SOCIO-ECONOMIC ASPECTS OF ADOPTING THE ROOFTOP RAINWATER HARVESTING SYSTEM AND ITS QUALITY ASSESSMENT AT MONGLA REGION

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ABSTRACT

Supply of safe water is one of the important environmental issues for human health protection in the coastal areas. Bangladesh has a long coastal area and approximately 28% of the total population (about 35 million) lives in the coastal areas of the country. Rainfall in the coastal areas is much higher than the average rainfall. Here, rainwater harvesting is a good potential water supply option for drinking and cooking purpose . People usually make complaints about the lack of water. During the monsoon, a remarkably big volume of water goes waste into the drainage system of dwelling areas. And this is when Rain water Harvesting proves to be the most effective way to conserve water. The Rainwater harvesting is the simple collection or storing of water through scientific techniques from the areas where the rain falls. It involves utilization of rain water for the domestic or the agricultural purpose. The method of rain water harvesting has been into practice since ancient times. It is as far the best possible way to conserve water and awaken the society towards the importance of water.This study focuses on the socioeconomic aspects of adopting the rooftop rainwater harvesting system and assessed the quality of stored rainwater in the coastal areas in Mongla Upazila under Bagerhat district. It was observed that regardless of socio-economic condition, the majority of people in Mongla region is well aware of severe water problem and are willing to adopt rooftop rainwater harvesting system. But most of the people in this area belong to low-income group. Laboratory investigation reveals that the stored rain water did not satisfy the drinking water quality standards for color, TC and E. coli. The concept of diverting the first flush would substantially improve the quality of stored rainwaer in the study area.

Keywords: Coastal area, Mongla upazilla, rainwater harvesting, socio-economic aspect, water quality.

1. INTRODUCTION

Water is the lifeline of any society. Water is essential for the environment, food security and sustainable development. Availability of safe drinking water is one of the basic minimum requirements for healthy living. Precipitation, every last drop or flake, was assigned ownership from the moment it fell in many Western states, making scofflaws of people who scooped rainfall from their own gutters. In some instances, the rights to that water were assigned a century or more ago (Johnson *et al.*, 2009). Rainwater harvesting (RWH) is any human activity involving collection and storage of rainwater in some natural or artificial container either for immediate use or use before the onset of the next season for domestic, agricultural, industrial and environmental purposes (Kemp, 1988; Kun *et al.*, 2004; Mati *et al.*, 2005). The concept of RWH systems can vary from small and basic, such as the attachment of a water bucket to a rainwater downspout, to large and complex, such as those that collect water from many hectares and serve large numbers of people (Gur, 2010; UNEP, 1982). In rural areas, the most common technique is small-scale rooftop rainwater harvesting (Pacey and Cullis, 1986). The quality of rainwater is directly related to the cleanliness of the atmosphere, cleanliness and quality of material used for catchment surface, gutters and storage tanks (Ariyananda, 1999). In areas where the rooftop is clean, impervious, and made from nontoxic materials, roof rainwater is usually of good quality and does not require much treatment before consumption (Lekwot *et al.*, 2012). Rapid population growth, combined with industrialization, urbanization, agricultural intensification and water-intensive lifestyles is resulting in a global water crisis. About 20 per cent of the population currently lacks access to safe drinking water, while 50 per cent lacks access to a safe sanitation system. Falling water tables are widespread and cause serious problems, both because they lead to water shortages and, in coastal areas, to salt intrusion. Both contamination of drinking water and nitrate and heavy metal pollution of rivers, lakes and reservoirs are common problems throughout the world. The world supply of freshwater cannot be increased. More and more people are becoming dependent on limited supplies of freshwater that are becoming more polluted. Water security, like food security, is becoming a major national and regional priority in many areas of the world. To face the global crisis of potable water, rainwater harvesting is the ancient practice by capturing rain runoff from roofs and other surfaces and storing it for a later purpose. With respect to the physical alternatives to fulfil sustainable management of freshwater, there are two solutions: finding alternate or additional water resources using conventional centralized approaches; or better utilizing the limited amount of water resources available in a more efficient way. To date, much attention has been given to the first option and only limited attention has been given to optimizing water management systems. Among the various alternative technologies to augment freshwater resources, rainwater harvesting and utilization is a decentralized, environmentally sound solution, which can avoid many environmental problems often caused in conventional large-scale projects using centralized approaches. Rainwater harvesting, in its broadest sense, is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques. Rainwater harvesting has been practiced for more than 4,000 years, owing to the temporal and spatial variability of rainfall. It is an important water source in many areas with significant rainfall but lacking any kind of conventional, centralized supply system. It is also a good option in areas where good quality fresh surface water or groundwater is lacking. The application of appropriate rainwater harvesting technology is important for the utilization of rainwater as a water resource. Rainwater harvesting, in its broadest sense, is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered technologies. (UN-HABITAT, 2005).It is a good option in areas where good quality fresh surface water or ground water is lacking. There are certain areas in the coastal belt of Bangladesh where tube wells are not successful, because ground water is mostly saline to depths of 700-1000 ft. (DPHE-UNICEF, 1994) and suitable freshwater aquifers are not available. At least 59 districts of Bangladesh out of 64 have been reported exposed to arsenic problem (DPHE-WHO, 2000). It is high time to be concerned about the drinking water problem of coastal area like Mongla. The high annual rainfall in coastal area in Bangladesh makes rainwater harvesting a great logical alternative solution to solve the present scarcity of water. The coastal rural areas of Bangladesh is among the most suffered places considering access to safe water where people are forced to buy and drink pond water for a certain period as they cannot afford to store rainwater, the most preferred option to them, for the whole year. In this study, it was intended to find out the socioeconomic constraints and opportunities that could determine the adoption of rainwater harvesting technology and assessed the quality of stored rainwater in the coastal areas in Mongla Upazila under Bagerhat district.

