectively.

Existing designing criteria of RWHS practiced in Garuikhali: Rain water harvesting system offers a good arsenic free alternative drinking water source. A set of criteria may be considered for the selection of the appropriate design of RWHS. The existing harvesting systems of the study area are analyzed according to following design criteria:

Rainfall quantities and pattern: It influences the capacity of the storage reservoir. The total amount of water available to the consumer is a product of the total available rainfall and the collection surface area. The climatic condition varies widely throughout the country. The average annual rainfall amount and pattern shows, the amount of rainfall that could be harvested is mainly occurred from April to October in all above over Bangladesh. The following table presents the rainfall data of last five years. (2000-2005)

Table 2: Annual rainfall of last five years in Goruikhali Union (in mm)

Month	Year wise rainfall (in mm)					
	2000	2001	2002	2003	2004	2005
January	59	00	15	00	00	15
February	114	00	00	00	00	-
March	221	00	14	155	07	148
April	105	15	74	63	85	47
May	156	172	254	124	180	215
June	198	194	800	251	383	103
July	336	426	366	287	253	435
August	276	380	483	255	266	194
September	292	375	357	136	621	363
October	157	169	22	315	182	
November	130	14	169	00	-	
December	00	00	00	22	-	

Source: Weather Forecasting Centre, Khulna, 2005

Daily consumption rate: Consumption per family varies with the no: pf family members and also their water use pattern. For design purpose, average daily water requirement (for cooking and drinking) for a nuclear family (5-6 members) may be taken 30 liter per day (2liter for drinking and 3 liter for cooking per person). The design calculation can also be made with different daily requirement per family.

Number of consumer: The system may design for a nuclear family consisting 5-6 members or the as per the actual number of the family member of the house. It is fact that the demand of water naturally increase with the increase of family members. It is found from the survey that each person consumes each day about 10 liters of water both for drinking and cooking. Here all most family consists of 5-6 members and such kinds of 78% family consume about 30 liters of water per day for drinking purposes.

Storage capacity (Liter): Major cost involvement in RWHS is the storage reservoir. It depends on the no: of family members and consumption pattern.It is found in the study area that only 2% household can harvest rainwater for above 9 month with the storage capacity of above 4000 liters. About 46% household can harvest for 3-5 month and here 28% households have the storage capacity among 3000-4000 liters. Beside this 32% household can harvest about rainwater for 5-7 month, in which 28% households have the storage capacity of 3000-4000 liters.

Construction material: Locally available material like brick, concrete ring, Ferro-cement, earthen motka etc may be used for construction of rainwater storage tank.

Catchment: Suitable catchment may also reduce the cost of construction. CI sheet roof, tile roof, thatched roof covered with polythene may be selected as catchment. CI sheet made shade or plastic sheet or clean cloths may also be considered in case of unavailability of suitable rooftop.

Guttering: Locally available material, durable, cost, ease of installation and available skilled mason etc may be considered during selecting material as gutter. The following material may be used for gutter: GI sheet, PVC pipe and split bamboo.

Flushing system: The design of flushing system is very significant to divert the first foul rainwater entering into the storage reservoir. The main considerations are to use locally available materials and ease of installation, easy operation, maintenance and durability.

Water collection point: The main considerations are to ensure maximum use of stored water, ease of collection, cost and reducing risk of accidental losses, hygiene purposes and drainage of water.

About 18, 16 and 14 households among the sample use cloth, straw/Golpata roof and polythene as catchment. Only two household have CI sheet roof which they used as catchment. Here locally available materials are using for gutter all most. About 38% and 32% households use bamboo and rope two locally available materials for guttering which is highest amount. About only 12% people use modern PVC pipe for guttering. Here there is no modern practice of using flush device to remove the first flush from the rain water. About 24% households use locally available earthen pot for collection point to reduce the wastage of water. Most of the people in these areas are poor and they can not involve cost for modern storage tank. About 41 households use earthen Motka as storage tank. Only two households has Pucca tank in which they can collect more rainwater than others.

