NATIONAL SEMINAR

GROUNDWATER RESOURCE : BANGLADESH PERSPECTIVE

Date : March 22, 1998
Venue : BRAC, Dhaka

Organised by :
NGO Forum
for Drinking Water Supply & Sanitation

Report Writing	:	Joseph Halder & Ferdaus Alam
Design	:	Saha Dipak Kumar
Photography	:	Saiful Alam Khan
Computer Compose	:	Mazedul Hoque Prodhan
Published by	:	NGO Forum for Drinking Water Supply & Sanitation 4/6, Block-E, Lalmatia, Dhaka-1207, Bangladesh
Printed by	:	S.S. Printing & Publications

National Seminar
on
Groundwater Resource: Bangladesh Perspective

Date: March 22, 1998
Venue: BRAC Auditorium, Mohakhali, Dhaka

Organized by:

NGO FORUM
FOR DRINKING WATER SUPPLY AND SANITATION
4/6, Block-E, Lalmatia, Dhaka-1207

NATIONAL SEMINAR
On
"Groundwater Resource: Bangladesh Perspective"

Table of Contents

	Page
Foreword	1
Executive Summary	2
Welcome Address	3
Speech of the Chief Guest	5
Speech of the Special Guests	6
Speech of the Chairperson	11
Working Session	13
Key-Note Paper Presentation	13
Panel Discussion	27
Floor Participation	28
Winding up	30
Annexure-A : Figures	
Annexure-B : Participants	

FOREWORD

Groundwater is now being abstracted at unsustainable rates. The water table is declining very rapidly. This happens when uncontrolled drilling of wells causes the overall rates of withdrawal of water from aquifers. This overabstraction causes many serious problems also in Bangladesh. Groundwater is considered as the only safe water source. We are surely dependant on that for getting safe water for all domestic needs. On the otherhand, irrigation is the largest sector in Bangladesh where groundwater is used massively. All these are causing rapid declining of groundwater table as well as different types of pollution.

The subsoil and the underlying soil and rock formations can eliminate many water pollutants by natural physical chemical and biological process. Natural capacity does not extend to all types of water pollutants and varies widely in degree in its effectiveness under different hydrogeological conditions. In some parts of Bangladesh this phenomena has contributed to different types of pollution in groundwater. Arsenic contamination in water from pump technologies is a new threat to the nation.

The declining rate and various pollution has been intensifying the safe water crisis specially in the community level. Though it is still to find out any specific cause, but the dissemination of different information on groundwater issues in a scattered form ultimately pushing the community back from safe water facilities what the country has already achieved. It is hopoed, the gaps may be filled and some of the deficiencies remedied soon.

The Forum's concentration with the groundwater issue in line with the theme of this year's World Water Day "Groundwater: The Invisible Resource" makes perfectly inteligible against these backdrop. Organizing a National Seminar in celebration of the Day helped consolidating important opinions and suggestions from different corners. All those are furnished here in the Report which may help the sectoral stakeholders contributing to develop the sector in the way they have conceived the tasks and to ensure safe water supply to the target community.

I believe the Report will be of interest to the readers.

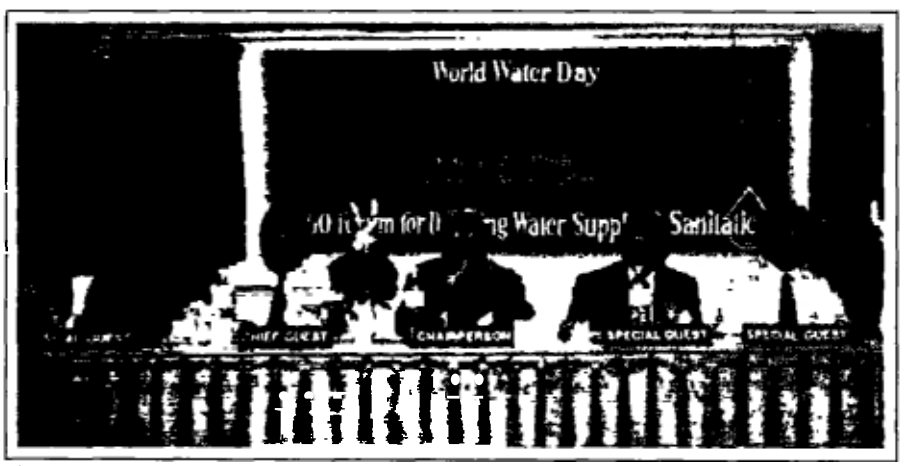
S.M.A. Rashid
Director

EXECUTIVE SUMMARY

At the forty-seventh session in November 1992, the United Nations General Assembly adopted a resolution designating March 22 of each year as the **World Water Day**. To mark the Day at the national level this year NGO Forum, the apex networking body of NGOs engaged in Water and Sanitation (WatSan) sector, organized a National Seminar "**Groundwater Resource: Bangladesh Perspective**".

The primary objectives of the Seminar was to critically analyze the groundwater as resource, its declining trend and pollution and the adverse effect on domestic water supply, social implication of the phenomenon, how gender and development being affected.

The Seminar was inaugurated by the Chief Guest of the Seminar, Secretary, Local Govt. Department, Ministry of LGRD&C, Government of the People's Republic of Bangladesh. Chief, WES Section of UNICEF and Chief Engineer of DPHE were present as the Special Guests. The Seminar was Chaired by Dr. Fazle Hasan Abed, Executive Director, BRAC.



The Seminar was attended by representatives from various government organizations, donor agencies, UN-bodies, World Bank, NGO community and from mass media.

Director, NGO Forum for DWSS delivered the welcome address. Welcoming the resource persons and participants he hoped that through their thoughtful discussions the objectives of the Seminar would be achieved.

The Seminar had a working session. A key-note paper on "**Groundwater Resource: Bangladesh Perspective**" was presented in the working session. The presentation was followed by panel discussion and open discussion.

Mr. Qazi Mahbubul Hasan, Sr. Information Officer, NGO Forum presented the vote of thanks to all. The Seminar was facilitated by Ms. Rehana Akhter, Development Communication Officer of NGO Forum.

