BRAC/DPHE/UNICEF Collaboration on Community-Based Arsenic Response

Final Report

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Abstract

The severity of the problem of arsenic in groundwater in Bangladesh is now well recognized. 97% of the population relies on ground water for drinking and cooking purposes and it is estimated that half of the country may have arsenic in the subsurface.

The source of the arsenic is geological and due to the sedimentary processes which lead to accumulation of arsenic and release to groundwater the level found in tubewell water are spatially variable-one well may be highly contaminated whereas nearby another is not. The severity of arsenic poising, or arsenicosis, also varies dependent on the length of exposure, the level of arsenic being ingested and the socio-economic (or nutritional) status of the individual concern.

BRAC, a non-governmental organisation, in conjunction with DPHE and UNICEF have begun efforts to assess and mitigate the arsenic problem in two thanas of Bangladesh - Sonargaon and Jhikorgacha.

Testing has so far been carried out in one union, Boiderbazar union of Sonargaon Thana. 61% wells of this union were contaminated with arsenic above the Bangladesh standard of 0.05 mg/l.

Installation and assessment of safe water options has begun. The options being advocated are: treatment of ground water with home based candle filters, treatment of surface water with Pond Sand Filter (PSF), Rain Water Harvesting (RWH).

These options are being assessed on several criteria: initial and operating costs; ease of implementation, operation and maintenance; continuity of supply; susceptibility of bacteriological contamination and acceptability to the community.

All of these options have their limitations and none are as easy as obtaining tubewell water directly, however, at present home based filter are proving most popular due to low cost, ease of use and acceptability. Continued manufacturing quality of these home based filter must be ensured and the lifetime of the candle assessed.

1. Introduction

1.1 Background to the arsenic problem

Bangladesh faces multi-faceted problems in relation to groundwater. Now there is also a new threat - arsenic contamination in ground water. It is estimated that over half of the Bangladeshi population are at risk of arsenic poisoning. Since 97% of the population relies on groundwater for drinking purposes, nearly everyone living in affected areas is at risk of arsenic poisoning.

The degree of toxicity of arsenic depends on its chemical form and speciation. Arsenic may be organic or inorganic. Humans are exposed to arsenic mainly through ingestion and inhalation. The World Health Organization (WHO) has recently revised its original guideline value for arsenic in drinking water of 0.05mg/l (WHO, 1984) to a provisional guideline value 0.01 mg/L (WHO, 1993). The Bangladesh government level is 0.05 mg/l (DoE, 1991). Water with high levels of arsenic leads to the development of health problems, such as melanosis, lenko-melanosis, hyperkeratosis, black foot disease, cardiovascular disease, hepatomegaly, neuropathy and cancer. Arsenic accumulates in the liver, kidney, heart and lungs. It is also deposited in bones, teeth and hair (Khan, 1997). The toxicity of arsenic depends on the chemical and physical forms of compound, the route by which it enters the body, the dose and the duration of exposure, dietary compositions of interacting elements and the age and sex of the exposed individuals.

For manifestation in a person's body the symptoms of arsenic toxicity may take several years after the starting date of drinking arsenic contaminated water. This period differs from person to person, depending on the quantity and volume of arsenic ingested, nutritional status of the person, immunity level of the individual and the total time period of arsenic ingestion. The hazards of arsenic toxicity are aggravated by malnutrition and poor socio-economic conditions. Although arsenicosis is not an infectious, contagious or hereditary disease, arsenic toxicity creates many social problems for the victims and their families (Khan & Ahmad, 1997).

The source of arsenic in drinking water is geological. Arsenic is naturally occurring in the sediments bound to amorphous iron oxyhydroxide. Due to the strongly reducing nature of Bangladesh groundwater this compound is broken down and arsenic is released to groundwater (Nickson et al, 1998).

There are over four million hand tubewells in Bangladesh but this number was only 185,000 in 1971. It has been estimated that capacity of a hand tubewell is about 18 litre per minute and maximum working hours per day is six from morning to evening. The number of irrigation wells was about a few hundred in 1971 but this number is now more than one hundred thousand. Capacity of a irrigation well is about 1700 litre per minute and this type of pumps usually works round the clock particularly during dry season (February- May).

Approximately 25% water of hand tubewells tested by the government to date in the apparently arsenic affected areas have shown the presence of arsenic. Arsenic contamination has been detected mainly in groundwater from the shallow aquifer (less than 50 meters deep). Now the main challenge is how to provide arsenic free drinking water to the millions of people at risk.

Many organizations have implemented different arsenic programs, most of which have focused on testing tubewell water for arsenic. The World Bank is taking the lead in coordinating an integrated response to the arsenic crisis and is supporting the Government of Bangladesh Arsenic Mitigation-Water Supply Project (BAMWSP). A key component of the BAMWSP will be the use of community-based, demand driven projects, in which community members play an active role in choosing and implementing solutions to the site-specific problems of arsenic contamination. However, the program is yet to be off the ground.

1.3 Project objectives

The objectives of the action research project were:

i. To determine the extent of arsenic contamination in all tubewell water of the project area by -

- training community members to test all tubewells using field kits, and mark all tested tubewells (red if arsenic detected, otherwise green);
- identifying arsenic affected patients in the project area.

ii. To determine the technical viability and effectiveness of different mitigation options and to assess their relative acceptance by villagers by -

- conducting a Participatory Rapid Appraisal (PRA) to map resources in each of the project villages;
- involving community members in selection and implementation of a source of arsenic-free drinking water;
- installing and/or supplying demonstration units of different alternate safe water options in the project area;
- monitoring operation and maintenance of alternate drinking water systems and continued promotion of safe water use in the community;
- monitoring quality of water supplied from different alternative sources for arsenic, coliform and others.
- interaction with the community and evaluation of their acceptance of different mitigation strategies

1.4 Project areas

Boiderbazar union of Sonargaon thana (Figure 1), Narayanganj was selected as our pilot project site. This union consist of 24 villages. Meghna river flows to the east of this union.

