Rain Water Harvesting Systems in Bangladesh: A Review

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Abstract

As the population of the world increases everyday, the demand of water for drinking and other domestic purposes also increases at the same rate. But the rate of utilization of surface and groundwater resources is much faster than that of their recharge. This is one of the reasons for scarcity of water. There are also other reasons for scarcity of water as the contamination of surface and ground water. The situation is very much concerning and the fact is not so different for Bangladesh. The scarcity of water in Bangladesh are due to over-exploitation of ground water aquifers specially in big cities and Barendro region, natural arsenic contamination of ground water in 61 districts, salinity in the coastal regions and lack of surface water and also lack of easy access to the aquifers due to hilly and rocky topography in the Chittagong Hill Tracts Region of Bangladesh. The benefits of this alternate source of water are found to curtail the burden on the public water supply, to be cost effective, to be used in case of emergency, to increase soil moisture to develop vegetation and to develop the chance of ground water recharge. Cost comparison and associated benefit between a rainwater harvesting system (RWHS) and traditional water supply system encountered and revealed a rainwater harvesting system as a cost-effective technology in Bangladesh especially in places where water is not easily available to consumers. Bangladesh government and NGOs should take clear steps forward for building RWHS to combat the situation. Mass education should be spread to aware the common people about the technology, benefits and cost effectiveness of rainwater harvesting system.

Key words: rainwater harvesting system, Bangladesh

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Introduction

Millions of the people of the world have no access to water for drinking and other domestic purposes. The JMP Thematic Report on Drinking Water 2011 by UNICEF and WHO stated that768 million people still use unsafe drinking water sources. The report also said that in 2008, 40% of the total population of the world (about 884 million people) had no access to improved drinking water sources and of those people without access to improved sources of drinking water, 25% live in Southern Asia.[1] The situation is very much concerning and the fact is not so different for Bangladesh. So we see that scarcity of water is everywhere in the world, as it is also in Bangladesh.

As the population of the world increases everyday, the demand of water for drinking and other domestic purposes also increases at the same rate. But the rate of utilization of surface and groundwater resources is much faster than that of their recharge. So the aquifers are on an increased pressure to supply water. This is one of the reasons for scarcity of water. There is also contamination of surface and ground water.[2] The sources of surface water pollution are mainly sewage, industrial and trade waste including physical pollutants and agricultural pollutants.[2,3] Rashid, Rahman and Hyder (2012) stated water can be polluted at the different levels such as at the source, during its distribution and also during the storage from its container or storage tank. They demanded that Rainwater can be a good source of drinking water specially in the villages of Bangladesh.[4] Ahmed et al. (2012) showed how the surface water sources of Dhaka, Bangladesh are being polluted by the industrial effluents.[5] On the other hand, the ground water contamination in Bangladesh are due to salinity from salt water incursion in the coastal areas[6,7]and naturally occurring arsenic contamination in the northern and middle zones of the country.[6,8] The hilly areas of Bangladesh have also scarcity of water specially due to its characteristic topography and other geographical phenomena.[9]

In this situation of crisis, it is very much essential to look for alternative sources to meet the over-demand of water and Rainwater Harvesting is thought to be one.[10] So many organizations installed hundreds of Rainwater Harvesting System in different areas of Bangladesh to solve the problem and their attempt is considered more or less successful. This review article is attempted to reveal the benefits, quality, cost effectiveness, effect on climate and the reasons of harvesting Rain Water in different parts of Bangladesh.

What Rainwater Harvesting System (RWHS) is ?