Welcome Address by Mr. S.M.A. Rashid
Director, NGO Forum for DWSS

It has been achieved a markable success in the field of water supply though a lot of limitations are there. A total of 92% rural people presently have access to safe drinking water while it was only 40% at the beginning of 1980s. About 1 million shallow handpumps have been installed by the Department of Public Health Engineering (DPHE) in this period while the NGOs of Bangladesh have contributed the same proportion in water supply sector.

We have many more miles to go though something has been achieved meanwhile. We see regularly on the cover page of the national Dailies, "Dread Scarcity of Drinking Water", "Women Carrying Water from Long Distances", "Deadly Drought in the Southern Part - Villages are Turning into Barren Fields", etc. On the other side this is still an on-going reality that our children under five are being attacked about 75 million times each year by the diarrhoeal diseases; among them about 260,000 die. The rest are living accompanied by various other illness and endless malnutrition. Needless to mention that lack of sufficient safe water and hygienic sanitation facilities are behind this unwanted scenario.

Of all the water on earth, 97.5% is saline water, and the remaining 2.5% is sweet water. In reality only 1% of the sweet water is safe and the rest is polluted by any means. More than 80 water-borne diseases are caused by polluted water. So, groundwater is the only option for our health and living. But it is a dreadful fear for our nation as the groundwater table is declining so rapidly. It is being feared that the shallow pumps of 35% area of our country are about to be inoperative. On the other hand arsenic invasion in Bangladesh has now become the new headache to the nation. Not all the tubewells in Bangladesh are now supplying safe drinking water. Many of them have become reservoirs of arsenic.

Of all the water on earth, 97.5% is saline water, and the remaining 2.5% is sweet water. In reality only 1% of the sweet water is safe and the rest is polluted by any means. More than 80 water-borne diseases are caused by polluted water.

Water is a basic requirement for a living being yet safe water resources i.e. groundwater is facing more and more demands from, and competition among users. Its rapid decline and various pollution as well as lack of proper management is making safe water a problematic issue. Emphasizing on this, in 1992 the United Nations General Assembly designated 22 March of each year as the **World Water Day**. The title of the Seminar "**Groundwater Resource:**

Bangladesh Perspective" has been adopted from the theme of this year's World Water Day "**Groundwater -The Invisible Resources**". Degradation of groundwater systems through rapid declining and pollution of aquifers, the economic implications of groundwater and lack of both professional and public awareness about the sustainable use of groundwater resource, etc. are some striking issues which pushed selecting the theme this year.

This is the time when the global awareness of the vital role groundwater plays in sustainable national development is increasing. Water i.e. safe water is vital for sustaining life on earth. On the other hand water is crucial for economic and social development including energy production, agriculture and domestic and industrial water supplies. And groundwater is being treated as the safe source for these. Therefore, every unit of groundwater should be used efficiently, equitably and soundly. The economic value that groundwater generates should be given due attention, when apportioning scarce of water resources between competing uses, without infringing on the rights to basic services for all people.

Women and water are very much integrated and for this the women should specially be encouraged regarding proper management and use of water resource.

The World Summit for Social Development held in Copenhagen made a 10 - point declaration where it has been stated very clearly and directly to create equal provision for the women making gender equality regarding their right in every step. The matters demand more importance in the context of our country. The half of our population are women while it is not possible to set any real development keeping women aside. Women and water are very much integrated and for this the women should specially be encouraged regarding proper management and use of water resource. This is a historical truth that the women are engaged in water collection along with child care and water related other household activities. But if the present declining rate and pollution of groundwater i.e. scarcity of safe water is continued the women will be the vital victim of the future reality.

We believe mass people are the key actor of any development initiative. So people of every sector should be integrated with safe water development process, and every family should be motivated. And it needs the integration of societal power and combined effort. It is not possible to solve safe water problem by only organizing seminar, meeting and publishing article in the magazine. Rather it requires to raise awareness among the community people as well as to sensitize the all other sectoral and trans-sectoral policy-makers in the govt. or in NGOs about the positive result of safe water i.e. the effective and economic use and management of groundwater. And we are responsible for all these. I welcome you all in this Seminar hoping a synergistic effort to our responsibility.

Speech of the Chief Guest
Mr. A.H.M. Abdul Hye
Secretary
Local Government Department, Ministry of LGRD&C

I express my gratitude to NGO Forum for inviting me in today's National Seminar on "Groundwater Resources: Bangladesh Perspective" as the Chief Guest. I also appreciate the organizer of the Seminar to mark the World Water Day in the most befitting manner.

The topic "National Seminar on "Groundwater Resources: Bangladesh Perspective", I believe, is very much inconsonance with the theme of the current year.

The groundwater is the most valuable resource of the country which may be compared with that of mine. As a valuable resource its utilization, extraction requires cautious and reasonable approach. Here the total perspective of the country must be taken into consideration as well as need of the particular area must be assessed properly. In the command areas for whom we profess to address must have taken into account, all option must be weighted and accordingly appropriate & alternative mix of technologies for supply of safe water is taken up immediately.

It has been observed that during the last few decades indiscriminate use and over extraction of groundwater led to consequences of serious magnitude. This causes two vital problems: declining of water table and arsenic contamination.

In the command areas for whom we profess to address must have taken into account, all option must be weighted and accordingly appropriate & alternative mix of technologies for supply of safe water is taken up immediately.

Ironically the world's most riverain country and its people are exposed to the danger due to rapid water table depletion and subsequent pollution of water including arsenic contamination may be termed as the tragedy of common people. Heavy dependence on the groundwater extraction in the city for safe water supply may lead to a situation where buildings and high-rise structures would collapse as low containing as well as recharging capacity of the soil is sharply eroding due to vacuum created by water table depletion. We also depend on groundwater for irrigation to a large extent. This scenario must be changed. Bangladesh possesses abundant supply of surface water which can be treated through appropriate technology. In this regard excavation of canals and rivers may be taken up and comprehensive water network should be created. And appropriate measures should be

taken in order to mitigate the arsenic contamination problem. Moreover, needless to say that water use should be planned. In the context of the present situation there is a need for formulating national water policy by the Government with the participation of all the stakeholders of the sector.