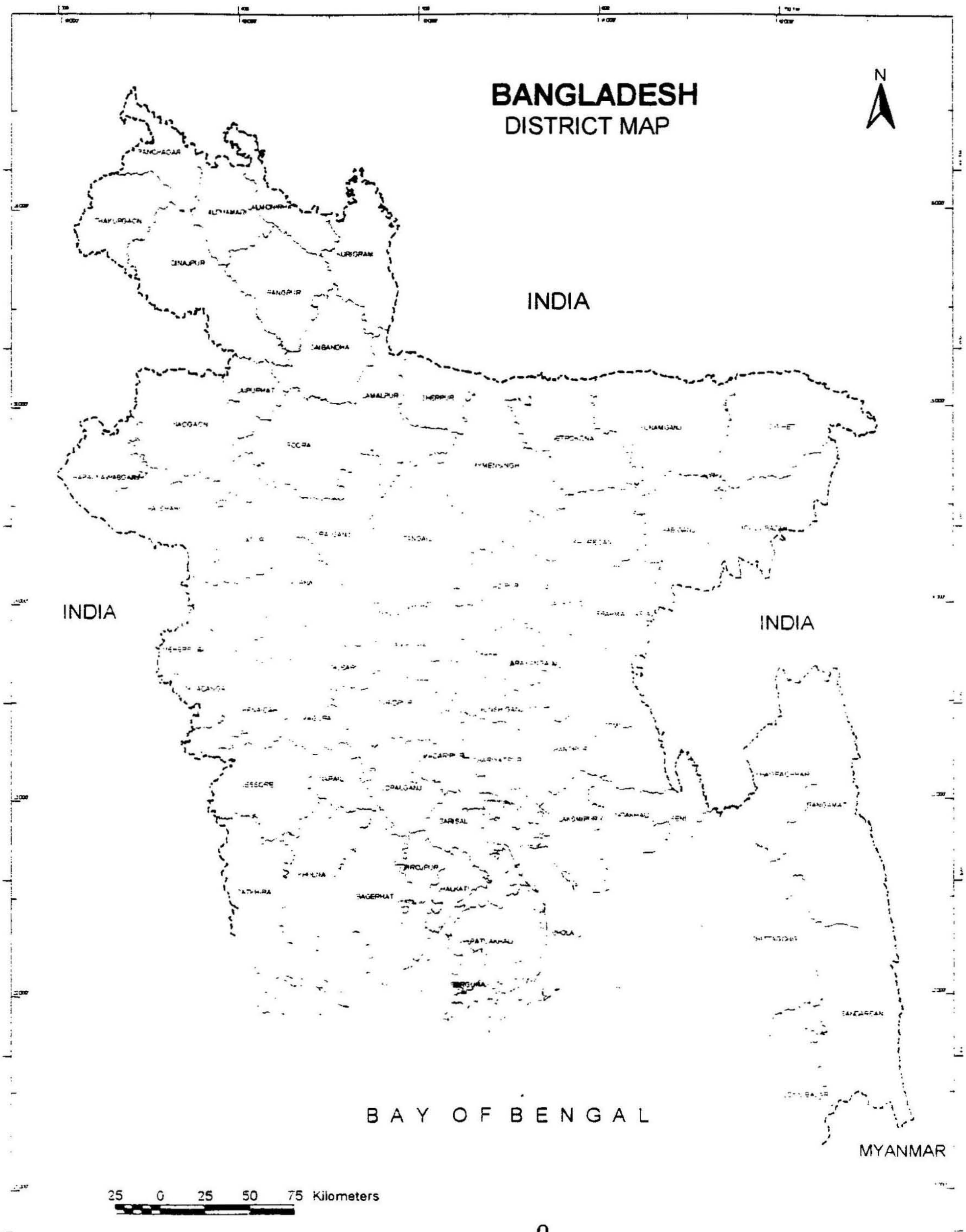
A good communication exist in the project area. The main goal of the project was to install alternate safe water options in arsenic affected areas. Priority was given to the villages where the arsenic problem was acute.

2. Testing of tubewell water for arsenic and identification of affected patients

2.1 Testing methods used

Field kits promoted by National Institute of Preventive and Social Medicine (NIPSOM) in Dhaka were used for testing. This kit costs Tk. 900 (US $ 19) and can test up to 85 water samples. This user friendly kit is able to detect arsenic contamination as low as 0.01 mg/L (Khan & Ahmad, 1997). Different reagents are used in the field kit procedure and the test is based on chemical reactions[1]. BRAC started using this kit in September 1997 when it started arsenic testing programme in the tubewell water. Till now, BRAC tested more than 25,000 tubewell water (all tubewells of Hajiganj thana, all tubewells of BRAC offices and all tubewell installed by DPHE during the year 1997-98).

[1]n ground water arsenic usually occurs as arsenite (As-III) and arsenate (As-V). To determine the existence of arsenic in water, arsenate is reduced to arsenite by the reducing agents Potassium Iodide (KI) and Stannous Chloride ($sncl_2$). The As-III is then reacted with Zinc and Hydrochloric Acid (HCl) to produce arsenic gas. A color change between light yellow to reddish brown (produced by the reaction of arsenic gas with mercury bromide paper) indicates the presence of arsenic in water. The absence of arsenic in the water is indicated by no colour change on the bromide paper.


BANGLADESH
DISTRICT MAP
N
INDIA
INDIA
INDIA
BAY OF BENGAL
MYANMAR
25 0 25 50 75 Kilometers

In Hajiganj thana we tested about 12,000 tubewells with the NIPSOM kit of which 92% of the field result were confirmed by the laboratory analysis (Chowdhury and Jakariya, 1999).

2.2 Training of personnel for arsenic testing

BRAC Community Health Workers from different villages were trained at local BRAC offices in health effects of arsenic, patient identification, arsenic testing and alternate sources. A two day training course was organized for the village health workers and the training was conducted by the environment group of BRAC. All hand tubewells in the villages were tested and painted by the VHWs, who also examined the villagers initially for symptoms of arsenic poisoning. Several village meetings were held with a cross section of villagers along with VHWs, and a Participatory Rapid Appraisal (PRA) conducted on the purpose of the project.

The village health workers (VHW) carried out the testing program kits. VHWs are illiterate women who had earlier been trained by BRAC to treat selected common illnesses in the village (Chowdhury et al. 1997). They were given two day training on use of the field kit. A total of 1,190 tubewells were tested in one union of Sonargaon. It took about 15 days to complete the testing and painting the tubewell spouts in both unions by 10 shasthy shebica.

