Changes in the Use of Safe Water and Water Safety Measures in Water, Sanitation and Hygiene Intervention Areas of Bangladesh: A Midline Assessment

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November 2011

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Working Paper No. 27

November 2011

Published by:

BRAC
75 Mohakhali
Dhaka 1212
Bangladesh

Telephone: (88-02) 9881265-72, 8824180-7 (PABX)
Fax: (88-02) 8823542
Website: www.brac.net/research

Printing and Publication
Altamas Pasha

Cover design
Md. Abdur Razzaque

Design and layout
Md. Akram Hossain

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Printed by BRAC Printers at Tongi, Gazipur, Bangladesh.

Acknowledgements

We are grateful to the participants who provided valuable information for this study. We also would like to extend our gratitude to Dr. Babar Kabir, Director, BRAC WASH and DECC Programme and Milan Kanti Barura, Programme Head of BRAC WASH, for their kind cooperation. Thanks are also to all the Senior Regional Managers as well as field staff of BRAC WASH programme for their cooperation and assistance while conducting the study. Thanks to Data Management Unit of RED for providing necessary support for cleaning the data in time. Thanks to the reviewers for their comments to enrich the report. Special thanks to Dr. Fazlul Karim, Research Coordinator, RED for his meticulous comments to improve the quality of this paper. Authors are also grateful to Hasan Shareef Ahmed, Coordinatior, Knowledge Management Unit for editing the manuscript. This study received financial support out of the grant of the government of the Kingdom of the Netherlands to the BRAC WASH programme.

RED is supported by BRAC's core fund and funds from donor agencies, organizations and governments worldwide. Current donors of BRAC and RED include Aga Khan Foundation Canada, AusAID, Australian High Commission, Bill and Melinda Gates Foundation, NIKE Foundation, Campaign for Popular Education, Canadian International Development Agency, Charities Aid Foundation-America, Columbia University (USA), Department for International Development (DFID) of UK, European Commission, Fidelis France, The Global Fund, GTZ (GTZ is now GIZ) (Germany), Government of Bangladesh, The Hospital for Sick Children, ICDDR,B Centre for Health and Population Research, Institute of Development Studies (Sussex, UK), Inter-cooperation Bangladesh, International Committee of the Red Cross, International Research and Exchange Board, Manusher Jonno Foundation, Micro-Nutrient Initiative NOVIB, OXFAM America, Plan Bangladesh Embassy of the Kingdom of the Netherlands, Royal Norwegian Embassy, SIDA, Stanford University, Swiss Development Cooperation, UNICEF, University of Leeds, World Bank, World Food Programme, Winrock International USA, Save the Children USA, Save the Children UK, Safer World, The Rotary Foundation, Rockefeller Foundation, BRAC UK, BRAC USA, Oxford University, Karolinska University, International Union for Conservation of Nature and Natural Resources (IUCN), Emory University, Agricultural Innovation in Dryland Africa Project (AIDA), AED ARTS, United Nations Development Program, United Nations Democracy Fund, Family Health International, The Global Alliance for Improved Nutrition (GAIN), The Islamic Development Bank, Sight Saver (UK), Engender Health (USA) and International Food Policy Research Institute (IFPRI).

Abstract

The BRAC Water, Sanitation and Hygiene (WASH) programme reached 150 *upazilas* (sub-districts) in collaboration with the Government of Bangladesh since 2006. This study assessed the changes in the use of tubewell water and water safety measures in the households in the 11 *upazilas* of Bangladesh after BRAC WASH interventions. Data were collected from 6,600 households where 3,812 tubewells were traced in baseline (2006-7) and 3,591 tubewells in midline (2009). Most of the households (98-99%) used tubewell water for drinking, 70-73% for cooking, 62-66% for washing utensils, 70-73% for cleaning after defecation, and 24-36% for bathing in midline both in the dry and rainy seasons. The numbers were significantly larger in midline than in baseline ($p<0.01$) except for drinking in the rainy season. Overall arsenic-free tubewells increased from 58% in baseline to 60% in midline and most households (83%) drank arsenic-free tubewell water in midline. The study revealed that water safety measures including awareness of cleaning/purifying water and hygienic management of water increased significantly ($p<0.01$). The concrete-built platform increased from 63% in baseline to 69% in midline. Tubewell platforms were cleaned (32%) in baseline, which increased to 46% in midline. However, there still remained impediments to 100% safe water use by the households include arsenic contamination of tubewell water, financial inabilities of the ultra poor and poor households for installing tubewells for arsenic-free water, unmarked tubewell (whether contaminated by arsenic or not). The study concluded that WASH intervention has succeeded in increasing access to safe water use, hygienic management of water, and cleanliness of water collecting point in the study areas. It is encouraging to note that ultra poor households had interest to get new tubewells and preferred to pay the costs in monthly instalments, which indicates that these households were aware of the benefits of safe water. Thus, BRAC WASH programme needs to pay further attention to these impediments at the household level in order to further improve the current situation.

Key words: BRAC, MDG, Tubewell, Ultra poor, WASH

Executive summary

Introduction

The discovery of widespread arsenic contamination of groundwater has effectively lowered safe drinking water coverage from 97% to only 74% of the population in 2006. BRAC WASH programme reached 150 *upazilas* in three phases (50 in each phase) to meet the safe water-related challenges of the Millennium Development Goals in collaboration with the government of Bangladesh. The water component of the programme aims to promote safe water and water safety measures effectively. The intervention is being offered to the household or community levels. Before WASH interventions began in 150 *upazilas*, a baseline study was carried out in 50 *upazilas* of the first phase of the programme. Thus, it is high time to explore whether the programme had any effect in improving the use of safe water in the intervention areas.

Objective

The general objective of the study was to assess the extent of improvement occurred in different indicators after 2 years of WASH intervention compared to baseline status. The specific objectives were to:

i. assess and compare the changes in the use of tubewell water for different purposes, including drinking at the household;
ii. assess the status of water safety measures (at source, carrying, and preservation) at the household level; and

ii. identify the issues for further attention to reach 100% safe drinking water coverage at household or institutional level.