Rainwater harvesting is the accumulation and deposition of rainwater for reuse before it reaches the aquifer. The harvested water can be used as drinking water as well as for storage and other purposes like irrigation.[11]

A report of UNEP (2009) stated that rainwater

harvesting locally collects and stores rainfall through different technologies, for future use to meet the demands of human consumption or human activities.[12]

A definition in a clear and more simple language is given by Norma Khoury-Nolde (in her website last accessed on 30 June, 2014). She defined Rainwater Harvesting as a technology used to collect, convey and store rain for later use from relatively clean surfaces such as a roof, land surface or rock catchment. The water is generally stored in a rainwater tank or directed to recharge groundwater. Rainwater infiltration is another aspect of rainwater harvesting playing an important role in storm water management and in the replenishment of the groundwater levels.[13]

Thomas and Martinson (2007) used the term 'Roof water Harvesting' as a subset of 'Rainwater Harvesting' as the later term is much broader though very widely used. They wrote (in their book 'Roofwater Harvesting: A Handbook for Practitioners') - 'Rainwater harvesting' is a widely used term covering all those techniques where by rain is intercepted and used 'close' to where it first reaches the earth. The term hasbeen applied to arrangements to cause rainfall to percolate the ground rather thanrun off its surface, to forms of flood control, to the construction of small reservoirs to capture run-off water so that it can be used for cattle or micro-irrigation and to the collection of run-off from roofs and other impermeable surfaces. Thus, roof water harvesting is a subset of rainwater harvesting, albeit an important one.[14] Their term is very much suitable in the context of our country as most of the Rainwater Harvesting Systems here use the roof as the catchment area.

Why and where Rainwater Harvesting System (RWHS) is ?

The practice of Rainwater Harvesting in our country is mainly to supply water for drinking and domestic purposes due to scarcity of water from the groundwater or surface water sources. This scarcity of water is caused as a result of lack of sufficient water or lowering of the water-table in the aquifers in some areas (due to excess withdrawal of water to meet the over demand of the fast expanding community or due to drought), or as a result of contamination of groundwater or the surface water sources in some other areas. There are also combined causes in some of the places. To combat this situation of scarcity of water, Rainwater Harvesting System is installed in many of the areas of the country. These reasons of scarcity of water, for which rain water harvesting systems are installed, are showed in brief in Table – 1.

Table 1: Reasons for RWHS in different areas of Bangladesh

Regions of Bangladesh	Reasons for using RWHS	Use of Harvested Water	Source of Information
Arsenic Affected Areas (61 districts)	Arsenic contamination of ground water	Drinking& domestic use	i) Reference – 19: Rahman MH et al (2002); ii) Reference – 22: Ivanov J, Tobias R and Molaer HJ (2013).
Dhaka	Lack of water in aquifers (due to over exploitation)	Drinking, recharge of ground water and toilet flushing & gardening	i) Reference – 23: Jahan and Haider (2012); ii) Reference – 24: Paul S (2012) iii) Reference – 25: Rashid and Ahmed (2012).
Coastal regions	Salt water incursion& lack of availability of suitable fresh water aquifer.	Drinking& domestic use	i) Reference – 6: Bangladesh Rio plus 20: National Report on Sustainable Development 2012. ii) Reference – 7: UN-HABITAT 2005
Hilly regions, specially Chittagong Hill Tracts	Lack of surface water and also lack of easy access to the aquifers due to hilly and rocky topography	Drinking & domestic use	i) Reference – 32: UNICEF, Chittagong Hill Tracts ii) Reference – 33: Alam R et al (2012).

Source: BBS 2012[48].

Of all the causes of scarcity of water mentioned above, for which Rainwater Harvesting System (RWHS) is suggested and installed as the alternate source of water in Bangladesh, the naturally occurring arsenic contamination of the groundwater is considered the worst of all. It was first detected in Bangladesh in 1993. With varying levels of contamination from region to region, groundwater in 61 out of the 64 districts in Bangladesh was found contaminated with arsenic. A total of 4.7 million tubewells in the country had been tested and 1.4 million of those were found to contain arsenic above the Government drinking water limit of 50 parts per billion (ppb). It was also reported that out of the Bangladeshi population of 125.5 million, up to 57 million people consumed water that had an arsenic concentration greater than the WHO guideline value and up to 35 million people consumed water that had concentrations in excess of the Bangladesh standard. The waters in the southwest and southeast parts of Bangladesh were found highly contaminated with arsenic.[15,16,17] [The WHO Guideline value for arsenic in drinking water is set at 10 ppb].[18] Nationwide, approximately 20 per cent of shallow tubewells were found contaminated. There were more than 8,000 villages where 80 per cent of all tubewells were contaminated. About 20 million people in Bangladesh were using tubewells with more than 50ppb of arsenic.[17]