2.3 Identification of affected patients

Village health workers were also given an initial idea how to detect arsenic affected patients. This initial screening of arsenicosis patients done by the village health workers was later confirmed by doctors. A total of 23 patients in Baidderbazar were identified by the village health works. The VHW's also took part in the social mobilization and awareness raising of the community people about arsenic and alternate safe water options.

2.4 Results

The results of the arsenic testing and identification of affected patients in Boidderbazer union, Sonargaon thana Tables 1.

Table 1: Detailed status of arsenic contamination in different tubewell water of Boidderbazer union, Sonargaon thana

Name of the villages	Total No. of Tested TW	No. of Red Tubewells	No. of Green Tubewells	No. of inactive Tubewells	% of Red Wells	No. of Patient Identified
Mamrakpur	62	41	19	2	66	2
Dhigichandpur	11	8	2	1	72	0
Nakatibhanga	17	12	5		70	0
Sonamoi	23	8	15		35	0
Khamargaon	35	27	8		77	1
Techpara	10	7	3		70	1
Sarkerbari	18	15	3		83	0
Basandardi	20	18	2		90	0
Bhabnadhigirpar	12	11	1		92	0
Chanpara	35	13	22		37	0
Nagerpur	5	2	3		40	0
Satbhaiapara	100	71	26	3	1	1
Mobarakpur	21	18	3		86	1
Khongsadi	36	33	3		92	1
Nagerbagh	6	2	3	1	33	0
Ramganj	25	21	4		84	1
Haria	173	83	89	1	48	8
Chandrakirti	16	4	12		25	1
Ulukandi	22	15	7		68	1
Khaserkanda	25	17	8		68	0
Hamsadi	191	180	11		94	2
Damadardi	218	82	136		38	2
Panchabati	65	7	57	1	11	1
Gabtoli	44	25	19		57	0
Total	1190	720	461	9		23

2.5 Discussion

It can be seen from Table 1 that in Boidderbazer union, Sonargaon thana roughly two thirds of the tested tubewells were found to be contaminated with arsenic above the acceptable limit of 0.05 mg/L This clearly indicates that the situation is quite alarming.

3. Village Meetings and Resource Mapping

3.1 Village Meetings

It has been proved that sustainable development can not be achieved without involving community people in any planning or development process. In this project usually several village meetings are held in each village to inform and involve community people. These are as follows:

i. Just after completing the tubewell testing to inform the villagers about arsenic and the testing results of that village.

At this meeting the potential safe water options are also discussed. The following topics are covered: different alternative safe water options and their merits and demerits, approximate cost and methods of operation and maintenance of these safe water options and possible demonstration site for the chosen alternative safe water options. The villagers express their opinions about the possibilities and express acceptance or rejection.

Taking into account the opinions of the villagers BRAC proceed with demonstration of different alternative safe water options, with no cost to the community at the initial stage. The community decide where the system would best be located, and commit to maintaining it.

ii. The second meeting occurs at the time of construction or distribution of the alternative safe water options in order to motivate villagers about the option as well as to involve them in the process of obtaining safe water.

iii. The final meeting is after constructing the alternative safe water options to inform about the monitoring, operation and maintenance and again to raise awareness level of the villagers about their alternatives.

3.2 Resource Mapping

Making a resource map of a village is an important tool for development projects. In this project the resource map is drawn by the BRAC supervisor in consultation with the villagers. Usually this resource map gives an idea of the resources available in the village and their locations relative to other important landmarks. In particular this is useful to give an idea of the water resources of the area to aid in selection alternative safe water options, and as well as to indicate arsenic free well locations. Examples of the resource maps can be seen in Appendix 1.

4. Safe Water Options

4.1 Introduction to safe water options

This action research project is unique in nature because at present very little knowledge is available on the different alternate safe water options. One of the objectives of the pilot project was to assess the technical viability as well as the effectiveness of different alternate safe water options and to discover the community acceptance of different options. The following alternate safe water options were selected for this project:

- Rain water harvesting (RWH)
- Pond sand filter (PSF)
- Safi filter

All of these alternative safe water options are not feasible for every place or for every class of people in society. Therefore, it is required to evaluate the viability, effectiveness and the acceptance of different options.

4.2 Training on Construction

For the constructed options (i.e. PSF and RWH) a two day training on construction methods followed by a practical demonstration of each of the alternative safe water options was organized for local masons. This training was conducted by the DPHE masons who have extensive experience in constructing these type of structures particularly in the coastal regions of Bangladesh. The other intention of involving local masons in the training and construction process was to build local capacity so that villagers can use their skills to continue construction of safe water options in future. The whole construction process was guided and overseen by the technical advisor and BRAC engineer.

At the time of implementing the alternative safe water options DPHE and UNICEF were duly consulted to utilize their long experience in this particular sector.