Methods

Arsenic prone 11 *upazilas* were selected from the 50 *upazilas* of the first phase of BRAC WASH programme. Baseline (2006-7) and midline (2009) surveys were conducted on 6,600 households selected through two-stage systematic sampling. Educational institutes (474 at baseline and 342 at midline) were studied by repeated cross-sectional method. Data collected through baseline and midline surveys were compared to assess the effect of BRAC WASH programme in changing the use of safe water at household and institutional levels. The relative change (RC) between baseline (BL) and midline (ML) statuses was calculated using the following formulae: {(ML-BL)/BL}*100.

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Key findings

Most of the households (98-99%) used tubewell water for drinking, 70-73% for cooking, 62-66% for washing utensils, 70-73% for cleaning after defecation, and 24-36% for bathing in midline both in the dry and rainy seasons. The numbers were significantly larger in midline than baseline ($p<0.01$) except for drinking in the rainy season. The increase of use of tubewell water was highest for poor households and also for bathing both in the dry and rainy seasons. The proportions of arsenic free tubewells increased to 60% in midline from 58% in baseline ($p>0.05$). The increase was found to be highest (6%) in midline among non-poor households. However, the proportion of arsenic contaminated tubewells decreased from 42% in baseline to 40% in midline among the ultra poor households. Most households (83%) drank arsenic-free tubewell water in midline at household level.

The water safety measures including awareness of cleaning/purifying and hygienic management of water increased significantly in midline ($p<0.01$). Boiling was the best options that 64% households reported in baseline, which increased to 80% in midline. The increase was highest (27%) in midline among the ultra poor households. Significant difference was found across households regarding awareness on prevention of waterborne diseases. Waterborne diseases could be prevented by drinking pure water that 52% respondents opined in baseline, whereas, the proportion increased significantly to 57% in midline. The increase was highest (19%) among ultra poor households. Besides, 19% of the respondents in baseline opined that waterborne diseases could be prevented by drinking tubewell water, but the proportion significantly increased to 37% in midline. The increase was highest (118%) among poor households in midline.

The level of satisfaction with existing water sources increased to 51% in midline from 50% in baseline. Significant difference was found across households on the interest to install new water sources. In baseline, 59% of the respondents were interested to install new water sources, which increased to 68% in midline ($p<0.01$). More than 75% households had preference for using tubewell water, which increased to 91% in midline, where non-poor had more preference for using tubewell water.

The proportion of concrete-built platform significantly increased to 69% in midline from 63% in baseline at household level. The status of more cleanliness of tubewell platform was observed in midline. Overall, 32% of the tubewell platforms were cleaned in baseline which increased to 46% in midline.

Discussion

The findings show the increase of using tubewell water for different purposes as well as for drinking at households in both dry and rainy seasons. In the rainy season, some households (0.7%) used rainwater for drinking purpose and this might have contributed to the declined use of drinking tubewell water in midline. Study also identified the improvement of water safety measures including improvement of awareness of cleaning/purifying water and hygienic management of water for drinking and cooking in midline.

Conclusion

This study concludes that WASH intervention has succeed in increasing the access to safe water and hygienic management of water in the household, community and educational institutions. Besides, significant improvement in water safety measures (at source, carrying, preservation and consumption) was identified in the study area. However, there still remained impediments to 100% use of safe drinking water by the households: arsenic contamination in tubewell water, financial inabilities of the ultra poor and poor households, unmarked tubewell (whether contaminated by arsenic or not). It is encouraging to note that ultra poor households had interest to get new tubewells and prefer to pay the costs in monthly installments which indicates that these households were aware of the benefits of safe water.

Recommendations

1. Opportunity of getting loan with affordable repayment schedules may encourage community people to install tubewell to get arsenic-free water and prevent possible health hazards.
2. Special attention should be given in the dry season when groundwater table usually fall beyond the suction lift of tubewell. Thus, more deep set pump and piped water supply systems can be installed for getting arsenic-free water, and arsenic removal filter and pond sand filter can be provided for cleaning water in the arsenic prone areas.
3. Proper guideline for installation of tubewell in relation to the latrines should be followed. Each tubewell must be provided with a concrete platform.
4. Besides, emphasis should be given on arsenic testing and to inform the households/community about the results of testing of tubewell water. Thus, BRAC WASH programme needs to pay more attention to these impediments at the household level to further improve current situation.

Introduction

A safe, reliable, affordable, easily accessible and sustainable water supply is essential for good health and improved life. An inadequate water supply also prevents good sanitation and hygiene practices (Hunter *et al.* 2010). Thus, implementation of proper water safety measures can improve health status (WHO 2005). While Bangladesh has made significant progress in supplying safe water to its people, regional and socioeconomic disparity in access to quality water exists across the country. Tubewells as the primary source of safe drinking water in rural Bangladesh, higher sanitation coverage, and improved primary healthcare have contributed to a significant drop in the mortality rate from diarrhoeal diseases (GoB and UNDP 2009). However, the discovery of the widespread arsenic contamination of groundwater has effectively lowered safe drinking water coverage from 97% to 74% in 2006 (GoB and UNDP 2009). Moreover, presence of arsenic in drinking water increased the mortality rate in Bangladesh (Tan *et al.* 2010). The Joint Monitoring Programme (JMP) of WHO and UNICEF (2010) reported that the world is on track to meet or even exceed the safe drinking-water target 10 of the Millennium Development Goal (MDG) 7. Although Bangladesh is on track to achieve the MDG target for access to safe drinking water 13% of its population are still drinking arsenic contaminated water (UNICEF 2010) and most respondents are unaware of the serious health consequences of consuming arsenic contaminated water (Ahmad *et al.* 2003). Besides, the country has not been able to achieve 100% coverage of safe water supply till date. Different agency reports show variability in national coverage of safe water supply, i.e. GoB (2008) shows 97% whereas WHO and UNICEF (2010) shows 80%. Therefore, access to safe water is hindered by a number of factors such as arsenic contamination, increased salinity in groundwater in the coastal belt, declining groundwater levels, urban and industrial pollution, anticipated increase of human excreta load, natural disasters, etc. (UNICEF 2010; Dey *et al.* 2010a).

A key target of MDG 7, which aims to ensure environmental sustainability, is "To reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015" (UN 2007). This water supply target underpins several other MDGs, including those relating to poverty (MDG 1), education (MDG 2), and gender (MDG 3). In particular, it underpins MDG 4, the reduction of child mortality. It is estimated that about 3,900 children die from waterborne diseases every day in Bangladesh (WHO and UNICEF 2005). Recent study findings reveal that prevalence of waterborne diseases reduced from 10% to 7% by the combined effect of water, sanitation and hygiene (WASH) after 2 years of intervention in rural Bangladesh (Rana 2009). WHO estimates that 94% of the diarrhoeal diseases are preventable through modifications to the environment, including access to safe water (WHO 2007). However, availability of safe water as well as hygienic management of household water is crucial for prevention of waterborne diseases. Proper hygiene education makes the community members aware about the correct use, storage and disposal of water, and general hygiene (Duncker 2000).