Finally, I would like to conclude by saying that the groundwater should be used most cautiously and this valuable resource must be treated as the last resort of us. Thank you all. Long live Bangladesh.

water use should be planned. In the context of the present situation there is a need for formulating national water policy by the Government with the participation of all the stakeholders of the sector.

Speech of the Special Guest
Mr. S.A.K.M. Shafique
Chief Engineer
Department of Public Health Engineering (DPHE)

Bangladesh is a riverain country. We have plenty of water in the rainy season, but we have scarcity of water both surface and groundwater in dry season.

The main water sources in Bangladesh used in drinking purpose as well as for irrigation is the Groundwater. After independence the installation of the tubewells for both the purposes got priority. During 80's for getting more food production, massive groundwater withdrawal began by installation of deep tubewells. Side by side DPHE under the assistance of various donor agencies and the government sunk over one million hand pump tubewells. A similar number of private hand pump tubewells have also been sunk. As a result the groundwater resources were exploited. However, we have plenty of groundwater in rainy season. But the use of groundwater has been increasing day by day which is aggravating the situation.

In 1994, DPHE & UNICEF conducted a study jointly to forecast the declining trend of groundwater. The study indicated that the area where suction mode handpumps would not operate would increase

from 43.56% in 1995 to 54.14% in the year 2000. This low-water table areas will increase to 62.18% by the year 2010. This means the use of groundwater resources has been increasing day by day and we have to be more cautious to utilize this resource properly by a comprehensive planning.

The main water sources of drinking water in Bangladesh is the groundwater. The present coverage of drinking water supply through handpump tubewells is 97%. Each family in a rural village has access to a tubewell within 150m. We have achieved this coverage but we also got a problem. The **Arsenic Problem in Groundwater**.

The moment when we are going to discuss the groundwater resources in Bangladesh, this arsenic problem in groundwater is giving a new thought to a different way of using groundwater resources. DPHE tested over 20 thousand samples from hand pump tubewells almost all over the country and about 19% were found contaminated by arsenic. From the existing survey 155 thana of 44 districts have got problem of arsenic in groundwater. This means we have to be more careful for using the groundwater resources in Bangladesh.

In this regard I would like to invite the NGOs to work side by side with the government and I believe that the concerted effort will solve the people's sufferings. DPHE has already extended cooperation to work with BRAC, Dhaka Community Hospital and other NGOs who have come forward.

I hope your active participation in today's National Seminar will enrich the capacity of the organizer to give a better and proper comprehensive planning in utilizing the present groundwater resources of Bangladesh for the benefit of the peoples and the nation.

The main water sources of drinking water in Bangladesh is the groundwater. The present coverage of drinking water supply through handpump tubewells is 97%. Each family in a rural village has access to a tubewell within 150m.

DPHE tested over 20 thousand samples from hand pump tubewells almost all over the country and about 19% were found contaminated by arsenic.

Speech of the Special Guest
Dr. Deepak Bajracharya
Chief, Water & Environmental Sanitation
UNICEF - Bangladesh

For all of us gathered here today to celebrate the **World Water Day**, it is a fitting time to engage in an accountability exercise to determine where we stand in relation to our groundwater resource in Bangladesh. First, however, on behalf of UNICEF, I want to thank the NGO Forum for Drinking Water Supply and Sanitation in organizing this seminar and bringing us all together for reflecting on current issues of critical importance.

Looking at this country, cris-crossed by endless streams and great rivers, and blessed with heavy annual rainfall that recharge underground aquifers, one would assume that access to water at least is one problem we do not have to worry about. The country sits upon a vast spongy aquifer. The polluted surface water is filtered as it percolates down layers of silty clay and sand with occasional rocky obstructions. A relatively inexpensive hand pump can be sunk to a depth of 35 metres using "sludging" technique that requires on sophisticated mechanical equipment and is within the capacity of a mistri.

Today, Bangladesh can be rightly proud of what has been achieved: 97 percent of the population now have easy access to safe drinking water, because of the tubewells that tap water stored in shallow aquifers. The number of people per tubewell now stands at 100, as compared to 400 in the early 1970's.

This success in ensuring supply of safe water have been the result of close collaboration, for the service of people, among DPHE, UNICEF, donors such as SDC and DANIDA, NGOs and other development partners. The private sector, too, has played a major role. A recent survey shows that as much as 70% of the inexpensive No.6 tubewells are privately installed.

Through improved communication, families can understand better the benefits of using safe water. This remains a major challenge because it involves effecting changes in deep-rooted behavioural patterns.

This is, however, only half the job done. Current evidence suggests that most families use tubewell water for drinking purposes only, while much of other household chores - washing, cooking, bathing - are done with surface water. Furthermore, home management of drinking water, particularly its storage, is not entirely hygienic. Such practices continue to expose families, particularly the children, to the

threat of water-borne diseases. This needs to change. Through improved communication, families can understand better the benefits of using safe water. This remains a major challenge because it involves effecting changes in deep-rooted behavioural patterns.

We are faced with several other significant new challenges. The first relates to the decline in groundwater recharge during the dry summer months, because of the heavy extraction of water for irrigation. In 1986, the groundwater was below the 7 metre suction zone in only 12% of the country. In 1994, this proportion had risen to 21%. Some forecasts suggest that by the year 2010, as much as 50% of the high water table areas may find their suction pumps without yield during the dry season.

The Tara pump was developed for tubewells where the table was below the suction level of 7 metres, but no deeper than 15 metres. Although the pump is inexpensive, compared to deep tubewells, it still costs 4-5 times more than the popular No.6 pump. In the worst affected areas, the ratio of Tara pump to people is as high as 1:500 in the dry season.

From the Bangladeshi villager's point of view, water shortage in a lengthening dry season is cause for anxiety enough. But from a public health point of view, the declining water table has other implications. People may revert to taking water from ponds or other unhygienic sources. The "Low-Water Table Area", which altogether contains about a third of the population, therefore needs extra water supply attention.

Another public concern is the discovery of growing arsenic contamination of groundwater. The government testing program, supported by UNICEF, has inspected over 20,000 tubewells using field kits. While this is only a small fraction (less than 1%) of the total number of three to four million tubewells in Bangladesh, it is providing us with preliminary information that, in 60% of the thanas tested so far, not a single arsenic contaminated well was found. Nationally, 20% of the tubewells that DPHE has tested with field kits show arsenic contamination.