4.3 Rain water harvesting (RWH)

4.3.1 Design of system

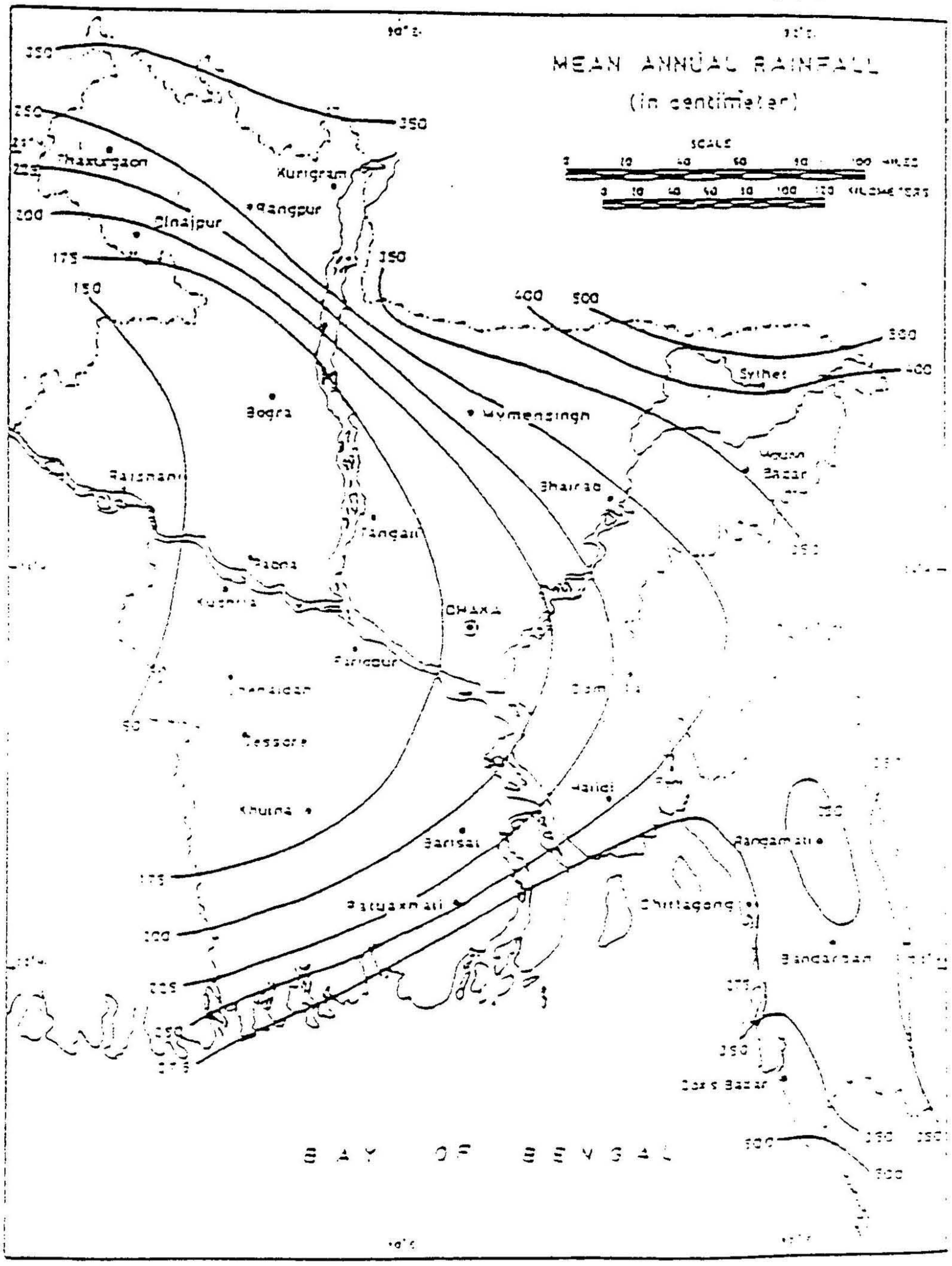
Bangladesh receives abundant rainfall throughout the year, mean annual precipitation ranges from 1,400 mm (about 55 inches) along the country's east central border to more than 5,000 mm (200 inches) in the far north-east. The wet months are from mid June to late September and the dry period is from January to April. About 80% of the annual precipitation occurs in the monsoon period (Fig : 2).

A family of six in Bangladesh needs about 30 litres per day of hygienically safe water for drinking, and food preparation. A 30-day dry period requires approximately 1,000 litres of stored water. Therefore, a 3200 liter container would be enough for two families. The cost of constructing such rainwater harvesting technique is about Tk. 9,600. Water from tubewells that are not necessarily arsenic free can be used for other purposes such as bathing, washing clothes and other domestic purposes.

Rainfall patterns should be confirmed with local communities to ascertain the feasibility of RWH, and alternatives and parallel use of other options considered before constructing RWH jars.

Rainwater harvesting is in use in many parts of the world. There is a long established tradition of rainwater collection in some parts of Alaska and Hawaii. City of Austin, Texas offers rebate for using rainwater for some household users. The island of Gibraltar has one of the largest rainwater collection systems in existence. Rainwater harvesting is also popular in Kenya, South Africa, Botswana, Tanzania, Sri Lanka, Thailand (Daily Star, 24 Sep. 1999).

F. 2


MEAN ANNUAL RAINFALL
(in centimeter)
SCALE
Thakurgaon
Kurigram
Rangpur
Dinajpur
Sylhet
Bogra
Mymensingh
Bhairab
Tangail
Pabna
Kushtia
DHAKA
Faridpur
Jessore
Khulna
Barisal
Patuakhali
Rangamati
Chittagong
Bandarban
Cox's Bazar
BAY OF BENGAL

4.3.2 Technical details

Rain water harvesters are constructed using pre-cast concrete blocks. These are set on a concrete base in a cylindrical arrangement and tied together with wire. The inner and outer surfaces are then covered with cement. Water is channeled from collection pipes on the roof into the RWH through a funnel with a mesh filter. The RWH is covered with a lid. This design can hold 3200 litres of rainwater.

The cost of constructing one RWH including the material, carrying and labour cost is about Tk. 9,600 and it takes about seven days to complete the whole construction process. After completing the construction the potential users are advised to fill the tank with rain water and not to use the water for at least seven days. At the end of the seven days they are also advised to wash the inside of the tank and add ½ kg. of bleaching powder to disinfect the tank. At the same time the caretaker of the rain water harvester is given training on the operation and maintenance of the system.

The first rainwater collected may carry with significant amounts of contaminant (debris, dirt, dust) which have accumulated on the roof and in the gutters. It is therefore recommended not to collect rainwater for the first 5/10 minutes after starting the rain. The quality of the collected water can be improved by the proper maintenance of the roof and gutters and the careful cleaning at the beginning of each wet season.

4.3.3 Monitoring

Monitoring the water quality for bacteria and others is an important component of the action research project. Analysis was done for total coliform bacteria to assess the standard of the RWH water for drinking.

Tests of RWH water some time showed high levels of total coliform bacteria. As these levels have always returned to normal in subsequent monitoring we assume that these high results are erroneous or reflect contamination during sampling.