Water safety measures also include installation of tubewell considering safe distance from latrines. However, proper design and construction, sound platform without cracks, and firmly attached of hand pump and maintenance of the headwork are identified as the sanitary indicators (Luby *et al.* 2008). Previous study identified that most of the households were not accustomed to clean or purify tubewell water or water from any other sources for drinking (WASH Research Team 2008). Besides, several studies have noted that tubewells in the low lying areas of Bangladesh are commonly contaminated with faecal organisms (Hoque 1999; Islam *et al.* 2001, Luby *et al.* 2006) and nearly 29% of the tubewells are contaminated with bacteria, which are mainly due to poor maintenance of the tubewell surroundings (GoB and UNDP 2009).

BRAC WASH programme

To address the above challenges to safe water use and commitment for attaining MDG 7 (target 10), the government of Bangladesh has set a target of safe water for all by 2011. To reach this target, the government has taken initiatives in collaboration with development partners and non government organizations for ensuring safe water and sanitation for the people of Bangladesh. BRAC as a partner of the mission initiated the water, sanitation and hygiene (WASH) programme in 2006. It included 150 *upazilas* in three phases (50 in each phase) across the country. It aimed to attain the MDGs, especially for underprivileged groups in rural Bangladesh and thereby improve the health situation of the poor. The BRAC WASH programme offers different interventions to the households/community, educational and religious institutions. The intervention package includes installation of tubewells, fixing sanitary latrines, advocacy meeting, capacity building, and hygiene promotion by cluster meeting.

The water component of the programme aims to promote use of safe water and water safety measures effectively. Under its water component, BRAC WASH programme is working on deep tubewell installation mostly in arsenic-affected areas and platform construction, deep set tubewell installation (in the areas where ground water level is very low), loan support to construct tubewell platform in the community, testing water quality (of only those tubewell installed under the programme) in the 35 arsenic contaminated areas. Besides, installation of piped water supply, arsenic removal filters and pond sand filters installation are provided in some selected areas. The software interventions include mainly awareness raising, advocacy campaign and community capacity building for informing people about safe water use and developing water safety measures. The practices of water safety measures include cleanliness of water collecting point, hygienic management of water i.e. collection, carrying, preservation and consumption, and maintaining safe distance between the tubewell and the latrine. The WASH programme staffs the village wash committee (VWC) members, religious leaders (Imam), community leaders, school student brigades, etc. implement these at the community and institutional levels. Before the WASH interventions in 150 *upazilas*, a baseline study was carried out in 50 sub *upazilas* of the first phase. Now, it is imperative to assess the effect of the programme on safe water use and water safety measures.

The general objective of the study was to assess the extent of improvement occurred in different indicators after 2 years of WASH intervention compared to baseline status. The specific objectives were to:

i) assess and compare the changes in the use of tubewell water for different purposes, including drinking at the household;

ii) assess the status of water safety measures (at source, carrying and preservation) at the household level; and

iii) identify the issues for further attention to reach 100% safe drinking water coverage at the household level.

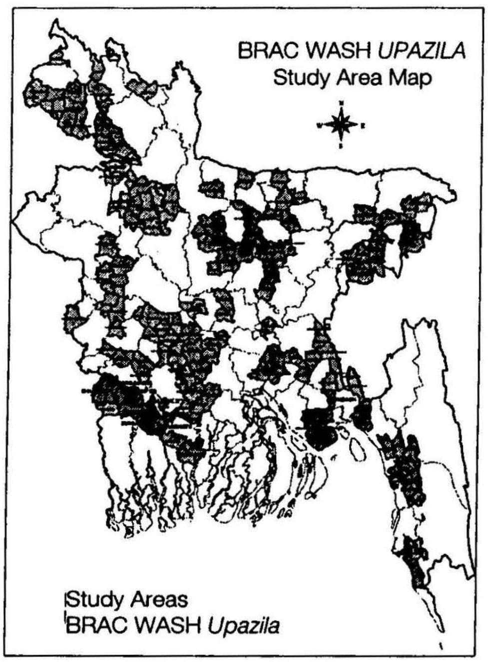
Methods and materials

This is a cross-sectional and comparative study between baseline and midline surveys.

Study area and sampling

BRAC WASH programme was initiated in 150 *upazilas* in three phases (50 in each phase) considering the geographical variations. The study households were selected through a two-stage sampling procedure. Arsenic prone 11 *upazilas* from the 50 sub-districts of the first phase of BRAC WASH programme were selected for both baseline (2006-7) and midline (2009) surveys (Fig.1). From each sub-district, 30 villages were selected using the systematic sampling method, followed by 20 households from each of the 30 villages for the study. Thus, 6,600 households were selected for interview. In the selected villages and households, 3,812 tubewells were found in baseline, while in the midline 3,591 tubewells were found due to missing households, death, displacement of house, or absenteeism of the respondents.

Figure 1. Study area



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Data collection techniques and tools

For the household survey a structured questionnaire was developed including the indicators, such as, tubewell water use in dry and rainy seasons, availability of tubewell water, awareness regarding cleaning/purifying water, prevention of waterborne diseases, hygienic management of water, satisfaction of existing water sources, willingness to pay for new water source, water safety plan including position of tubewell compared to latrine, tubewell platform-concrete built or not, cleanliness of tubewells platform and drainage system of tubewell water. The questionnaire was pre-tested, modified and edited on the basis of feedback received before finalization.

Economic statuses of households were classified as ultra poor, poor and non-poor. Ultra poor refers to the people who are landless or homeless and who do not have fixed source of income. The household who have up to 50 decimal of land (agricultural and homestead) and any adult member of the household used to sell 100 days of manual labour per year for living called poor. On the other hand, the households that do not fall in any of the above categories defined as the non-poor (Seraj 2008). The rural water is being supplied basically from single-used tubewell, share-used tubewell, publicly-used tubewell, whereas urban water supply adopts piped/tape water from deep tubewell. A tubewell is called single-used when only one household used to collect water for their daily uses. When a tubewell is used by a group of households, like neighbour and/or relatives, who may or may not follow any particular time to collect water are called shared, and public tubewell is open for all and have no time restriction for collecting water.