2. METHODOLOGY

This study was conducted in the Monglaupazila of Bagerhat district. From the upazila three locations (Malgazi, Chandpai, and Mithakhali) were selected as the study area. Preliminary and detailed field investigation was done through questionnaire survey among 60 households to identify socioeconomic constraints and opportunities that could determine the adoption of rainwater harvesting technology. Male or female members in the household were interviewed using RWHS questionnaire. Observation of the RWHS was also done during the survey. Stored rainwater sample were collected from different types of rooftop rainwater harvesting system and then transferred to the laboratory for laboratory test and finally propose a practically viable model for improvements of rainwater harvesting system.

2.1 Study area

Mongla is an Upazila of Bagerhat district in the Division of Khulna Bangladesh. The Mongla Upazila has been founded in 1983. It is situated in the south-west of Bangladesh from 21^0 49´ to 22^0 33´ north latitude and from 89^0 32´ to 89^0 44´ east longitude. It is located 30 km South-west away from Bagerhat district and 45 km south-east from the Khulna district. The area of this upazila is 184.13 square km. Moreover 1083 square km mangrove forest is located in this upazila (BBS, 2011). It has 83 villages, 28 mouzas, and 6 unions named Burirdanga, Chandpai, Chila, Sonailtala, Mithakhali, and Sundarban. Mongla Upazila is surrounded by Rampal Upazila in the north, Dakopupazila upazila in the west, Morolgong upazila in the east and the Sundarban in south.