Rahman MH et al. (2002) also declared that arsenic in groundwater above 50 µg/L had been found in 61 districts (these included the number of administrative areas with at least one sample exceed 50 µg/L of

arsenic) out of total 64 districts in Bangladesh.[19] This finding was based on the studies conducted by British Geological Survey (BGS),Department of Public Health Engineering (DPHE), Mott MacDonald Limited (MML) and Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP). BGS, DPHE and MML conducted the study in two phases and examined 3,534 distributed water samples from 61 districts (except 3 hill districts) in an approximate grid of6km x 6km.[16,20] These included an average of 58 samples per district and 8 samples per Upazilla (the lowest administrative unit), and 25% tested samples exceeded the concentration of 50 µg/L, Bangladesh Standard but 42% tested samples exceed the concentration of 10 µg/L, provisional World Health Organization (WHO) guideline value for arsenic in drinking water[18]. And in terms of population, about 20 million and 45 million people were found to be exposed to concentrations above the national standard of 50 µg/L and the World Health Organization's guideline value of 10 µg/L, respectively.[21]

So Rahman MH et al. (2002) suggested Rainwater Harvesting as one of the major alternate sources of water for drinking purpose here, as rainwater is available in abundance during the rainy season in this country.[19] And for this reason, many of the Rainwater Harvesting systems were installed as one of the major alternate sources of drinking water in these arsenic affected regions of Bangladesh.[22]

Jahan and Haider (2012) said that the water situation of Dhaka is the worst of all the cities of Bangladesh with rapid population growth and unplanned infrastructural development. Excessive withdrawal from upper aquifer created large groundwater depression in upper aquifer at the central part of the city. It was estimated that groundwater table of upper aquifer is declining at a rate of 3 m/year in Dhaka city posing a new challenge for the entire community. On the other hand, water-bodies are disappearing very rapidly from the city and at the same time, paved areas are increasing very fast. All these factors had serious implications which reduce natural vertical recharge of groundwater. As a result, there is scarcity of water. They also stated that the average annual rainfall in Dhaka is more than 2100 mm which is about three times of the world's average. Unfortunately, there was no plan for using this huge amount of rainwater to contend the water crisis in Dhaka and other cities.[23] In this situation, the Rainwater Harvesting Systems in Dhaka city were installed to supply water for drinking and domestic purposes. Some of them were set up to recharge the aquifers too.[24] Sultana and Ahmed (2012) identified 24 potential sites necessary for artificial recharge of the aquifer of the region of Dhaka City and they recommended rooftop rainwater harvesting as one of the effective methods for the purpose.[25]

Rashid and Ahmed (2012) suggested that every home should have its own collection system to get enough rainwater for the use of flushing and gardening in Dhaka City.[26]

Saline contamination of the surface water and the salt-water incursion of the aquifers are the main problems in the coastal region of Bangladesh. Due to non-availability of suitable surface and ground water sources (high salinity and non-existence of shallow aquifer), Rainwater Harvesting (RWH) has been practiced for a long time for drinking water supply in these areas.[27] During the last few years, several programs have been undertaken by government and international organizations to promote rainwater harvesting in the region.[28] Rahman and Dakua (2012) also discovered that Rainwater Harvesting system is practiced in some of these areas as an alternate source of drinking water.[29]

Khanom and Salehin (2012) found salinity in the surface and ground water in the areas of Tungipara, Gopalganj district causing a lot of problems to human health and agriculture there. They also suggested Rainwater harvesting system to solve the problem.[30]

The Centre for Coastal Environmental Conservation (CCEC) constructed 14000 Litre capacity Ground Rainwater Harvesting Systems for only 175 beneficiaries of 35 families in the cyclone affected Sundarban coastal communities in the district of Satkhira and they recommended that more alternative sources of drinking water should be constructed to combat the drinking water crisis in the region.[31]