Respondent in a household was the adult female member who had general knowledge on the use of safe water, sanitation and hygiene practices. The reason of choosing female respondents was that the women usually responsible for household activities. BRAC WASH programme promotes household hygiene practices through involving the female members of the households. The administrative heads or the acting heads of educational institutes were interviewed in the institutional survey.

Informed consent was obtained from the participants. Field enumerators were trained on data collection. Each enumerator was given a training manual containing instructions for reference during data collection (BRAC WASH baseline report 2008).

The enumerators were divided into groups where each group had four members. The supervisor went through all the questionnaires to identify inconsistencies and re-interviewed if necessary. In addition they were also told to verify 5% of the previous weeks' filled-up questionnaires. The field managers checked the quality of each interview by randomly picking 12 completed questionnaires of a particular day and visited the field to verify answers of some previously selected questions. Whenever any such issues became evident a re-interview was conducted on the following day for the necessary amendment.

The responsibility of field coordinator was to supervise overall field activities. Field coordinator was the contact person for the WASH research team. Field coordinator is also responsible to document all the inquiries from the field for immediate dissemination to the concerned researchers. He also maintained a log book of field activities. Besides, a team of core researchers monitored the field activities closely by visiting some selected field locations to ensure the correct way of sampling and data collection and minimize the problem arose in the filed.

Data management and analysis

Filled-in questionnaires were edited and coded for computer entry under the close supervision. Twenty percent of the questionnaires were re-checked for consistencies. The relative change (RC) between baseline (BL) and midline (ML) statuses was calculated using the formula {(ML-BL)/BL}*100. The analysis was performed using SPSS 16.0. Chi-square test compared the significance of differences between baseline and midline statuses, and between different economic groups. Additionally, a binary logistic regression was used to estimate the odds ratio. The difference is statistically significant at $p<0.05$ (two-tailed test) level.

Results

Socioeconomic and demographic profile of the respondents

Nearly two-thirds (64%) of the respondents completed primary and higher level education. More than half of the respondents were non-poor, 30% were poor, and the remaining were ultra poor. All respondents were adults. The overwhelming majority (93%) of the respondents were engaged in household work and 1.9% involved as day labourers (Table 1).

Table 1. Socioeconomic and demographic profile of the respondents

Indicators		Percent
Literacy		
	Illiterate	35.6
	Primary	30.2
	Secondary	31.7
	Higher secondary	1.2
	Bachelor	1.3
Economic status		
	Ultra poor	17.7
	Poor	29.5
	Non-poor	52.8
Main occupation		
	Household works	93.2
	Day labourer	1.9
	Student	1.2
	Employee	0.8
	Business	0.2
	Others (Agriculture, rickshaw pulling, work in bus, etc.)	2.7
Marital condition		
	Married	90.8
	Unmarried	2.7
	Others (widow, separated and divorced)	7.5
Age (Years)		
	15-30	43
	31-50	49
	51-60	6
	61-above	2

n = 6,593

Changes in the use of water from different sources

Most of the households (98-99%) used tubewell water for drinking, 70-73% for cooking, 62-66% for washing utensils, 70-73% for cleaning after defecation, and 24-

36% for bathing in midline both in the dry and rainy seasons. For educational institutes, use of tubewell water for drinking increased to 100% in midline from 99% in baseline both in the dry and rainy seasons. The numbers were significantly larger in midline than in baseline ($p<0.01$) except for drinking at household level in the rainy season (Tables 2 and 3, Fig. 2). In both the seasons, use of tubewell water for drinking and bathing was highest among the poor households. However, 27-30% of the households used surface water for cooking in midline, which is significantly lower than the baseline both in the dry and rainy seasons.

Status of availability of tubewell water

The availability of tubewell water decreased in midline than in baseline in both dry and rainy seasons for households of all economic categories (Table 4). But no significant difference between baseline and midline on the availability of water was seen in the rainy season. In dry season, the availability of water decreased from 80% in baseline to 73% in midline from single-used tubewell. In case of shared and public tubewells, the availability of water decreased from 83% and 61% in baseline to 74% and 27% in midline, respectively. The decrease in availability of tubewell water was found to be highest (59%) among non-poor households and public tubewells in the dry season. However, no significant decrease in the use of tubewell water was found in rainy season.

Status of arsenic-free tubewells

The proportions of arsenic-free tubewells increased in midline at households and educational institutions (Table 5). The proportions of arsenic-free tubewells increased to 60% in midline from 58% in baseline ($p>0.05$) at household levels. The highest increase was found among non-poor households, however, the proportion of arsenic-free tubewells decreased among the ultra poor households in midline (Table 5). We found that 17% (17% ultra poor, 20% poor and 16% non-poor) households drank arsenic contaminated tubewell water in midline (Fig. 2) where more poor households drank arsenic contaminated tubewell water than non-poor and ultra poor households.

Table 2. Use of water in dry season for different purposes from different sources by economic status of households (%)