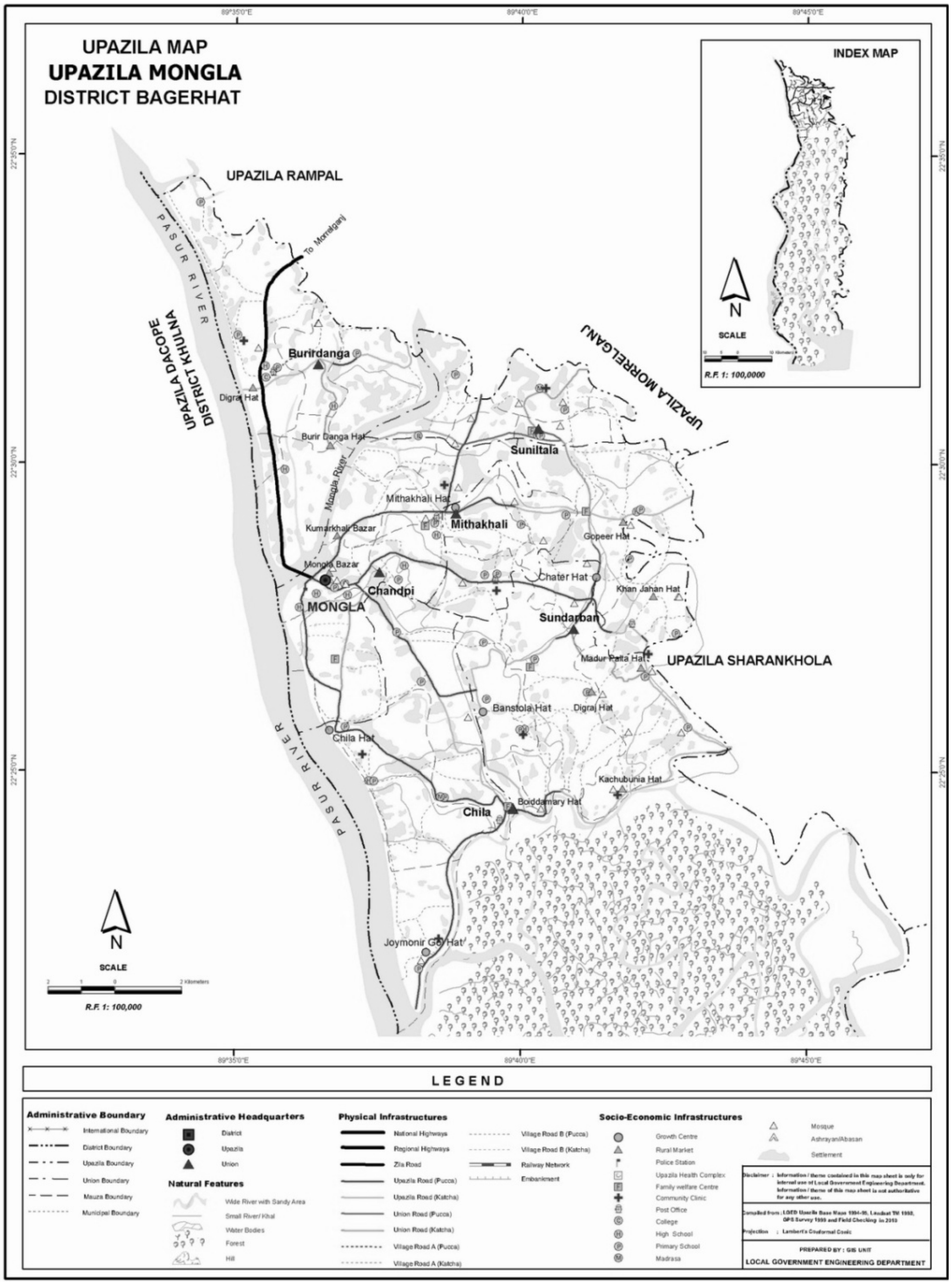


Figure 1: Map of Mongla Upazila

2.2 Existing rainwater harvesting system at Mongla

The pictures (Figure 2) show the present rainwater harvesting system in Mongla. In most of the cases roof with proper installation of pipe attached to the roof is used for rainwater harvesting in Mongla. Then the harvested water is collected in Concrete tank, Motka tank, PVC tank, etc.