In the hill tracts of Bangladesh, the main reason for the crisis of water is lack of shallow aquifers and also lack of sufficient surface water due to the hilly and rocky topography of the area.[32] UNICEF also declared that access to safe drinking water in Chittagong Hill Tracts (CHT) had been difficult due to the topography of the area. Often the safe water options available are costly and require specific technical support not easily found in the region[33]. This fact is also supported by Alam et al. (2012), who found in their study that there is lack of suitable groundwater aquifers in the hilly areas and the cost of setting up tube-wells is very high due to deep underground water table and stony layers.[34]

Ahmed et al. (2013) said that the hilly region of Bangladesh has serious water source problem, though it lies in high rainfall areas. They commented that proper harvesting system can utilize the rainfall properly and can be used for both storage and groundwater recharge.[35] In fact the people of hilly areas like Kaptai, Bandarban and other hilltract areas harvest rainwater locally to use the collected water for household as well as for irrigation and navigation purposes.

Kabir and Faisal (1999) stated more specifically that the indigenous people living in the hilly areas of Bangladesh have practiced water harvesting for centuries. As many as fifty-two indigenous methods had been indentified that are being practiced by tribal people of Bangladesh for watershed management as shown in that study.[36] The main difference of these systems from that of the flat plain land is the catchment area, which is only the ground surface here (instead of rooftops in the flat lands) and water is stored subsequently in wells, ponds etc.

In a socio-economic baseline survey of Chittagong Hill Tracts, Barkat et al (2009) found crisis of drinking water almost all over the area and they also discovered many of the tribal people traditionally harvest rainwater to use for drinking and cooking.[37]

Dev Con (2009) found that only 60% people in CHT region have access to safe water, which abnormally reduce to 4% in the dry season. It was also found that traditional water supply technologies such as tube wells, ring wells etc are not workable in all places. Ground water is not available in most parts of the towns. So different technologies are feasible for different areas.[38]

According to the study by Mainuddin et al (2007), water from the deep set tube-wells during dry season was found inadequate by all the respondents there, while it was found adequate during non-dry season by 67% only. Piped water supply is not available for 50% of the people. The study was conducted in the three hilly districts of Chittagong Hill Tracts i.e. Khagrachhari, Rangamati and Bandarban. And the overall condition of availability of water is not satisfactory.[39]

So Rain Water Harvesting System may be proposed as a good alternate source of drinking and other household purposes in this region. Actually it was practiced there traditionally for long.

Benefits of Rainwater Harvesting

Rainwater harvesting is a simple and primary technique of collecting water from natural rainfall. At the time of a water crisis, it would be the most easily adaptable method of mitigating water scarcity specially due to arsenic and saline contamination. The system is applicable for both critical and normal situations. It is an environmentally friendly technique that includes efficient collection and storage that greatly helps local people. The associated advantages of rainwater harvesting are that

(i) it can curtail the burden on the public water supply;

(ii) it can be used in case of an emergency (i.e., fire);

(iii) it is solely cost effective as installation cost is low, and it can reduce expense that one has to pay for water bills;

(iv) it extends soil moisture levels for development of vegetation;

(v) groundwater level is highly recharged during rainfall.[40]

Quality of Rainwater

The quality of harvested rainwater is an important issue, as it could be utilized for drinking purposes. Quality of captured water from roof top depends on both roof top quality and surrounding environmental conditions, that is, local climate, atmospheric pollution, and so forth.[41] Tests must be performed to check its viability and applicability before using as drinking water. Previous researches [42-44] showed that water quality of collected water did not always meet standard limits due to unprotected collection. Local treatment of harvested water could easily make water potable. Again rainwater could be also identified as non-potable sources for the purpose of washing, toilet flushing, gardening, and so forth, where quality is not a great concern. In this respect, treatment of collected water is of no such importance; rather it is used for household purposes.