Sources	Economic status												Total			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	P	BL	ML	RC	P	BL	ML	RC	P	BL	ML	RC	p
Drinking																
Tubewell water	98.8	99.7	0.9	>0.05	98.6	99.2	0.6	>0.05	98.6	99.3	0.7	<0.05	98.7	99.4	0.7	<0.01
Supply water	0.2	0.0	-100.0		0.2	0.1	-50.0		0.4	0.2	-50.0		0.3	0.1	-66.7	
Surface water	1.0	0.3	-70.0		1.2	0.7	-41.7		1.1	0.5	-54.5		1.1	0.5	-54.5	
Cooking																
Tubewell water	66.7	75.0	12.4	<0.01	65.9	73.0	10.8	<0.01	62.6	70.8	13.1	<0.01	65.1	72.9	12.0	<0.01
Supply water	0.2	0.0	-100.0		0.2	0.1	-50.0		0.4	0.2	-50.0		0.3	0.1	-66.7	
Surface water	33.1	25.0	-24.5		33.8	27.0	-20.1		37.2	29.1	-21.8		34.7	27.0	-22.2	
Washing utensils																
Tubewell water	61.5	68.1	10.7	<0.01	56.2	65.3	16.2	<0.01	57.7	65.6	13.7	<0.01	58.5	66.3	13.3	<0.01
Supply water	0.3	0	-100.0		0.4	0.2	-50.0		0.4	0.2	-50.0		0.4	0.1	-75.0	
Surface water	38.2	31.9	-16.7		43.4	34.5	-20.5		41.9	34.1	-18.6		41.2	33.5	-18.7	
Cleaning after defecation																
Tubewell water	62.8	72.4	15.3	<0.01	60.8	72	18.4	<0.01	64.8	73.9	14.0	<0.01	62.8	72.8	15.9	<0.01
Supply water	0.4	0.1	-75.0		0.6	0.2	-66.7		0.9	0.4	-55.6		0.6	0.2	-66.7	
Surface water	36.8	27.5	-25.1		38.6	27.8	-28.0		34.3	27.5	-19.8		36.5	27.6	-24.4	
Bathing																
Tubewell water	28	37.9	35.4	<0.01	22.4	33.3	48.7	<0.01	26.9	36.7	36.4	<0.01	25.8	36.0	39.5	<0.01
Supply water	0.3	0	-100.0		0.5	0.2	-60.0		0.6	0.3	-50.0		0.5	0.2	-60.0	
Surface water	71.7	62.1	-13.4		77.1	66.6	-13.6		72.5	63	-13.1		73.8	63.9	-13.4	
n	1165	1003			1938	1773			3425	3219			6528	5995		

HH: Households; BL: Baseline; ML: Midline; RC: Relative Change (ML-BL)*100/BL

Table 3. Use of water in rainy season for different purposes from different sources by economic status of households (%)

Sources	Economic status												Total			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	P	BL	ML	RC	P	BL	ML	RC	P	BL	ML	RC	p
Drinking																
Tubewell water	98.6	98.0	-0.6	>0.05	98.5	97.5	-1.0	>0.05	98.3	97.8	-0.5	<0.05	98.5	97.8	-0.7	<0.01
Supply water	0.3	0.0	-100.0		0.2	0.1	-50.0		0.4	0.2	-50.0		0.3	0.1	-66.7	
Surface water	1.1	2.0	81.8		1.3	2.4	84.6		1.3	2	53.8		1.2	2.1	75.0	
Cooking																
Tubewell water	64.5	72.1	11.8	<0.01	64.2	68.7	7.0	<0.01	60.9	67.8	11.3	<0.01	63.2	69.5	10.0	<0.01
Supply water	0.3	0	-100.0		0.2	0.1	-50.0		0.3	0.1	-66.7		0.3	0.1	-66.7	
Surface water	35.2	27.9	-21.0		35.6	31.2	-12.4		38.8	32.2	-17.0		36.6	30.4	-16.9	
Washing utensils																
Tubewell water	60.2	64.1	6.5	<0.05	55.3	60.3	9.0	<0.01	56.8	61.7	8.6	<0.01	57.4	62.0	8.0	<0.01
Supply water	0.3	0	-100.0		0.4	0.2	-50.0		0.3	0.2	-33.3		0.3	0.1	-66.7	
Surface water	39.5	35.9	-9.1		44.3	39.5	-10.8		42.8	38.1	-11.0		42.2	37.8	-10.4	
Cleaning after defecation																
Tubewell water	61.8	69.9	13.1	<0.01	60.2	68.7	14.1	<0.01	64.1	71.9	12.2	<0.01	62.0	70.2	13.2	<0.01
Supply water	0.5	0.1	-80.0		0.6	0.2	-66.7		0.9	0.4	-55.6		0.7	0.2	-71.4	
Surface water	37.8	30	-20.4		39.2	31.1	-20.7		34.9	27.7	-20.6		37.3	29.6	-20.6	
Bathing																
Tubewell water	21.1	31.9	51.2	<0.01	17.3	24.4	41.0	<0.01	22.2	28.9	30.2	<0.01	20.2	28.4	40.6	<0.01
Supply water	0.4	0	-100.0		0.5	0.2	-60.0		0.5	0.3	-40.0		0.5	0.2	-60.0	
Surface water	78.5	68.1	-13.2		82.2	75.4	-8.3		77.2	70.8	-8.3		79.3	71.4	-10.0	
n	1165	1003			1938	1773			3425	3219			6528	5995		

HH: Households; BL:Baseline; ML: Midline; RC: Relative Change (ML-BL)*100/BL

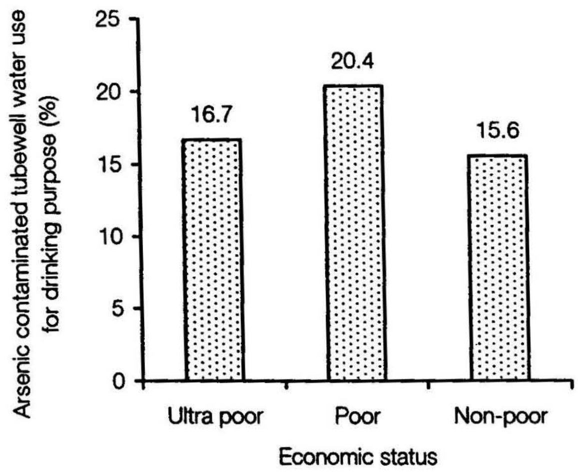
Table 4. Availability of water from different tubewells and supply source during dry season (%)

	Economic status												Total			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p
Dry season																
Single-used tubewell																
Sufficiently available	80.2	77.4	-3.5	>0.05	78.6	72.1	-8.3	>0.05	80.7	72.6	-10.0	<0.01	80.1	73.1	-8.7	<0.01
n	237	248			547	591			1443	1434			2227	2281		
Shared tubewell																
Sufficiently available	83.9	75.1	-10.5	<0.01	82.1	73.6	-10.4	<0.01	83.7	73.9	-11.7	<0.01	83.3	74.0	-11.2	<0.01
n	776	720			1151	1142			1726	1814			3653	3680		
Public tubewell																
Sufficiently available	57.3	30.5	-46.8	<0.01	59.3	27.2	-54.1	<0.001	64.2	26.1	-59.3	<0.01	61.5	27.2	-55.8	<0.01
n	988	768			1694	1476			2974	2561			5656	4813		
Rainy season																
Single-used tubewell																
Sufficiently available	98.7	99.6	0.9	>0.05	99.5	98.7	-0.8	>0.05	99.1	99.1	0.0	>0.05	99.2	99.0	-0.2	>0.05
n	237	248			547	591			1443	1434			2227	2281		
Shared tubewell																
Sufficiently available	99.6	99.4	-0.2	>0.05	99.2	99.0	-0.2	>0.05	99.1	99.0	-0.1	>0.05	99.2	99.1	-0.1	>0.05
n	776	720			1151	1142			1726	1814			3653	3680		
Public tubewell																
Sufficiently available	99.4	99.9	0.5	>0.05	99.7	99.2	-0.5	>0.05	99.3	99.2	-0.1	>0.05	99.4	99.3	-0.1	>0.05
n	988	768			1694	1476			2974	2561			5656	4813		