Figure 2: Different types of rainwater harvesting system used in Mongla

2.3 Rainfall pattern in Mongla region

The monthly rainfall data from 2008 to 2013 was collected from Meteorological Department and analyzed to know about the rainfall pattern and quantity. The monthly distribution of rainfall in the study area follows the usual pattern of monsoon with heavy rains starting in May and ending in September and very little of no rainfall during the rest of the year (Table 1). The rainfall in the area varies from about 1673 to 2247 mm. The average annual rainfall of the study area is around 1825 mm and the highest average monthly rainfall occurs in the month of August is around 390 mm.

Table 1: Monthly rainfall data of the study area (Bangladesh Meteorological Department)

Month	**Rainfall(mm)**						
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**Average**
January	50	0	0	0	40	0	15
February	36	1	0	0	13	5	9.17
March	12	8	0	8	8	2	6.33
April	7	23	19	112	85	28	45.67
May	146	191	143	132	61	359	172
June	252	177	350	504	193	244	286.7
July	474	424	204	392	359	401	375.67
August	217	478	265	639	449	287	389.16
September	299	316	263	421	420	219	323
October	197	96	324	39	114	286	176
November	0	6	94	0	34	0	22.33
December	0	0	11	0	8	0	3.166
Total	1690	1720	1673	2247	1784	1831	1824.2

3. RESULTS AND DISCUSSION

3.1 Socio-economic status and response to RWH

This section addresses the results arising from the analysis of the field questionnaire survey. It shows the educational qualification of respondents. Among the respondents in the study area, illiterate 8%, only signature 17%, SSC 17%, junior secondary 22%, HSC 5%, and up to primary level 25% were observed. Most of the respondents were aware of the concept of rainwater harvesting system (RWH).

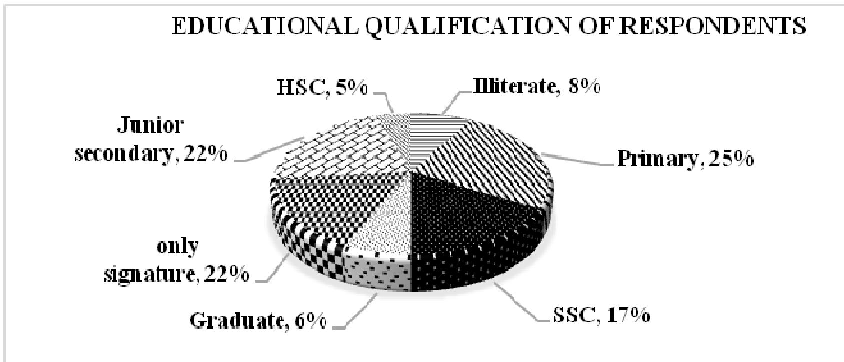
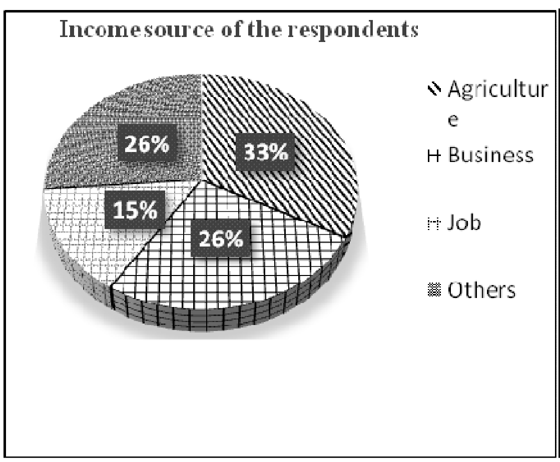


Figure 3: Educational qualification of the respondents.

In the study area, the main source of income was found to be agriculture. The respondents were engaged in agriculture to about 33%, business 26%, job 15%, and others 26%. Most of the people in this area belong to low-income group. The livelihood options have become more limited due to its impact on the local environment.