However, field kits do not always give precisely accurate results, and samples are collected disproportionately from high-risk areas. Until a significant proportion of tubewells from all parts of the country has been tested, we cannot say with any certainty how many people are actually at risk. The fact remains that, although much lower than the often cited figure of 65 million, the population drinking arsenic-contaminated water is still in the range of millions. This is no doubt a matter of serious concern for all of us.

Surface water in Bangladesh is heavily contaminated with faecal bacteria. The ingestion of untreated or inadequately treated water can cause cholera, diarrhoea, and parasite infestation. The threat of a return to increased mortality and morbidity rates due to diarrhoea, cholera and other water-borne diseases by 'switching off' tubewells is unthinkable.

One of the ethical dimensions to this complex and confounding problem is the question of whether the tubewell programme should be stopped. Tubewells have contributed to the dramatic decline of infant mortality rate in the country - from 132 per thousand in 1980 to less than 77 per thousand today. Surface water in Bangladesh is heavily contaminated with faecal bacteria. The ingestion of untreated or inadequately treated water can cause cholera, diarrhoea, and parasite infestation. The threat of a return to increased mortality and morbidity rates due to diarrhoea, cholera and other water-borne diseases by 'switching off' tubewells is unthinkable.

In heavily contaminated areas, though, the government has already decided that tap shallow aquifers are no longer allowed to be installed. We are now sponsoring projects to ascertain if deeper aquifers can be considered safe here. We are also looking into the viability as well as the potentials of promotion of whatever alternative sources of safe water are available, including rainwater harvesting, pond sand filters, and low-cost home-based arsenic removal systems. An important part of this effort is the development of local capacity to enable the widespread adoption of safe techniques by the affected population.

People have a right to information that will help them to make an informed decision on what to do if their tubewell water contains arsenic. They need to know the risks of continuing to drink arsenic-bearing water, and the risks of turning to unsafe surface water sources. They must know that, as an immediate measure, there is a choice for people to go to tubewells that have been tested safe for drinking, even if they have to walk further to collect the water and that arsenic-contaminated water can still be used, at least temporarily, for domestic and household chores. They must realize that social ostracization of affected victims must be stopped. With these in mind, UNICEF is also providing assistance to the government, to develop communication materials, with the help of a social marketing agency. These are going to be field-tested soon and finalized for country-wide use.

These are, of course, initial efforts. Our hope is that, when the World Bank assistance starts in the near future, these efforts will provide sufficient basis for scaling up the activities effectively, much beyond what our limited resources can do.

Bangladesh has, however, had prior experience in overcoming such adversities successfully. Based on UNICEF's long history of cooperation, more than two and a half decades, with the Government and people of Bangladesh, we can say with confidence and optimism that tackling the complex issues around groundwater decline and arsenic mitigation will be no exception. This will require, of course, the coordinated and combined effort of government, civil society and donors.

Speech of the Chairperson
Dr. Fazle Hasan Abed
Executive Director
Bangladesh Rural Advancement Committee (BRAC)

Today is 22nd March, the sixth Annual World Water Day. The occasion is being celebrated in many countries over the world as per recommendation of the 17th meeting of the ACC Sub-Committee on Water Resource. The first International Drinking Water Supply and Sanitation Decade (1981-1990) declared by UN has ended and a new Decade inaugurated to be ended by the year 2000. The first Decade commences to ensure safe water and environmental sanitation to each and every one on the earth while the second decade intends to review the success and failure of the decade proceeded to it with the slogan "Safe Water and Sanitation for All by the Year 2000".

The theme of this year's World Water Day is "Groundwater: The Invisible Resource", and I am happy to note that NGO Forum has selected "Groundwater Resource: Bangladesh Perspective" as theme of the Seminar in consonance with the theme of the current year. I believe, groundwater resource with its prospects and problems can better be understood and appreciated in the current context and perspective of Bangladesh.

Our groundwater table is on the decline rather rapidly due to indiscriminate and over extraction. Heavy dependence on groundwater extraction particularly in the urban area for safe water supply may lead to major catastrophes like land slides. Arsenic contamination of groundwater particularly in the northern region of the country is surfaced recently which, I think, must be tackled with proper care.

I would like to thank the Chief Guest of the Seminar for delivering thought provocating and valuable speech. He is a man of letters and the issues he has dealt with is of critical importance as regard groundwater resources in Bangladesh. Groundwater resources has its prospects as well as limitations. In the past many civilizations have perished as a result of lack of proper water supply network. Almost 30 million people around the world require to use potable water. But the task of providing such water is a gigantic work. The problem is much more severe in Bangladesh. Bangladesh does not have resources to sustain its people in this regard. We must search for tangible solution to the problem keeping in mind the resources and technologies at our command.

Our groundwater table is on the decline rather rapidly due to indiscriminate and over extraction. Heavy dependence on groundwater extraction particularly in the urban area for safe water supply may lead to major catastrophes like land slides. Arsenic contamination of groundwater particularly in the northern region of the country is

surfaced recently which, I think, must be tackled with proper care.

The scarcity and pollution of groundwater is a crucial issue in Bangladesh. In this regard I would like to suggest devising of sound surface water management. Water policy and investment should aim at for sustaining water environment for multiple uses and its development should be taken up through close and meaningful cooperation of actors operating in the sector.

We must find out alternative technologies like new modes of irrigation, sub-soil moisture, conservation, rain-water harvesting and use of surface water treatment plant.

Water policy and investment should aim at for sustaining water environment for multiple uses and its development should be taken up through close and meaningful cooperation of actors operating in the sector.

Working Session

Chairperson : Ms. Rasheda K. Chowdhury
Director, Campaign for Popular Education (CAMPE)

The Working Session was conducted with the presentation of the key-note paper "**Groundwater Resource: Bangladesh Perspective**" by the resource persons. Presenters of the key-note paper were Dr. Mohammad Ali Bhuiyan and Dr. Ashraf Ali from Bangladesh University of Engineering and Technology (BUET). Prof. Mujibur Rahman from BUET and Mr. Harun-Or-Rashid from the World Bank, Dhaka took part in discussion on the key-note paper presentation as the Panel Discussants. The presentation was also followed by floor participation.