Table 5. Status of responses on the results of testing of tubewell water for arsenic contamination (%)

Status	Economic status												Total			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p
Arsenic free tubewells	61	60	-2.8	>0.05	56	58	3.0	>0.05	57.8	61.1	5.7	>0.05	58	60	3.6	>0.05
Arsenic contaminated tubewells (%)	39	40	4.4		44	41	-6.1		41.9	38.5	-8.1		42	40	-5.7	
n	160	156			374	382			1135	1035			1669	1573		

Figure 2. Arsenic contaminated tubewell water use for drinking by economic status at household level



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Association between selected background variables and tubewell ownership

The logistic regression analysis for selected variables was performed to examine the prevalence of tubewell among the study households. It showed that the prevalence of tubewell was correlated with the level of economic status as well as self-rated economic status, land ownership and literacy of household head both in baseline and midline (Table 6). The extent of tubewell ownership increased with the increase of economic status of the households both in baseline and midline. Similarly, landowner households had more tendency of owning tubewell than the landless. Though the literacy of household heads showed a higher tendency of owning tubewells in baseline, but in midline, this was identical for both the literates and illiterates.

Table 6. Odds ratio of selected variables predicting the issues of having tubewell

Associated variables	Baseline			Midline		
	OR	95% CI	P Value	OR	95% CI	P Value
Poverty						
Ultra poor	1			1		
Poor	1.2	1.1-1.5	< 0.01	1.2	1.0-1.4	> 0.05
Non-poor	1.6	1.4-1.9	< 0.001	1.6	1.4-1.9	< 0.001
Self rated economic status						
Deficit	1			1		
Equilibrium	1.2	1.1-1.3	< 0.01	1.4	1.2-1.6	< 0.001
Surplus	1.7	1.5-2.0	< 0.001	2.6	2.1-3.1	< 0.001
Land ownership						
Landless	1			1		
Landowner	1.6	1.2-2.0	< 0.001	2.3	1.8-3.0	< 0.001
Literacy of household head						
Illiterate	1		< 0.001	1		
Literate	1.1	1.0-1.2	< 0.05	1.0	0.9-1.2	< 0.05

Water safety measures

Table 7 shows the water safety measures including placement of tubewell compared to latrine, platform condition and its cleanliness and drainage condition.

Placement of tubewell

The placement of the tubewells at upper plane than latrine increased from 14% in baseline to 28% in midline among all economic categories of households. However, more than 42% tubewells were placed in the lower plane than latrine, which significantly increased to 44% in midline. Most of the tubewells were placed within 10 m of latrine, which increased by 1% in midline.

Table 7. Conditions of tubewells by economic status

Characteristics	Ultra poor				Poor				Non-poor				Total			
	BL	ML	RC	P	BL	ML	RC	P	BL	ML	RC	P	BL	ML	RC	p
Functional/defected tubewells																
Functional	92	92.2	0.3	>0.05	91	95	4	>0.05	95	96	0.8	>0.05	93.6	95	1.5	
Needs minimum repair	7	6	-10.3		7	4	-38.2		4	3	-28.2		4.9	3.6	-26.5	>0.05
Needs maximum repair	1	1	50		2	1	-40		1	1	33.3		1	1.1	10.0	
n	237	248			547	591			1450	1446			2227	2281		
Placement of tubewell compared to latrine																
Tubewell is at higher place	14.2	27.8	48.9	<0.01	16.9	30.1	43.9	<0.01	11.9	27.2	56.3	<0.01	13.6	28	105.9	<0.01
Tubewell is at lower place	37.9	41.9	9.5		41.8	41.5	-0.7		42.2	46	8.3		41.5	44.3	6.7	
n	338	389			667	783			1534	1669			2539	2851		
Mean distance of tubewell from latrine																
<2m	13.7	11.1		>0.05	11.1	11.7		>0.05	14.6	14		>0.05	13.7	13	-5.1	>0.05
2-10m	86.3	88.9			88.9	88.3			85.4	86			86.3	87	0.8	
n	204	217			352	386			970	953			1523	1559		
Condition of tubewell platform																
Concrete built platform	58.2	62.9	7.5	>0.05	57.3	63.2	9.3	<0.01	67.5	73.6	8.3	<0.01	63.4	69.4	9.5	<0.01
Broken platform	6.7	5.7	-17.5		6.3	7.6	17.1		6.7	6.7	0		6.6	6.8	3.0	
n	524	455			1070	999			2257	2133			3851	3598		
Cleanliness of tubewell platform																
Clean	31.5	40.3	27.9	<0.05	27	36.5	35.2	<0.01	34.2	41.6	21.6	<0.01	31.8	46	44.7	<0.01
n	523	454			1070	997			2254	2132			3851	3598		
Drainage system of tubewell																
Concrete drain	14.7	17.6	19.7	>0.05	12	14.2	18.3	>0.05	16.4	20.7	26.2	<0.01	15	18.6	24.0	
Earthen drain	63.7	60.1	-5.7		66	62.1	-5.9		61.5	54.5	-11.4		63.1	57.3	-9.2	<0.01
Pipe	10.7	11.2	4.7		11.3	13.9	23		14.1	16.7	18.4		12.8	15.2		
n	524	454			1070	998			2257	2131			3851	3598		

Status of concrete-built platform of tubewells

The proportion of concrete-built platform significantly increased in midline at household level (<0.01) but no significant difference was found at educational institutions and at mosque ($p>0.05$). The highest increase (10%) was seen in midline from 63% in baseline at household level. In the educational institutions concrete-built platform increased to 92% in the midline from 88% in baseline.