Cost: The aim of RWHS is to develop low cost and affordable reservoir. In the study area all most RWHS is based on low cost materials due to relatively poorer condition of the villagers.

Stage construction: Required size of tank may consider for nuclear family and may also use those. Extra tank may build if money is available to ensure high level services.

In RWHS the major cost involvement require the cost of storage reservoir. In the study are maximum households use earthen motka as reservoir and install cost among 500-1000 and this scenario is real for 82% household. Abut only 3 households install cost more than 15oo taka and these households have either Pucca tank or plastic tank for storage.

Operation and maintenance: The sustainability of a technology depends upon proper O&M. so ease of operation & user's friendliness should be taken in to consideration during design. Maintenance is generally limited to the annual cleaning of the tank and regular inspection of the gutters and down-pipes. Maintenance typically consists of the removal of dirt, leaves and other accumulated materials. Such cleaning should take place annually before the start of the major rainfall season. However, cracks in the storage tanks can create major problems and should be repaired immediately. In the case of ground and rock catchments, additional care is required to avoid damage and contamination by people and animals, and proper fencing is required.

Social aspect: Social acceptability of the user can be considered, use and management of stored water, women involvement and security (in wet and dry season) in comparison to other sources.

Economic aspect: It includes Investment cost , O&M cost, Minimum investment cost for getting rainwater collection benefit & tank size versus cost & affordability & rainfall pattern and quantity.

Women played an important role in RWHS and they have been the ones who had to provide and manage the water use of households. Therefore they want and need to be included in everything that relates to improving the water supply. On a local scale, women are the water managers, responsible for its collection and distribution

Table: 3: Cost installment and Participation for O&M according to different household

EVENT	FREQUENCY		COST INVOLVEMENT (TAKA PER YEAR) FOR O&M			
	male	female	below 100	100-200	200-300	above 300
Operation	8	42	23	3	1	-
Maintenance	13	37	31	2	3	1

Source: Field Survey, 2005

It is shown from table that 88% female engaged in operation of rainwater harvesting like collection, purification, and consumption etc where as male participation is only 16%. For operation activities of RWHS people spend a little amount of money and a major portion of people do not think the necessity of such expenditure. Only 23 households spend money and that amount is below 100 taka. On the other hand like operation activities in maintenance activities maximum involvement is found for women and it is 74%. The maintenance scenario is same like operation and here about 31 households install like expenditure and it is also below 100 taka.

Total cost analysis of the existing system: At present major cost involvement is found for the storage reservoir. Here Motka (mud jar) is used for water storage. It is assumed for the cost estimation that earthen Motka might be used at least five years without any chemicals contamination. At the same time operation and maintenance cost is also added to estimate the total cost of the exiting system. O&M cost is calculated for per year. The estimated cost for collection of 500 liter rain water is given below

Description of material	Quantity	Rate (tk)	Amount (tk)
Motka (500 liter)	1 no	200/no	200
O&M (for 500 liter)		200/year	100 (approx)
Total			**300**

Problems associated with existing system: In the study area maximum people use rain water without any proper hygienic and purification practices. Here people collect rain water without considering the design criteria of RWHS and they do not use all the components of the system properly. So that most often people fail to collect rain water properly in rainy season which is essential as there are serious scarcity of water exist. At the same time people of that area are not well known about proper operation and maintenance of rainwater harvesting system. They spend a little amount of money for O&M annually. So that most often they drink unpurified rainwater which causes waterborne diseases to them.