Prepared by : Dr. Mohammad Ali Bhuiyan
Professor, Department of Water Resources Engineering;

Dr. Ashraf Ali
Associate Professor, Department of Civil Engineering; and

Dr. A.B.M. Badruzzaman
Department of Civil Engineering
Bangladesh University of Engineering and Technology.

Paper Groundwater Resource: Bangladesh Perspective.

INTRODUCTION

Over the last few decades there has been a rapid growth in the utilization of groundwater for irrigation in Bangladesh. Over the same period the country has achieved commendable success in the provision of water supply, primarily through extensive use of hand tubewells. Progress in sanitation coverage during this period is also significant. Thus, the rapid expansion of irrigated agriculture and advances in the water supply and sanitation sector - both relied heavily on groundwater. However, indiscriminate withdrawal of groundwater for irrigation is causing a progressive lowering of groundwater table and this is rendering many suction handpumps for drinking water inoperable, especially during the dry period covering March-May. In recent years, widespread presence of arsenic in groundwater has added a new dimension in the planning for safe drinking water supply. In fact, arsenic poisoning of groundwater has reached such an alarming state that it is now threatening the hard-earned successes in the provision of safe drinking water supply achieved during the past decades. In view of these recent developments, questions are now being asked regarding the sustainable use of this resource, socio-economic and health impacts of present day approach to groundwater exploitation, the overall potential and the most effective ways of utilization of groundwater.

GROUNDWATER AVAILABILITY AND USE

Groundwater and Irrigation

The earliest project to abstract groundwater commenced by the East Pakistan Water and Power Development Authority (EPWAPDA, created in 1959, now split into the Bangladesh Water Development Board, BWDB and Bangladesh Power Development Board, BPDB) during the period 1962-64 with the installation of 259 deep tubewells (DTWs) in the Thakurgaon, Panchagarh and

Dinajpur areas. BADC (Bangladesh Agricultural Development Corporation) introduced groundwater abstraction programme by sinking DTWs in 1967. Although a high rate of return to tubewell irrigation was demonstrated, the method did not gain momentum readily because of Government's lack of commitment to the alternative (Hanratty, 1983). Moreover, the rapid expansion of well technology was constrained by the lack of comprehensive knowledge regarding hydrogeological conditions of Bangladesh. In 1967 a USAID mission assessed the potential and state of knowledge of the groundwater resources and proposed a study and an organization (Groundwater Circle) as part of the EPWAPDA to carry out future groundwater works. The study indicated that groundwater existed in considerable quantities which was replenished annually and were sufficient to support a programme of further expansion (McDonald, 1969, IBRD, 1969). Later a preliminary hydrogeological map (Water Supply Paper 386, 1974) was prepared by the Groundwater Circle of the BWDB based on their survey results.

Prof. Mohammad Ali presence Key-Note Paper

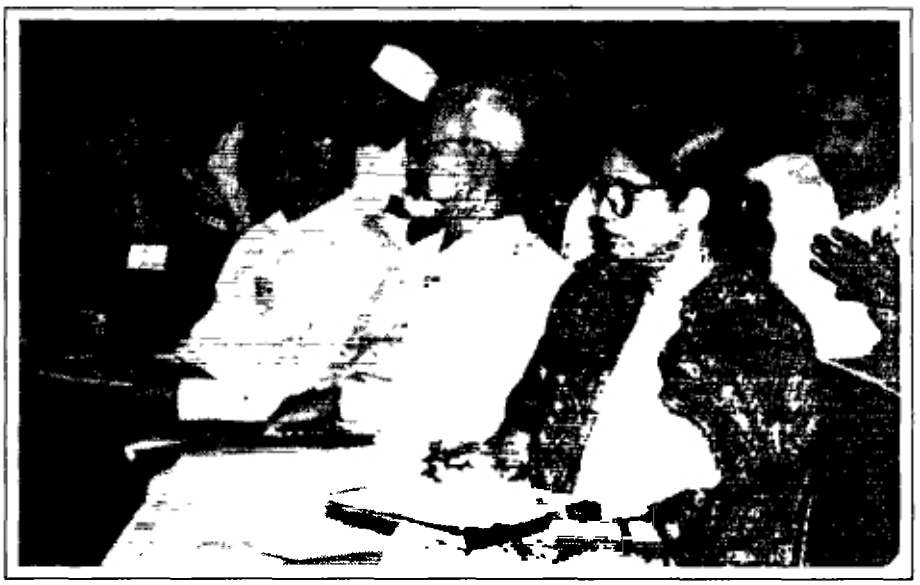
The promising data on groundwater resources led to a re-evaluation of national water plan in 1970 under the increasing demand for irrigation due to introduction of HYV rice. With fewer than 1000 tubewells in operation in 1970, the motivation of the decision-makers to its rapid development was well founded. After the major step forward by IBRD in 1972 on appraisal of land and water resources, a series of regional investigations and development projects gave rise to installation of more than 10,000 DTWs by the end of the seventies mainly in the north and nor-west regions of Bangladesh. Simultaneously, shallow tubewells (STWs) which were rare before 1970, started to make their advances from 1973 and by 1980 there were about 25,000 in operation.

The recognition of groundwater as the major source of irrigation supplies led to a massive study in the overall water resources assessment under the National Water Plan Project (NWPP) in 1983 by the Government of Bangladesh (GOB), the World Bank (IBRD), and the United Nations Development Programme (UNDP). The purposes of the project were to prepare a comprehensive Master Plan for development of water resources and for the establishment of a permanent Master Plan Organization (MPO) now known as Water Resources Planning Organization (WARPO). The first phase of the project was completed in March 1987 with the submission of the draft National Water Plan (NWP). NWP estimated that for irrigation purpose upto 1985, there were 19,800 DTWs, 156,000 STWs, and 285,000 manually operated shallow tubewells for irrigation (MOSTI) throughout the country (MPO, 1987). The rapid increase in exploitation of groundwater occurred in response to a shift in Government policies to emphasize private trade and investment in irrigation equipment.