Table 2: MONITORING OF RAIN WATER HARVESTERS (June- August 1999)

Location of RWHs	Date of Sample Collection	Total Coliform Bacteria		
		June	July	August
DIGHICHANDPUR	1st week	270	10	0
	2nd week	0	-	0
	3rd week	0	36	0
	4th week	10	0	-
HARIA	1st week	130	0	no data
	2nd week	--	0	no data
	3rd week	0	1200	0
	4th week	0	0	0
KHONGSADI	1st week	540	130	0
	2nd week	0	4	-
	3rd week	70	0	0
	4th week	130	0	-
RAMGONJ	1st week	120	-	no data
	2nd week	0	0	no data
	3rd week	0	100	0
	4th week	-	0	0
HAMSADI	1st week	30	5	0
	2nd week	0	0	0
	3rd week	0	32	0
	4th week	50	4	0
BASANDARDI	1st week	-	6	0
	2nd week	-	0	0
	3rd week	0	0	0
	4th week	60	0	0
MOBARUKPUR	1st week	-	175	0
	2nd week	-	27	0
	3rd week	-	1000	0
	4th week	175	0	0
KHAMARGAON	1st week	-	0	0
	2nd week	-	-	2
	3rd week	-	4	0
	4th week	-	0	0
SARKERBARI	1st week	-	9	0
	2nd week	-	-	0
	3rd week	-	0	0
	4th week	90	0	0
TECPARA	1st week	-	-	0
	2nd week	-	-	2
	3rd week	-	-	0
	4th week	-	0	0

There have been concerns that rainwater may pick up unhealthy substances whilst falling through the atmosphere, whilst running down a roof or whilst resting into a store. The danger from the first of these, namely atmospheric pollution, seem slight. Measurements of precipitation even in industrialized areas indicate a fairly low take-up of heavy metals from the air and wholly tolerable levels of acidity; however no doubt it is wise not to harvest the rainwater of the first 5/10 minutes.

4.3.4 Problems and constraints

From the statistics given at the start of this section it can be seen that in Bangladesh there is good potential for collecting rainwater. However, due to the seasonal distribution of this rainfall a large amount of storage is required to make this a year round option.

Experience gained so far indicates that beyond the wet seasons storage of rainwater is not economically feasible at family level because of its construction cost. This leaves two options: smaller, cheaper RWH for use of rainwater only during wet season with a need for another option during the rest of the year; or a communal approach to collect large amounts of rainwater for year round use.

4.4 Pond sand filter (PSF)

4.4.1 Design of system

Filtration is the process whereby water is purified by passing it through a porous material or media. In slow sand filtration a bed of fine sand is used through which the water slowly percolates downward. The suspended matter present in the raw water is largely retained in the upper 0.5-2 cm. of the filter bed. This allows the filter to be cleaned by scrapping away the top layer of sand. The filter cleaning operation need not take more than one day, but after cleaning one or two more days are required for the filter bed to again become fully effective.

devices. These have the function of keeping both the raw water level and the filtration rate constant. The design in use is based on the DPHE/UNICEF 'Small Pond Sand Filter', (drawing no. PSF-02, December 1988) designed by Sohrab Bagheri (DPHE and UNICEF, 1988-93).

It takes about nine days to complete the construction of a normal pond sand filter (PSF). The cost for constructing one normal PSF is about Tk. 31,000.
As the project progressed it was noticed that the PSF was not wholly effective. In order to facilitate removal of particulate matter and bacteria some design improvements have been made.

First, a 'roughing filter' containing brick chips was added. This is an extra chamber added onto the side of the PSF through which the water flows horizontally before entering the sand bed.

Another innovation which is being tested as a pre-treatment before PSF filtration is addition of alum to the water followed by coagulation and settling. Small pieces of solid alum and brick chips are contained in a funnel under the tubewell spout. The water flows through this funnel then flows into a sedimentation basin constructed on the side of the PSF where coagulation and settling occurs. It then flows into the normal PSF system.

The construction cost of a PSF with roughing filter or sedimentation basin is about Tk. 41,000 and it takes about eleven days to construct these styles.

A water management committee composed of potential users of the PSF was formed for each of the constructed PSF. They were given training on operation & maintenance of PSF. Their activities were monitored frequently by the project supervisors.

In areas where saline intrusion has affected groundwater up to a depth of 1000 feet along the coastal belt in Bangladesh, the local population are dependent on surface water from dug ponds. However, the water from these ponds is unpotable without adequate treatment. DPHE with funding from UNICEF have installed slow sand filtration units into which pond water is fed using a handpump. These units are called Pond Sand Filters (PSF). The use of PSF technology to filter surface water is also considered appropriate for areas where groundwater is contaminated with arsenic. One pond sand filter can supply the daily requirement of pure water for about 40/50 families.

At the beginning of the project two PSFs were constructed in Sonargaon thana. These two ponds were selected based on the following criteria:

- Pond will not be used for fish culture
- Pond should be protected in all respects, e.g. free from over bank spill and domestic runoff etc.
- Pond will not be used for cattle washing or other domestic purposes.
- Pond should be perennial.
- Finally, community pledge involvement in operation and maintenance of the pond and PSF.

4.4.2 Technical details

The PSF is a tank containing the bed of filter material. Water is pumped into the PSF using a tubewell head connected to a pipe which intakes water from the pond. At the bottom of the tank an underdrain system (the 'filter bottom') is placed to support the filter bed. The bed is composed of fine sand, usually ungraded free from clay and loam, and with as little as possible organic matter in it. The filter bed normally is 1.0-1.2 m thick, and the water to be treated stands to a depth of 1.0-1.5 m above the filter bed. The slow sand filter is provided with a number of influent and effluent lines fitted with valves and control

4.4.3 Monitoring

A sample was collected weekly of both pond water and treated water to assess the effectiveness of the PSF. This sample was analyzed for Total coliform bacteria/100ml.

The results of this testing is shown in Table 3. Although the quality of this data appears to be rather variable in most cases it shows that both the constructed PSF's are able to remove the micro-organisms. Despite the generally high rate of removal the results still exceed the WHO standard for coliform bacteria. Except for a few cases both PSFs of Nakativanga and Satbhiapara categorized as red (>1000 count) which mean very high risk level of bacterial contamination. The term "risk" indicates here potential danger to human health from water source. However, the applicability of the WHO guideline values for bacteriological water quality in developing countries is a subject of some debate (R. Cash, pers. com. 1999[2]).

Some of the results are unusual (particularly for the Satbhaiapara) either suggesting that the sampling or analysis is poor, or that some bacteriological contamination is being introduced to the water inside the PSF. BRAC are continuing to monitor this situation and if it is not proved that these units are in an acceptable working condition they will be overhauled.

[2] Professor Richard Cash, Harvard School of Public Health, US.