Suggestions for Improved Rain Water Harvesting System:A package of software and hardware activities should be implemented for the improvement of existing rainwater harvesting system practiced in the study area. Here all most people involved in rain water harvesting system but they are unknown about the hygienic and proper management practice for rain water collection system. Maximum people collect water and directly use it for consumption. So here software activities mainly include various motivation tasks such as court yard session, school session, rally and popular theatre under community mobilization for better management and use of hygienic rainwater for consumption. Mason training for design consideration of the storage tank and other components of rainwater collection system should be conducted and caretaker training for better and efficient management, education and communication of rainwater under training activities. Under hardware activities a modification of the existing system is suggested which is described below:

Modification of the existing do-it yourself model (Motka):
It is an indigenous process of RWHS and in the study area already people collect rain water in large earthen pot called motka from a long time ago. It is no need to have a sophisticated system for harvesting rain water but the issue is that the collection method should be scientific and hygienic. During rainy days rain water could be collected in clean pot just hanging a piece of clean polythene or cloth with four stick. Or a piece of split bamboo/wooden channel can be hanged along the ridge of clean roof and clean rain water can be harvested in to pitcher. This could be served the crisis of water for the rainy season (about six months).

1) Demand side approach: The simple method assumes sufficient rainfall and catchment area which is adequate, and is therefore only applicable in areas here this is the situation. It is a method for acquiring rough estimates of tank size. a simple calculation has been shown to quantify the size of the tank on the basis of set considerations such as consumption per capita per day, number of people per household and longest average dry period.
Assumption: According to Water Aid Bangladesh

- Consumption per capita per day: (C) = 5liter
- Number of people per household:(n) = 6
- Longest average dry period :(T) = 5 months or 150 days

Annual consumption, Q = C*n*365
= 10,950 liter (in 12 months)
Storage requirement, q = (10950*150)/365 = 4500 liter
(It is a method for acquiring rough estimate of tank size)

2) Supply side approach: In low rainfall areas where the rainfall is of uneven distribution, more care has to be taken to size the storage properly. During some months of the year there may be an excess of water, while at other times there will be a deficit. If there is sufficient water throughout the year to meet the demand, then sufficient storage will be required to bridge the periods of scarcity. As storage is expensive, this should be done carefully to avoid unnecessary expense
Assumption:

- Consumption per capita per day : (C) = 5 liter
- Number of people per household: (n) = 6
- Longest average dry period : (T) = 5 months or 150 days

Demand of water per month for a nuclear family = 30*30 = 900 liters
Reconsideration:

- Roof area : 10 m2
- Runoff coefficient (for CI sheet roof) : 0.8
- Average monthly rainfall (April to October) : 125 mm/month

Monthly available water which can be collected from the mentioned roof = 10*125*.8
= 1000 liter

So if RWHS supply water all the year to meet the needs of a nuclear family, the demand can not exceed 1000 liters per month. The available harvested water can not meet the expected demand.. The following table shows the comparison of water harvested and the amount of water required for a nuclear family (6 members) in a given year and rainfall data is assumed for a year:
Table: 4: Demand and Supply calculation from the rainfall data

MONTH	RAINFALL (MM)	CATCHMENT (SQ.M)	RUNOFF COEFFICIENT	SUPPLY (LITER)	CUMULATIVE SUPPLY(LITER)	MONTHLY DEMAND(LITER)	CUMULATIVE DEMAND(LITER)	SURPLUS (LITER)
April	86	10	0.8	344	344	900	900	-556
May	482	10	0.8	1928	2272	900	1800	472
June	597	10	0.8	2388	4660	900	2700	1960
July	566	10	0.8	2264	6924	900	3600	3324
August	539	10	0.8	2156	9080	900	4500	4580
Sept.	255	10	0.8	1020	10100	900	5400	4700
October	177	10	0.8	708	10808	900	6300	4508

Sources: Weather forecasting Centre, 2005

While calculating the greatest excess of water over and above consumption, the accumulated inflow (supply) and outflow from the tank and the capacity of the tank are taken under consideration. This occurs in September with a storage requirement of 4700 liters. All this water will have to be stored for dry period and this estimation is given for fixing tank size.