Cleanliness of tubewell

Significant improvement of cleanliness of tubewell platform was seen in midline compared with baseline across households. Cleaned tubewell platform was found 32% in the baseline, which increased to 42% in midline among households of all economic categories. Relatively higher proportion of cleaned tubewell platforms were observed in midline among non-poor households.

Drainage system of tubewell

More than 60% of the tubewells had earthen drain in baseline, which decreased from 63% to 57% in midline, wheras the proportion of concrete drain significantly increased from 15% in the baseline to 19% in midline ($p<0.01$). The proportion of pipe drain increased in midline among all categories of households where non-poor had higher proportion than poor and ultra poor households.

Awareness regarding cleaning/purifying water and prevention of waterborne diseases

The awareness of cleaning/purifying water increased significantly when major options used in the household level ($p<0.01$) (Table 8). Boiling was the best option that 64% households reported in baseline, which increased to 80% in midline. The increase was found to be highest (27%) among the ultra poor households. The proportion of respondents who did not know how water could be cleaned/purified significantly decreased from 19% to 8% in midline. Respondents noted that water could be cleaned/purified by using medicine, which increased significantly in midline.

Significant difference was found across the households regarding awareness on prevention of waterborne diseases. Waterborne diseases could be prevented by drinking pure water that 52% respondents opined in baseline, which increased significantly to 57% in midline. The increase was highest (19%) among the ultra poor households. Drinking tubewell water could prevent waterborne diseases that 19% respondents opined in baseline, which increased significantly to 37% in midline. The increase was highest (118%) among the poor households.

Table 8. Respondent's awareness regarding cleaning/purifying water and prevention of waterborne diseases (%)

Awareness issues	Economic status												All			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p
Opinions regarding cleaning/purifying water																
By boiling	60.9	77.6	27.4	<0.01	62.8	79.0	25.8	<0.01	66.1	80.6	21.9	<0.01	64.2	79.6	24.0	<0.01
With medicine	6.9	16.6	140.6	<0.01	6.5	14.7	126.2	<0.01	8.9	18.7	110.1	<0.01	7.8	17.1	119.2	<0.01
By filtering	0.8	2.8	250.0	<0.01	1.6	4.5	181.3	<0.01	2.7	5.3	96.3	<0.01	2.1	4.6	119.0	<0.01
Don't know	22.8	9.1	-60.1	<0.01	20.9	9.1	-56.5	<0.01	16.9	7.8	-53.8	<0.01	19.1	8.4	-56.0	<0.01
Others	19.2	19.3	0.5	>0.05	20.5	18	-12.2	>0.05	22.2	18.7	-15.8	<0.01	21.2	18.6	-12.3	<0.01
n	1168	1003			1941	1773			3491	3219			6600	6007		
Opinions regarding prevention of waterborne diseases																
Drinking pure water	46.4	55.1	18.8	<0.01	51.4	55.1	7.2	<0.05	53.7	59.3	10.4	<0.01	51.7	57.3	10.8	<0.01
Drinking tubewell water	16.8	36.2	115.5	<0.01	18.4	40.1	117.9	<0.01	20.6	36.0	74.8	<0.01	19.3	37.3	93.3	<0.01
Others	5.2	2.2	-57.7	<0.01	5.0	1.1	-78.0	<0.01	4.3	1.7	-60.5	<0.01	5.2	2.0	-61.5	<0.01
Don't know	34.8	13.6	-60.9	<0.01	28.9	11.8	-59.2	<0.01	26.4	12.2	-53.8	<0.01	28.6	12.3	-57.0	<0.01
n	1168	1003			1941	1773			3491	3219			6600	6007		

Table 9. Covering of water buckets during carrying and storing water for drinking and cooking purposes (%)

Status	Economic status												Total			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p
Covering of water buckets for drinking purpose																
During carrying	52.4	70.7	34.9	<0.01	54.0	71.9	33.1	<0.01	54.8	72.7	32.7	<0.01	54.1	72.1	33.3	<0.01
During storing	64.0	65.6	2.5	>0.05	59.3	65.1	9.8	<0.01	59.9	64.1	7.0	<0.01	60.5	64.7	6.9	<0.01
Covering of water buckets for cooking purpose																
During carrying	48.5	61.9	27.6	<0.01	53.4	66.1	23.8	<0.01	49.2	61.9	25.8	<0.01	50.3	63.1	25.4	<0.01
n	1168	1003			1941	1773			3491	3219			6600	6007		

Satisfaction of existing water sources, interest in and preference to install new water sources

The level of satisfaction with existing water increased from 50% in midline to 51% in baseline among the households ($p>0.05$). It was highest among the ultra poor (<0.01). At the same time, we asked the respondents whether they were interested to install new water sources. Significant difference was found across households on the interest to install new water sources. In baseline, 59% of the respondents were interested to install new water sources, which increased significantly to 68% in the midline. The increase was highest among non-poor than the ultra poor and the poor households. Moreover, in the case of installing new water sources, we asked which types of water sources they usually would prefer. In baseline, 74% of the respondents opined that they would prefer tubewell water. Significant increase was found in midline where 91% opined that that they would prefer tubewell water, which was 74% in the baseline. It was highest among non-poor households (<0.01) (Table 10).

Preferred amount of monthly instalment for loan repayment

The respondents were asked if a new tubewell was installed through loan from government or any organization, then how much money they could repay per month. Significant increase was found in the midline on the willingness to repay the preferred monthly instalment (Table 11). More than 40% of the respondents in baseline reported that they could pay Tk.75-150 per month to install tubewell, which increased significantly to 45% in midline ($p<0.01$). It was highest among non-poor households.