Table3: MONITORING OF POND SAND FILTERS

Date of Sample collection	NAKATIBHANGA			SATBHAYAPARA		
	Pond Water	PSF Water	% removal of coliform bacteria	Pond Water	PSF Water	% removal of coliform bacteria
	JUNE					
20.4.99	-	33		-	140	-
3.5.99	250	40	84%	1350	125	91%
4.5.99	26	120000	?	7000	1000	86%
6.5.99	14000	1000	93%	14000	18000	?
7.5.99	6000	3000	50%	30	7000	?
8.5.99	10000	1000	90%	120	4000	?
9.5.99	74000	15000	80%	66000	6000	91%
10.5.99	2000	1000	50%	25000	19000	24%
JULY						
1.7.99	19000	400	98%	32000	5000	84%
7.7.99	26000	420	98%	1000	6000	?
15.7.99	106000	5000	95%	7000	21000	?
21.7.99	29000	520	98%	-	-	-
29.7.99	3000	450	85%	6000	3000	50%
5.8.99	4000	94	98%	3000	2000	33%

4.4.4 Problems and constraints

Surface water available in Bangladesh is highly turbid in both dry and wet seasons. In the dry season, there is excessive growth of algae in pond and lake water. In the wet season, rain water drainage from the catchment area brings a lot of suspended sediment and makes the surface water highly turbid. Slow Sand Filters (SSF) do not work properly for turbidities above 30 NTU. Pond Sand filters operating on the principles of SSF in Bangladesh require frequent washing for high turbidities. Bacteriological quality of filtered water often is also beyond the acceptable limit. Pre-treatment by horizontal roughing filtration or sedimentation with coagulation can reduce load on slow sand filters. This reduction in load results in a longer operation time between washings as well as better bacteriological quality of water.

We also encountered problems identifying ponds which were not used for fish culture or other domestic purposes. For fish culture, fish farmers use aldrin/dieldrin, which are highly toxic, to kill predator fish before releasing fish fry. They also put different chemical fertilizers, cow dung, mustard cake etc. into the pond as fish feed. These chemicals have long residual impacts and are dangerous both for human health and aquatic life. An attempt will be made to check the quality of surface water for chemical contamination in Matlab area where BRAC is planning to extend its arsenic mitigation programme in collaboration with ICDDR,B. Availability of large numbers of perennial waterbodies was the strong point in favor of constructing PSF in the project areas. But the obstacle of this system was that many of the ponds are engaged for fish culture which, apart from the potential chemical impacts, makes people reluctant to reserve their pond for drinking water only.

4.5 Safi filter

4.5.1 Design of system

This household level filtration device locally developed by Prof. Safiullah (Jahangirnagar University, Savar) works by filtering arsenic out of contaminated water. Field tests with one of these units showed good removal capacity. Quality control and production capacity seem to be the main issues of concern with the filter.

One small unit of Safi filter can filter approximately 40 liters of water per day. This should be more than sufficient for the needs for hygienically safe and arsenic free water of a family of six. Water that is not arsenic free can be used for bathing, laundry etc. The cost of such filter is Tk. 900.

Previous limited field tests showed that the Safi filter has good arsenic removal capacity. Water containing up to 0.2 mg/l of arsenic was filtered and tested negative on analysis with a NIPSOM field kit. This removal rate has to be tested further both in a laboratory and in a field setting.

4.5.2 Construction details

The Safi filter comprises two concrete buckets of different sizes, one of which is placed inside the other. The upper bucket is filled with tubewell water which then flows through a 'candle' and is collected in the lower bucket where it is stored. When needed it is drawn off with a tap.

The 'Safi filter' candle is prepared from a chemical mixture of laterite soil, ferric oxide, Manganese Di-oxide, Aluminium Hydroxide, Mizoporoum silica. Due to this reason surface of the Safi filter becomes strong ionized and porous which helps trapping arsenic and other pathogens into the candle from the contaminated water. It is claimed that after two years of continuous use, the candle will need to be replaced with a new one.

4.5.3 Monitoring

It is claimed by the inventor of the 'Safi filter' that it can remove both arsenic and pathogenic bacteria successfully. It was also claimed that the life of the candle, which traps arsenic in it, is about two years although this depends on the initial concentration of arsenic in the groundwater. Therefore it is very important to monitor the effectiveness of the candle on a regular basis. Accordingly a system was developed to monitor the arsenic removal capacity of the candle. The arsenic content of the source (i.e. tubewell) and the filtered water were measured. It was observed that generally the filters could remove arsenic from the contaminated water successfully (table 4). In a few cases arsenic was not removed to within the safe limit mainly because of a mechanical problem with the setting of the candles. This was later adjusted by re-fixing the candles properly.

The distribution date of each 'Safi filter' was recorded properly not only to monitor the removal efficiency of the candle but also to replace candles whenever needed. Disposal of these high arsenic contaminated candles is a big issue. Although the inventor of the filter claims that disposal of the candles into the normal environment would not create any problem but, before getting any strong scientific evidence BRAC would like to collect and dispose these candles properly into its own medical waste disposal site.

It was also claimed by the inventor that this candle can remove pathogens but the monthly water quality monitoring results from ICDDR,B laboratory were disappointing. None of the provided 'Safi filter' could provide bacteria free water (table 4). Preliminary investigation suggested that this bacteria grew in the second jar where the filtered water is stored. The people were advised to clean both of the compartments of the filter every week but many of them did not follow this advice. However, referring back to the point made about the applicability of imposing standards for bacteriological quality in Bangladesh drinking water, it was noted that none of the users complained about stomach upsets.

Table 4: MONITORING OF SAFI FILTER (June - August , 1999)

Location of Safi Fitter	Date of Sample Collection	As content of the TW Water (ppb)	As content of the filtered Water (ppb)	% of As Removal	Total coliform bacteria
MADRAS, ULUKANDI	10.6.99	500	10	98%	380
	20.7.99	500	>10	98%	
	30.7.99	out of order	-	-	---
	19.8.99	500	20	96%	
	25.8.99	-	-	-	4000
PERVIN, RAMGONJ	10.6.99	>1000	<50	95%	50
	29.6.99	500	50	90%	
	20.7.99	300	20	93%	
	30.7.99	300	20	93%	3000
	19.8.99	300	20	93%	
	25.8.99	-	-	--	7
AYSHA, RAMGONJ	10.6.99	300	<10	97%	1000
	29.6.99	300	10	97%	
	20.7.99	200	50	75%	
	30.7.99	200	50	75%	14
	19.8.99	>200	50	75%	
	25.8.99	-	-	-	22
SCHOOL, SATBHIAPARA	10.6.99	>600	100	83%	1050
	29.6.99	600	>10	98%	---
	20.7.99	300	20	93%	
	30.7.99	300	20	93%	2
	19.8.99	300	>20	93%	
	25.8.99	-	-	-	--
SHAMMEN, HARIA	10.6.99	550	-		
	29.6.99	550	50	91%	
	20.7.99	500	<50	90%	
	30.7.99	400	<50	87%	5000
	19.8.99	400	<50	87%	
	25.8.99	-	-	-	19
MADRASA, HAMSADI	10.6.99				BROKEN
	29.6.99				
	20.7.99				
	30.7.99				
	19.8.99	400	10	97%	
	25.8.99	-	-	-	20
EMBER, HAMSADI	10.6.99				no data
	29.6.99	-	-	-	
	25.8.99	-	-	-	
SCHOOL, KHONGSADI	10.6.99	-	-		Vacation
	29.6.99	600	<50	92%	
	20.7.99	300	50	83%	
	30.7.99	300	100	67%	1
	19.8.99	300	100	67%	
	25.8.99	-	-	-	3