Availability of Groundwater: Recharge Estimates

The difficulties in estimating recharge with a reasonable accuracy justifies the need to develop a more complex model with proper understanding of the geological processes. In this regard, the prime objectives of the MPO studies (MPO, 1987, 1991) were to provide a national assessment of

the volume of groundwater available for development, its impact on other uses, physical constraints to development, safe yields of groundwater to different modes of wells, and quantification of existing groundwater use to determine the future resource available for development under National Water Plan (1985-2005). For these studies, a complex integrated water balance type multi-cell, multi-layer model was selected.



The groundwater system of the country schematized in the model comprises four layers - a main aquifer, a semi-confining layer, a root zone and a surface storage over the top of the ground surface (MPO, 1987). There are significant regional variations in much of the alluvial aquifer system which underlies most of the plains of Bangladesh. Comparison of characteristics of the main aquifers of the country are presented in the Table.

Characteristics of Main Aquifers for Different Regions (MPO, 1991)

Regions	Thickness, m		Transmissivity, m^2/d			Specific Yield (%)	
	Max.	Min.	Max.	Min.	Typical	Min.	Max.
Northwest	0	>60	1000	4500	3000	<2	>15
Northeast	20	>60	500	4500	1000	<2	15
Southeast	10	60	500	1000	650	<2	15
Southcentral	0	60	500	2500	650	<2	5
Southwest	10	60	500	2500	650	<2	5

The recharge model used in Phase-I (MPO, 1987) was subsequently used in Phase-II study (MPO, 1991) with an updated database. In these studies, usable recharge has been defied as 75 percent of potential recharge, the remaining 25 percent being placed in reserve to account for uncertainty in the estimate, unplanned groundwater development, cropping pattern changes and reduction of flooded area. For estimating available recharge, the usable recharge is reduced further due to geographic and physical constraints on groundwater use for agriculture (salinity, peat, soil, terrain, etc.), water needs for existing surface water projects, and losses of recharge as outflow to rivers and evapotranspiration is shown the Table. It is important to note that while potential as well as usable recharge estimates were increased by around 8,500 Mm^3 and 6,380 Mm^3, respectively by the Phase-

II of the NWP, the available recharge estimates came down by about 3,320 Mm^3. The decrease relates to adjustments for regional physiographic constraints to abstraction, mostly in the country's north-east region. The higher deep percolation rate used in Phase-II under the resource potential model was responsible for showing potential recharge higher in this study compared to the Phase-I study.

Potential Recharge, Usable Recharge, and Available Recharge of Groundwater for Different Regions (MPO, 1987, 1991)

Regions	Gross Area Mha	Potential Recharge, Mm^3		Usable Recharge, Mm^3		Area Mha	Available Recharge Mm^3	
		Ph-I	Ph-II	Ph-I	Ph-II		Ph-I	Ph-II
Northwest	3,016	17,850	16,100	13,390	12,100	2,919	9,480	9,790
Northeast	3,569	23,750	30,800	17,810	23,100	2,213	9,620	6,600
Southeast	3,007	11,950	13,000	8,970	9,800	364	1,540	1,500
Southcentral	1,426	4,800	4,700	3,610	3,500	503	1,800	1,250
Southwest	2,562	5,250	7,500	3,940	5,600	1,181	1,980	1,960
Total:	13.580	63,600	72,100	47,720	54,100	7,180	24,420	21,100

In the MPO studies, the resource potential model computes the volume of groundwater that can be withdrawn from the aquifer based on drawdown induced abstraction limits associated with various pumping technologies. Limiting pumping lifts in the resource potential model were assumed to be 7 m for STWs, 9 m for DSSTWs, and 20 m for DTWs under low capacity (DTW1, 28 litre/s) as well as high capacity (DTW2, 57 litre/s). Under these technological constraints, the volumes of usable recharge to each pumping type are summarized in the Table. In much of the north-east, south-east, and south-central regions, development by the force-mode technology will be required to attain maximum levels of groundwater abstractions. The force-mode development potential using DTW1 (28 litres/s) is substantially higher than that using DTW2 (57 litres/s). This is probably due to the fact that higher capacity pumps are not able to run under full capacity in a low permeability area (e.g., in Sylhet) because of slower movement of water in the water bearing strata. On the other hand, using lower capacity pumps have an opportunity to abstract more volume of water by increasing its number of installations and operating for an extended period of time. However in reality, the possibility to popularize this equipment is diminishing mostly due to its high cost involvement at the individual farmer level.

Usable Recharge to Well Technologies for Different Regions (MPO, 1987, 1991)

Regions	Maximum Usable Recharge to Technologies, Mm^3							
	STW		DSSTW		DTW1		DTW2	
	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II
Northwest	5,200	7,700	8,300	9,900	N/A	11,900	9,480	11,700
Northeast	2,300	2,900	4,860	5,000	N/A	14,500	9,620	10,500
Southeast	450	600	800	1,200	N/A	4,700	1,540	3,100
Southcentral	660	600	1,900	1,000	N/A	2,500	1,800	2,000
Southwest	1,430	2,000	1,900	3,200	N/A	4,900	1,980	4,200
Total:	10,040	13,800	16,950	20,300	N/A	38,500	24,420	31,500

Potable Water Use

Groundwater, available in adequate quantity in most areas of Bangladesh, does not usually contain any disease producing microorganisms. As a result, rural water supply in Bangladesh has developed mainly based on hand tubewells. Urban water supply is also heavily dependent on groundwater. For piped urban water supply system, mechanized production wells are most widely used, and likely to provide the most cost-effective source. In 19 district towns, however, surface water treatment plants have been constructed. But in short term, it is not seen to be cost effective compared to groundwater. Provision of potable water and improved sanitation are basic elements of primary health care and are essential preconditions for a healthy environment. Municipal, rural domestic, and industrial water demands were assigned highest priority claim to water resources by MPO (1991) in its planning procedures. The guiding principles were: (i) water sufficient to meet projected requirement of this sector at the end of the planning period (year 2010) is to be reserved in each planning area before allocation of water are made for other uses; (ii) water table depletion to a maximum limit of 15 m below the village mound was analyzed as an alternative in determining the groundwater availability for various developments. During National Water Plan (NWP), the domestic water requirement was estimated with projections upto the year 2010 and the estimates are given in the Table.