Cost Effectiveness Analysis

The financial benefit associated with a rainwater harvesting system is solely connected with cost. The associated costs of a rainwater harvesting system are for installation, operation, and maintenance. Of the costs for installation, the storage tank represents the largest investment, which can vary between 30% and 45% of the total cost of the system dependent on system size. A pump, pressure controller, and fittings in addition to the plumber's labor represent other major costs of the investment. Rainwater provides sufficient quantity of water with small cost. Hence, the system can promote significant water saving in residential buildings in many countries. Herrmann

and Schmida[45] studied that potential saving of roof captures water was about 30–60% of potable water demand in a house depending on the demand and catchment area. Coombes et al. [46] analyzed 27 houses in Australia with rainwater harvesting system and found that about 60% of potable water could be saved. A case study in Dhaka city showed that the total cost related to construction and yearly maintenance of a rainwater harvesting system in a building with 1850 sq.ft catchment area for 20 years' economic life is about 30000 BDT. About 300 thousands liter water can be harvested from rain over one year in this building. The yearly consumption of this selected building stands at approximately 3000 thousands liters.[40] Therefore utilizing harvested rainwater for this building can save up to 10% of the public water supply annually. This volume of rainwater can serve a building with 60 members for about 1.5 months in a year without the help of traditional water supply. Furthermore, considering Dhaka WASA current water bill, about 8360 BDT can be saved per year, and about 125400 BDT can be saved in 15 years if rainwater is used for daily consumption. So, within three to four years, the installation cost of a rainwater harvesting system can be easily returned. Moreover, the building owner would be exempted from paying large amount of water bill as well as additional taxes and fees charged by the city authority with the water bill if rainwater is utilized for daily consumption. Cost comparison and associated benefit between a rainwater harvesting system and traditional water supply system encountered and revealed a rainwater harvesting system as a cost-effective technology in Bangladesh especially in places where water is not easily available to consumers.

Effect on Climate

Conventional use of water imparts critical impacts on natural resources. Water collection from ground and surface sources, treatment, and distribution are closely associated with energy consumption, however, being related to climate consequences. The extraction of water from the sources, the treatment of raw water up to the drinking standards and the delivery of water to the consumers require high energy. Moreover, there should be some energy losses during performing extracting, treating, and delivering of water. Therefore, the water sector consumes a huge amount of electricity from local and national grid. Approximately 300 billion kilowatt hours of energy could be saved if potable water demand could be reduced by 10%.[47] Adoption of RWHS is one of the most potential solutions that could save energy directly by reducing potable water demand. Reduction of water demand by 1 million gallons can result in savings of electricity use by 1,500kWh. In the previously mentioned case study, with an 1850 sq. ft. catchment area, about 300 thousands liters could be harvested over one year. However, this amount could reduce potable water demand and approximately 100kWh electricity could be saved in the selected residential building by introducing rainwater capturing system. Integrating rainwater harvesting system with the conventional water collection and distribution approach in residential as well as large scale, nonresidential applications suggest a potential method of reducing energy use. However, limiting energy demand has critical impact on carbon dioxide emissions, as release of carbon dioxide is closely associated with electricity generation. There should have sufficient reduction in carbon dioxide emissions when fossil fuel is used for power generation. Hence, limited contribution is to be expected from lower carbon release in climate change concept. However, water use should be critically judged from availability, safety, and sustainability of natural resources. Energy conservation is a critical component in sustainability concern. Decreased use of conventional potable water reduces energy demand that in turn reduces emission of carbon dioxide. Integrated water management approach with rainwater harvesting along with gray water and reclaimed water reuse could limit contributions to climate change and conserve limited water and energy resources in Bangladesh.

Conclusion

As the population of this country is growing fast, the demand for water is also increasing very fast. The water table is lowering day by day, and the recharge of groundwater table is facing difficulties. But the alternate sources of water are not yet given proper emphasis both at the policy makers' level as well as at the level of common people. Some voluntary organizations are working to install rainwater harvesting system in the regions of water crisis throughout the country, but the coverage is still not very satisfactory. So it is the government sector who should take clear steps forward to combat the situation. Mass education should be spread to aware

the common people. The technology for rainwater harvesting system should also be available and cheap everywhere.

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