4.5.4 Problems and constraints

Due to the social status which it confers people still like to obtain their water from their own tubewell. The Safi filter provides a means by which they can remove the arsenic and continue to use this bacteriologically good quality water. The present cost of this filter is already comparatively cheap at Tk. 900, and with a new design which is being developed the price should be brought down to Tk. 500 or less. This will put the Safi filter within the affordable range of many rural households.

The problems with this system are that it is occasionally subject to mechanical breakdown i.e. the filter casing is concrete and can break, or the candle may be defective or not secured properly thus allowing some arsenic contaminated water to pass through. The first problem should be eliminated by a plastic model which BRAC have encouraged the inventor to develop. The second is a problem of quality control which can only be overcome by strengthening of the manufacturing process.

The other main concern is the life of the candle and its disposal. With further monitoring of these candles it should become apparent for what length of time these filters remain effective for different concentrations of arsenic in the water. There is also some evidence from BRAC monitoring that the Safi filter may take several hours of filtration before it becomes effective and removes arsenic to an acceptable level. This will be monitored.
Also it was noticed that sometimes the families complained that the amount of water that the filter can provide was not enough.

5. Treatment of Arsenic affected patients

Spirulina, a microscopic blue green alga, rich in protein, vitamins (B 12 and A) and iron has been used as an ideal survival food in recent years. It has already been established through research that one kilogram of spirulina is equivalent to 1000 kilogram of different vegetables and that the protein content of meat is about 35% but in spirulina it is 50-70%. It has also been reported by a group of medical doctors of the Post Graduate Medical

Hospital that spirulina tablets have positive impact in retrieving the arsenic affected patients into normal life. To measure this, spirulina tablet was distributed among 20 serious arsenic patients and this distribution will continue for at least six months. All of these 20 people are getting arsenic free water, either from Safi filter or from deep tubewells installed by the Government. Another group of arsenic affected patients were given only 'Safi filters' to compare the effect of the Spirulina tablets. Preliminary results of this initiative indicated that many of them already started feeling better.

6. Conclusions and Recommendations

From the results of the testing it can be seen that the arsenic problem in this thana is very serious. In Boidderbazer union, Sonargaon thana roughly two thirds of the tested tubewells were found to be contaminated with arsenic above the acceptable limit of 0.05 mg/L. It was observed from some of other observations that the level of arsenic varies widely from well to well as does the manifestation of arsenicosis. This may be due to higher concentrations of arsenic in the well water or the poor socio-economic status of the people of this area.

Resource maps of the villages were prepared and show the nature of the available water sources. These were then used in consultation with the villagers to choose alternative options for safe water supply.

A number of alternate safe water options are now in operation as demonstration units. The idea of constructing these demonstration units is to raise awareness level of the community people about this alternate safe water option which, later will help in developing a system of involving community members in choosing, financing, and implementing safe water systems on their own.

Alternative safe water which have been implemented in the field are: pond sand filters, rain water harvesters, Safi filters and dug wells. These have been assessed with reference to:

initial and running costs, ease of implementation, requirement for maintenance or ongoing supervision, provision of an intermittent or continuous supply, susceptibility to bacteriological contamination and acceptability to the local community. The matrix below shows ratings of each of these factors rated on a scale of 1 to 5. The maximum possible is 40 and a higher rating is better.

	PSF	RWH	Safi Filter
Initial Cost	1	2	5
Running Costs	4	4	3
Ease of implementation	1	1	5
Maintenance required ?	4	4	1
Monitoring required?	2	4	1
Continuity of supply	4	2	5
Susceptibility to bacteriological contamination	2	4	2
Acceptability	1	1	5
TOTAL	19	23	27

It can be seen from this that all of the options have their limitations. At present the Safi filter is proving to be the best option for its ease of use, low cost and simplicity. If the Safi filter is to be spread nationally it will be necessary to ensure that the quality is consistent, that there is a set life for the filter candle and that there is a system for replacing them.

Obtaining water from these alternative options is not as easy as obtaining water from a tubewell. A well structured motivational programme, such as that responsible for the success of converting 97% of population to tubewell water, is needed to change people's attitude and make these options popular

In conclusion, as suspected, it is likely that multiple solutions will need to be adopted by the local people. In this program we are giving them ideas and technical aid which hopefully will be taken up locally to start to attack the arsenic problem. It goes without saying that

arsenic mitigation activities in Bangladesh must continue for the foreseeable future and be taken to a larger scale wherever possible.

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Appendix 1

The following are examples of resource maps prepared in every village in consultation with the villagers.