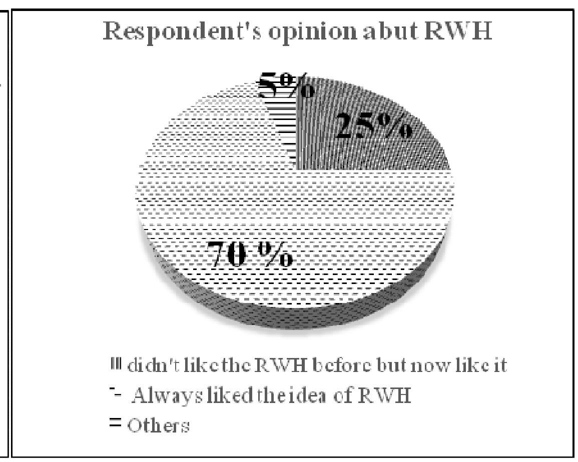


Figure 4: Income source of the respondents.

Figure 5: Respondents' opinion about RWH.

In this survey work while asking for their opinion towards rainwater harvesting system (RWH), about 70 % of the respondents in study area expressed that they always liked the idea of rainwater harvesting as they believed by this technology would make their life easier. However, 25% respondents mentioned that they didn't like the idea of rainwater harvesting before but now they like this system.

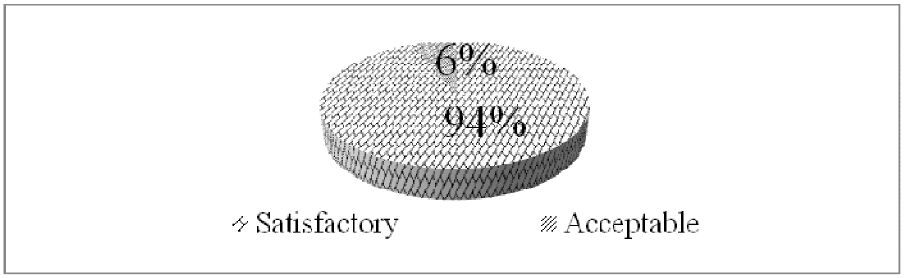


Figure 6: Respondent's opinion about the quality of rainwater.

As a whole, this study revealed that 94% of the total respondents were more or less happy while only 6% took the option okay but none were unhappy about the quality of store rainwater. In most of the cases rainwater was used for drinking and cooking purposes.

3.2 Stored rainwater quality

Stored rainwater samples from different type's rainwater harvesting systems were collected and tested at the environmental engineering laboratory to assess the water quality parameters. For water collection from the study area, bottles and sterilized bags were used. The summary of test results of water quality parameters are presented below:

Table 2**:** Test results of stored rainwater quality from various RWHS

Parameters	**Concrete roof (Concrete tank)**	**Corrugated iron sheet (Concrete tank)**	**Corrugated iron sheet (Motka tank)**	**Corrugated iron sheet (PVC tank)**	**Straw roof (PVC tank)**	**Bangladesh standard (ECR,1997)**
pH	8.3	7.82	7.95	6.95	7.7	6.5-8.5
Color (Pt. Co.)	5	Nil	4	16	Nil	15
Turbidity(NTU)	2.17	0.77	3.27	2.15	2.27	10
Alkalinity(mg/l)	72	85	60	30	41	<130
TDS(mg/l)	160	80	680	70	80	1000
Chlorine(mg/l)	11	6	13	9	10	150-600
TC (N/100ml)	13	17	53	19	22	0
E. coli(N/100ml)	1	0	1	4	1	0
BOD_5 (mg/l)	0.46	0.32	0.16	0.34	0.4	0.2
COD (mg/l)	64	32	96	128	160	4

It is shown that the maximum value of pH was obtained in concrete roof and concrete rainwater tanks .The concrete properties may have affect on the pH of the stored rainwater. In all cases chloride content was foud to be significantly lower than the standard limit. The test results identified the presence of both total coliform and fecal coliform in the stored rainwater.