Domestic Water Demands (Mm^3/month)

Zone	Year 1995		Year 2000		Year 2005		Year 2010	
	SW	GW	SW	GW	SW	GW	SW	GW
NW	-	37.75	-	50.34	-	72.95	-	99.18
NE	10.54	62.72	28.51	83.08	28.51	121.75	28.51	202.21
SW	2.90	33.10	2.90	46.97	2.90	71.45	2.90	102.71
SE	0.08	25.17	0.08	35.05	0.08	52.38	0.08	75.22
SC	.01	15.18	0.01	20.43	0.01	30.32	0.01	42.42
Total:	13.53	173.92	31.50	235.87	31.50	348.85	31.50	521.74

Note: SW = Surface Water, GW = Groundwater

Basically the procedure involved estimating populations and the fractions of those served by different types of water services at selected time intervals and then applying estimates of per capita water use by type of water services for the same intervals to obtain water withdrawals. Water consumption, which is less than water withdrawal, was projected in order to determine the net effects of these water demands on the availability of water for other uses. A significant fraction of water withdrawn is returned to the water source and may be reused. In fact, the only water truly consumed is that which evaporates or is incorporated in some product. MPO (1991) has assumed that 40 percent of water withdrawn for municipal uses is consumed through evaporation or incorporated into products. Expected level of services by tubewells for projected populations in rural areas upto the year 2005 are given in the Table.

Population Covered by Technology Under Rural Water Supply Programme

Year	Population Figures in 1000						
	Rural Population	HTW	Deep HTW	Deep-Set & Ringwells	Research & Develop-ment	Total Coverage	% of Rural Population Covered
1990	92,000	38,288	6,321	6,863	500	51,972	56
1995	99,600	34,000	7,700	18,000	1,500	61,200	61
2000	105,000	29,000	8,900	30,000	25,000	70,400	67
2005	105,800	29,000	10,000	50,000	3,000	92,000	87

The requirements of commissioned wells of each type assuming the current objective of one well per 75 people and 80 percent of wells operating are given in the Table.

Required Number of Commissioned Wells Under Rural Water Supply Programme

Year	Shallow HTW	Deep HTW	Deep-Set & Ringwells	Research & Development Wells	Total Units
1990	638,130	105,350	114,380	8,330	866,190
1995	567,000	128,000	300,000	25,000	1,020,000
2000	483,000	148,000	500,000	42,000	1,173,000
2005	483,000	167,000	833,000	50,000	1,533,000

Groundwater Available for Development

According to MPO (1987, 1991) future groundwater development potential is the difference between the available recharge and the present agricultural groundwater use plus the reserve for potable and industrial water supplies. The Table summarizes the regional values of available recharge and future agricultural use of groundwater by STWs and DTWs and the balance beyond years 2005 and 2010. From the Table, it appears that there is considerable scope for future development in the north-west region using DSSTWs and DTWs. However in the north-east, south-east, south-central, and south-west regions there appears to be little scope for future development using STWs and DSSTWs. Maximum developments in these regions will occur using DTW technology.

Resource Potential of Future Development for Different Regions (MPO, 1987, 1991)

Resource Potential (Mm)	REGIONS											
	NW		NE		SE		SC		SW		Total	
	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II
Usable Recharge	13,390	12,100	17,810	23,100	8,970	9,800	3 610	3,500	3,940	5,600	47,720	54,100
Maximum Usable Recharge to Technology	9,480	11,700	9,620	10,500	1,540	3,100	1,800	2,000	1,980	4,200	24,420	31,500
Available Recharge	9,480	9,790	9,620	6,600	1,540	1,500	1,800	1,250	1,980	1,960	24,420	21,100
Domestic & Industrial Reserves	160	550	310	1,280	180	640	80	260	130	470	860	3,200
Present Agriculture Uses	2,130	3,890	1,800	2,830	290	630	90	170	550	1,290	4,870	8,810
Surplus to Agriculture	1,080	1,030	70	0	0	0	460	0	80	0	1,690	1,030
Future Development Potential	6,110	4,320	7,440	2,850	1,070	630	1,170	980	1,220	680	17,000	9,460

Resource Potential (Mm)	REGIONS											
	NW		NE		SE		SC		SW		Total	
	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II
Future Agriculture Use upto 2005 & 2010												
DSSTW	3,790	2,160	400	0	200	0	290	0	1,070	270	5,750	2,430
DTW	1,150	1,570	5,210	2,760	350	370	310	970	50	400	7,070	6,070
Total	4,940	3,730	5,610	2,760	550	370	600	970	1,120	670	12,820	8,500
Balance Beyond 2005 & 2010	1,170	590	1,830	90	520	260	570	10	100	10	4,180	950

According to well type for groundwater development planning, MPO (1987) has divided Bangladesh into a number of zones. There are areas where it is possible to fully utilize available recharge with STW and DSSTW. Installing wells with grater lifting capability is unnecessary and uneconomic. DTW, if installed in a STW zone, could withdraw more than the available recharge and cause suction pumps to run dry. Areas suitable for different modes of pumping technologies are shown in Figure-2. Full development of the resource potential available to suction mode well technologies in the areas shown (Figure-2) risks that pumps will periodically run dry at full development because of large annual variability of rainfall distribution.

GROUNDWATER IN WATER SUPPLY AND SANITATION

In the last decade, Bangladesh has achieved commendable success in the provision of water supply as well as in the sanitation sector. Although reported estimates on water supply and sanitation coverage vary, over 85 percent of rural and about half the urban population have access to safe water. Progress in the urban and rural sanitation coverage during this period is also significant. As noted earlier, rural water supply in Bangladesh has developed mainly based on hand tubewells and urban water supply is also heavily dependent on groundwater.