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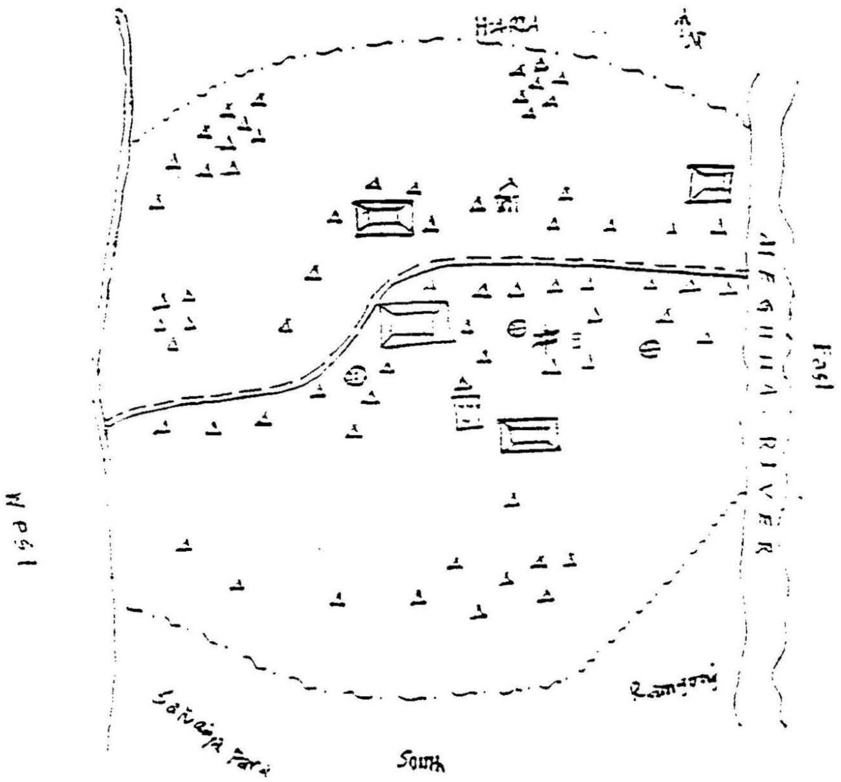
Appendix 1

The following are examples of resource maps prepared in every village in consultation with the villagers.

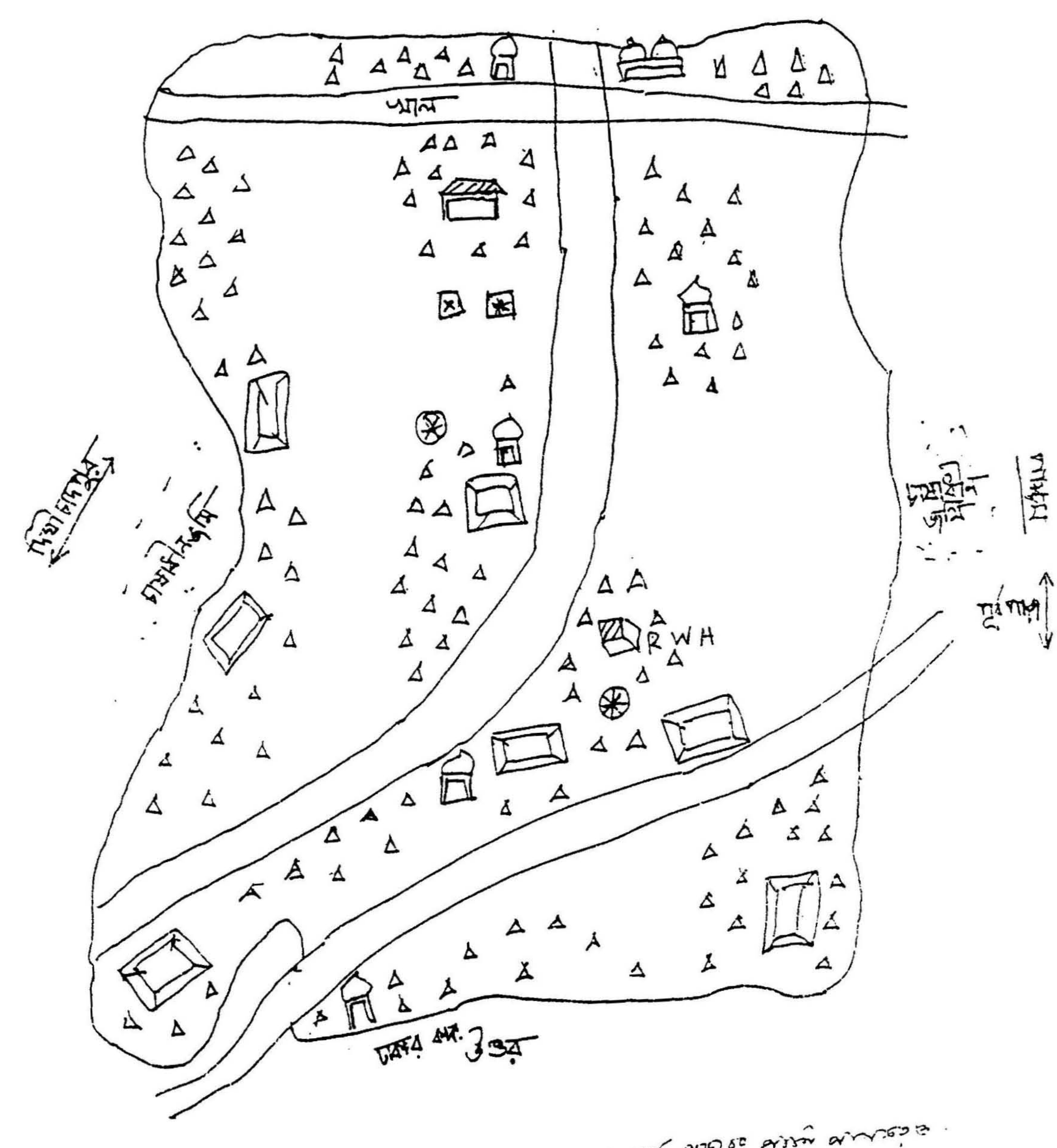
RESOURCE MAP

Village : Haria
Union : Boiderbazar
Thana : Sonargaon



RWH -
Mosque
House
Green wells
Pond
Dugwell

Before 20 years villagers used to drink pond and water from Dugwells. At that time there were about [illegible] dugwells in the village. There are four ponds in this villages and the bank of the ponds gets flooded every year. [illegible] the ponds are preserved, these ponds are used for [illegible] and for this reasons they used poison to kill the [illegible] fish before releasing fish [illegible] and also use fish and [illegible] fertilizer to grow [illegible] which [illegible] used as fish feed. It seems [illegible] difficult to use surface water as drinking water.



গ্রাম: হামছাদি; U.P - বৈদ্যবাজার

- মসজিদ - ৫টি
- R.W.H. - ১টি
- পুকুর - ৭টি
- প্রা: বিদ্যালয় - ১টি
- মন্দির - ১টি
- ঈদগাহ/কবরস্থান
- গাছ - ১২০-১৫০ প্রকার

* ২০ বছর পূর্বে