Table 10. Status of satisfaction with existing water sources, interest to install new water sources and preference of tubewell as water source (%)

Subject	Economic status												Total			
	Ultra poor				Poor				Non-poor							
	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p	BL	ML	RC	p
Satisfied with existing water sources	43.3	49.1	13.4	<0.01	47.6	50.1	5.3	>0.05	53.5	52.8	-1.3	>0.05	50.0	51.3	2.6	>0.05
n	1168	1003			1941	1773			3491	3219			6600	6007		
Interested to install new water source	61.8	69.0	11.7	<0.01	63.8	70.2	10.0	<0.01	56.0	65.7	17.3	<0.01	59.3	67.7	14.2	<0.01
n	1168	1003			1941	1773			3491	3219			6600	6007		
Preference of tubewell as water sources	80.8	91.2	12.9	<0.01	76.3	90.0	18.0	<0.01	70.4	90.8	29.0	<0.01	74.2	90.7	22.2	<0.01
n	722	692			1238	1244			1955	2116			3915	4064		

Table 11. Distribution of respondents according to willingness to pay for tubewells (%)

Preferred instalment	Ultra poor			Poor			Non-poor			Total		
	BL	ML	RC	BL	ML	RC	BL	ML	RC	BL	ML	RC
>400	1.3	1.2	-7.7	1.8	2.4	33.3	3.7	4.5	21.6	2.6	3.3	26.9
300-400	0.1	0.2	100.0	0.2	0.2	0.0	0.6	0.4	-33.3	0.4	0.3	-25.0
250-300	0.6	1.2	100.0	1.4	1.8	28.6	2.5	2.7	8.0	1.8	2.1	16.7
200-250	1.1	0.9	-18.2	1.3	1.3	0.0	1.8	1.8	0.0	1.5	1.5	0.0
150-200	6	10	70.0	9.7	12	23.7	14.7	13.3	-9.5	11.5	12.4	7.8
75-150	37	41	10.4	41.7	44.1	5.8	39.2	46.5	18.6	39.6	44.9	13.4
50-75	2.2	2.1	-4.5	2.5	2.3	-8.0	1.5	1.5	0.0	1.9	1.9	0.0
25-50	19	17	-10.2	13.2	16.1	22.0	8.9	10.3	15.7	12	13.1	9.2
<25	33	26	-20.1	28.2	19.9	-29.4	27.3	19.2	-29.7	28.6	20.6	-28.0
n	722	657	-9.0	1237	1169	-5.5	1954	1952	-0.1	3913	3790	-3.1
p	<0.05			<0.001			<0.001			<0.001		

Discussion

Findings show the increase in the use of tubewell water for different purposes as well as for drinking at households in both dry and rainy seasons. In rainy season, some households (0.7%) used rainwater for drinking which might have contributed to the declined use of tubewell water in midline. The availability of sufficient tubewell water decreased in midline, which might be due to the decline of groundwater level. In the dry season, generally groundwater table falls beyond the suction lift of tubewell. This might be caused by more lifting of groundwater for irrigation and domestic purposes. Besides, little rainfall also again causes less recharge of groundwater. However, more than 86% of lifted water is used in the agricultural sector (Hoque *et al.* 2006). Groundwater level in some locations under WASH programme falls between 5-10 m in dry season. Research shows that in the dry season, most of the tubewells failed to lift sufficient water (Dey *et al.* 2010a).

Baseline data were not available on the use of arsenic contaminated tubewell water in the households and educational institutions. However, the proportion of respondents reporting drinking tubewell water in baseline and midline at household level was almost similar. Thus, the study found that most households (83%) drank arsenic-free tubewell water. An UNICEF study (2010) supports this finding that, on an average, nearly 87% population of Bangladesh drink arsenic-free water.

The prime reason for using tubewell water was their health concern, though some proportion of households drank arsenic contaminated tubewell water. Ultra poor (17%) and poor (20%) households drank much more arsenic contaminated water than the non-poor (16%) households. Financial inabilities for installing deep tubewell, non-availability of arsenic-free tubewell water, unmarked tubewell whether contaminated by arsenic and not, were identified as the major reasons for drinking arsenic contaminated tubewell water by the households. It is noteworthy that wide-spread information plays important role in refraining people from drinking arsenic contamination water. Studies indicate that drinking arsenic contaminated water causes various arsenic-related diseases, where at least 6,500 people may die from cancer every year and 2.5 million people will develop some kind of arsenicosis in the next 50 years (Mitra *et al.* 2002; Roy *et al.* 2008).

A study identified the improvement of water safety measures including improvement of awareness of cleaning/purifying water and hygienic management of water for drinking and cooking in midline (Dey and Ali 2010b). This can be attributed to the BRAC interventions for raising awareness on safe water use and its hygienic management at the households/community levels. Other research also shows that proper hygiene education makes the community members aware of the correct use, storage and disposal of water and general hygiene (Duncker 2000).

Significant improvement occurred among the study households on awareness on the prevention of waterborne diseases. This may help prevent diarrhoeal diseases especially among children. Our current study also reveals that 94% of the diarrhoeal diseases are preventable through modifications to the environment, including access to safe water (WHO 2007). Studies in BRAC WASH programme also found that the combined effect of safe water, sanitation and hygiene practices reduced the prevalence of waterborne diseases nearly by 30%, after 2 years of interventions (Rana 2009).

The observed significant increase in concrete-built tubewell platforms and their cleanliness at households and at educational institutions might be the impact of BRAC WASH programme the study shows that concrete-built tubewell platforms and keeping them clean may reduce the chances of water contamination at the source (Luby *et al.* 2008). Thus, BRAC WASH programme's loan support to the households and motivation to build tubewell platforms with concrete seems to be beneficial.

The study has some methodological weaknesses. A weakness of the study is exclusion of control group. Provision of comparison group heels to precisely measure the actual effects of the interventions (Habicht *et al.* 1998). Nevertheless, availability of baseline information and random selection of the study participants allow attributing the changes due to the intervention.

Conclusion

WASH intervention has succeeded in increasing the access to safe water in the households/ community. Besides, significant improvement in water safety measures (at source, carrying and preservation) was identified in the study area. However, there were still some impediments of drinking safe water by the households include arsenic contamination of tubewell water, financial inabilities of the ultra poor and poor households, unmarked tubewell (whether contaminated by arsenic or not). It is encouraging to note that the ultra poor households had interest to get new tubewells and prefer to pay the costs in monthly instalments, which indicates that these households were aware of the benefits of safe water.

Recommendations

Opportunity of getting loan with affordable repayment schedules may encourage community people to install tubewell to get arsenic-free water and prevent possible health hazards.

Special attention should be given in the dry season when groundwater table usually fall beyond the suction lift of tubewell. Thus, more deep set pump and piped water supply systems can be installed for getting arsenic-free water, and arsenic removal filter and pond sand filter can be provided for safe water in the arsenic prone areas.

Proper guideline for installation of tubewell in relation to the latrines should be followed. Each tubewell must be provided with a concrete platform.

Besides, emphasis should be given on arsenic testing and to inform the households/ community about the results of testing of tubewell water. Thus, BRAC WASH programme needs to pay more attention to these impediments at the household level to further improve current situation.

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