3.3 Proposed model for improved RWH

In the existing rainwater harvesting system in the study area, there are no suitable options to diversion of first flush. But first flush should be necessary because first spell rain contaminated with the relatively more amount of pollutants through the air and rooftop areas. A floating ball technique is use for the purpose of first flush. The container has a ball that floats and rises with the filling water. When it becomes full, this chamber is automatically blocked by the ball. The advantage of this method is that the operator doesn't have to be around during a rainstorm. Anyone can remove the foul flush after the rainfall event.

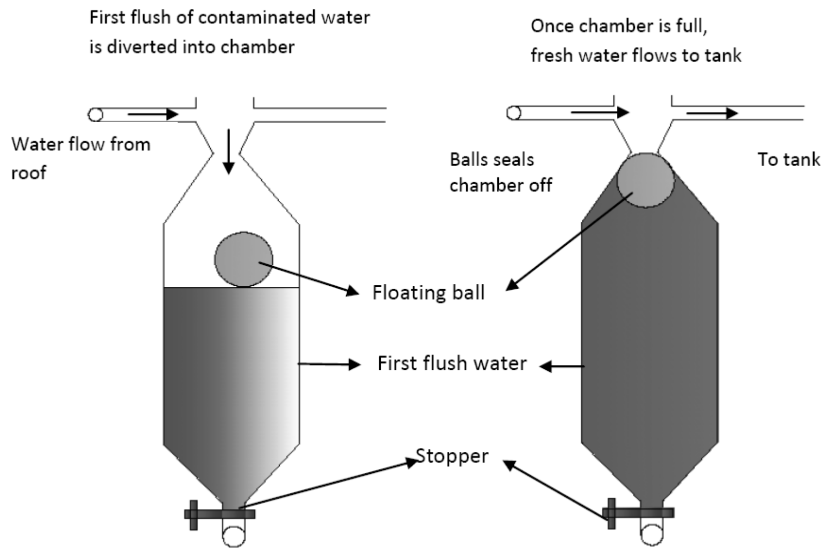


Figure 7: Floating ball technique first flush diversion system.

5. CONCLUSIONS

From the questionnaire survey, it is observed that the majorities of peoples in Mongla region is well aware of the severe water problems in the coastal areas and are willing to adopt rooftop rainwater harvesting systems. Most of the respondents in study area expressed that they liked the rainwater harvesting system as this technology would make their life smooth and healthy. But most of the people in this area belong to low-income group. During rainy seasons they cannot store the required quantity of rainwater to fulfill their demand due to small size of the reservoir. Therefore, they collect water from ponds during dry season. It was found that the stored rainwater quality from different rainwater harvesting system was beyond the acceptable limit of drinking water standards in Bangladesh and also got some bacteria which might be harmful for human health. This is only because of the less awareness of O & M. By proper maintenance of roof, gutter, using filter units and regular intervals of tank cleanliness all water quality parameters of the rainwater could be within the standard limit and bacteria would be removed. A practically viable model was proposed in this study for the improvement of existing rainwater harvesting system. In this context, diversion and washout of the first flush rainwater was the major concern with regards to improve the quality of stored rainwater in the proposed model. It may be also appropriate to standardize the design of the rainwater utilization system, at least at the regional level. Various implementation policies should be established to make rainwater utilization and other measures a part of the social system. Together with this, there is a need to train specialists with a thorough grasp of these technologies and devices. To promote rainwater harvesting and utilization as an environmentally sound approach for sustainable urban water management, a network should be established involving government administrators, citizens, architects, plumbers and representatives of equipment manufacturers. It is essential to encourage regional exchanges amongst public servants, citizens and industry representatives involved in rainwater storage as well as the conservation and reclamation of water.

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