3) Cost estimation for the modified model from demand analysis In the existing system there is no integrated use of all components of RWHS and safety and hygienic practice is also absent. This type of RWHS may be different capacities such as 250 liters, 500 liters. The construction requirements of different capacity of RWHS by Motka with modification are described below:

Table: 5: Cost analysis for different capacity of storage reservoir

STORAGE CAPACITY (LITER)	SIZE OF THE RESERVOIR	MINIMUM CATCHMENT AREA(IN SQ.M)	TYPE OF CATCHMENT	NO: OF RESERVOIR	AVERAGE CONSTRUCTION COST (TAKA)
250	Depend on local condition& availability of pot	2-2.5	CI sheet, Tiles ,Polythene, Cloth	One or multiple	200
500	Depend on local condition& availability of pot	3-4	CI sheet, Tiles ,Polythene, Clot	One or multiple	350

Source: WAB, 2000 & Field Survey, 2005

The following table shows the total cost needed for the modification of the existing system. It is assumed that the system will be used without any type of problems and contamination up to five years. At the same time O&M cost is estimated for one year. So the cost of the total system for a year is given below:

Table: 6: Detail cost analysis of do it yourself (Motka) model (Capacity 500 liter):

DESCRIPTION OF MATERIAL	QUANTITY	RATE (TK)	AMOUNT (TK)
Cement	5kg	5/kg	25
Sand	1cft	7/cft	7
Brick	8 nos	2.5/no	20
Motka (500 liter)	1 no	200/no	200
Gutter	2 nos	30/no	60
Hanger for Gutter	5 nos	-	30
Mosquito net	as required	-	10
Operation and Maintenance		250/year	250
Total			**602**

Source: WAB, 2000 & Field Survey, 2005

Affordability analysis of the modified system: There are several modern system found for RWHS. But these systems involve a high amount cost not suitable for poor people to afford. In the study area maximum people are poor and these modern costly systems will be not feasible for the poor people of the study area. So a modification is proposed of the existing system which involves better opportunities and safety for RWHS than the previous unhygienic practices. Affordability of a system mainly depends on income pattern of the people. The income of the local people is given in the following table:

Table 7: Monthly income pattern of the respondent (in taka)

MONTHLY INCOME RANGE (TAKA)	FREQUENCY	PERCENTAGE (%)
Below 1000	2	4
1000-2000	27	54
2000-3000	9	18
3000-4000	8	16
Above 4000	4	8

Source: Field Survey, 2005

Here, maximum people are poor and within the income range from 1000-2000 and it is about 54% household. For the existing system they spend 300 taka. At the same time there are no hygienic practices in the existing system so that they suffer by various waterborne diseases for which they also spend money for treatment. Beside this an opinion survey has been performed by taking their response about interest for further cost involvement for improved system.

Table 8: Opinion about Further cost involvement for improved RWHS

FURTHER COST INVOLVEMENT (TAKA)	FREQUENCY (NO: OF HH	PERCENTAGE (%)
100-200	5	10
200-300	7	14
300-400	33	66
Above 400	5	10

Source: Field Survey, 2005

From the above table it is shown that about 76% households are interested to involve further 200- 300 and taka for an improved and hygienic system with the existing cost 400 taka (for 500 liter).
So the existing cost of the system for 500 liter of storage tank = 300 taka
Cost of the proposed modified system = 602 taka
Near about 80% people are interested to spend further money (300-400 tk and above) with the existing system. So that it can be said that the proposed modified system will be affordable for all as the further cost involvement has no significant impact of their annual income and expenditure.

Conclusion: The effective management of water resources demands a holistic approach linking social and economic development with protection of natural ecosystem. Water development and management should be based on a participatory approach involving users, planners, and policy makers at all levels. Both women and women play a vital part in providing, managing, and safeguarding water. Day by day due to over exploitation of underground water, scarcity and contamination by various pollutants is increasing over the world. So day by day people are undertaken many initiatives to use water for their consumption in a proper way. Rainwater harvesting is a milestone in this pace of water consumption in a proper way. In the study area rainwater harvesting is running over from long period but not in a proper and hygienic way. So people are facing various waterborne diseases in each season. The situation is alarming and calls for judicious planning and execution of projects that utilize the abundant rainwater.

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