Water Supply

The activities in the water supply and sanitation sector can be broadly classified into (i) Rural Water Supply and Sanitation and (ii) Urban water supply and sanitation. The entire rural water supply is based on groundwater. The rural water supply programme of the Government comprises of installation of tubewells, iron removal plants (IRPs), very shallow shrouded tubewells (VSST) and pond sand filters (PSF) (for coastal saline areas). According to a 1994 estimate (Wan, 1994), there were an estimated 2.4 million tubewells in rural Bangladesh, of which about 900,000 were public tubewells. Public tubewells account for about one third of total but serve about half the population. The shallow water table areas of the country are relatively well covered by tubewells (LGRD 1994). The installation of deep-set component (DSSTW) is expanding rapidly, particularly in response to the lowering of groundwater table, with a yearly target of 10,000 to 15,000 Tara handpumps. The deep-set component of the government's programme has already become larger than the shallow tubewell component.

Groundwater is the preferred water source in all urban centres except Chittagong where 20 of 34 IMGD (Imperial Million Gallons per Day) is produced through the Mohra surface water treatment plant. Of the 150 IMGD water produced in Dhaka, about 9^% is from a network of 220 deep wells linked in a grid to minimize costs of transmission and pumping, while the remainder is from a Chandnighat surface water treatment plant. Only 19 district towns partially depend on surface water. Large industries and institutions in major cities and towns operate their own deep tubewells. In urban slum areas, the main source of water is handpump tubewells. Although about 64 percent of the tubewells are privately owned, about 91 percent of the urban slum population depends on public tubewells (UNICEF, 1993). In Urban fringes areas as well, handpump tubewells are principal source of water. In fringe areas, about 70 percent of tubewells are privately owned, while about 83 percent of population depends on public tubewells (UNICEF, 1993).

Technological Issues/Constraints

A variety of technologies have been developed to serve different hydrogeological conditions as well as to keep costs low. The primary tubewell/pump technologies in rural areas include shallow tubewells (STW), deep-set handpump such as Tara, and deep tubewell (DTW). In saline areas, technologies used include very shallow shrouded tubewells (VSST) and pond sand filters (PSF). Shallow tubewells are easily sunk and use the well-known No.6 handpump. Virtually all wells in urban slums and fringe areas are of this type. In rural areas 87% of public wells and 94% of private wells are shallow tubewells (Mitra, 1992). They are relatively inexpensive to install and maintain, but can only lift water from about 7 metres below ground.

For water table eight metres or more below ground level, deep-set handpumps are needed. Deep-set Tara handpumps, which were locally produced and fielded in the mid 1980s, have similar service capacity as shallow tubewells. Heavy withdrawal of groundwater and consequent groundwater lowering is rendering many suction handpumps inoperable, particularly during the dry period. As a result use of the Tara handpumps are rapidly expanding. About 90,000 Tara handpumps are currently in operation in Bangladesh and as estimated 1.2 million suction handpumps would require to be replaced by direct action Tara handpumps by the year 2000.

Deep tubewells (DTWs) are expensive and take much longer to construct than shallow tubewells. In 1991 these served 12% of the total rural population (Mitra, 1992). The size of the user group is larger for DTWs based on the high costs of the well as well as bottlenecks in installation capacity, not on greater production capacity of the well.

Very shallow shrouded tubewells (VSST) are appropriate for pockets of fresh water in the saline belt and are very inexpensive. However, drilling failures are common. The other alternative for saline areas is a Pond Sand Filter (PSF) which uses a handpump to deliver pond water into a small sand filter unit in which the water quality is significantly improved. Although survey shows high level of acceptance for this system, there are problems with operation and maintenance, pollution and improper use (WHO-DPHE-UNICEF, 1991).

Social Issues/Constraints

Despite the overall gains in water supply coverage, disparities remain within urban areas and within and between regions. The coverage in low-water table areas and saline areas is much lower than the national average and the poor and disadvantaged social groups are less well served. Service provision, particularly in the urban areas, has been inadequate with absolute number of people without services in urban areas increasing due to rapid growth of the urban population. Although more than two third of the total investment in water supply and sanitation over the period 1981-90 was in the urban areas, slum dwellers and squatters have relatively low level of access to safe water supply and sanitation (LGRD, 1994).

Despite improvements in water supply and sanitation, there has been no significant improvements in the general health of the population. Improved access to water has not resulted in proportionate declines in water-borne diseases (LGRD, 1994). While almost 92% of all rural households drink tubewell water, use of tubewell water for all domestic purposes is only about 16%. Awareness of the linkages between use of safe water, proper disposal of excreta, practice of personal hygiene and good health is generally low. An integrated approach combining water, sanitation and hygiene education is needed for achieving overall success in this sector.

Role of Women

In Bangladesh, women play the role of the manager of family water and hygiene. The reason behind limited use of tubewell water for all domestic purposes is that the time and physical effort required to haul tubewell water into the household from across the village makes unsafe surface sources nearer the household a handy but unsafe alternative. Until the cost of time and energy in more equal to the perceived benefits of tubewell water for all purposes, unsafe surface water will continue to be used as a major source of supply. Women's desire for and use of latrines, for themselves and for young children is often based on convenience and privacy rather than perceived health benefits. Awareness and hygiene education, particularly among women, are therefore essential pre-requisites for achieving desired goal in the water supply and sanitation sector. Although women are the main users of tubewells, their participation in the users committee responsible for operation and maintenance of pumps is very low. Involvement of women must be ensured from the very beginning and their responsibility in O&M must be enhanced for successful use of tubewells. Participation of women in water projects and their utilization of water and sanitation facilities must take into account the value of women's time and the opportunity costs of participation.

Role of Private Sector and NGO

The government's water and sanitation programme has stimulated a demand to which the private sector is responding well. Private handpumps comprise about two third of rural and urban handpumps. Sanitary latrines are also mostly private, although urban areas have some public latrines. It has been found that fewer private tubewells have missing parts, indicating either better maintenance or better availability of parts in the private sector (LGRD, 1994). It has been found

that private mechanics provided repair services to 22% of public tubewells and 27% of private tubewells, compared to DPHE mechanics who serviced 10% of the public wells and 3% of the private wells (Mitra, 1992) Non-government organizations are very active in water and sanitation programmes financing and implementing in both urban and rural areas. BRAC, Proshika, and numerous other NGOs are actively involved in different rural development programmes and are having a major impact. The NGO Forum, an apex service body is the premier NGO in the WSS sector, assisting about 560 partner NGOs and CBOs by providing hardware support, advocacy, networking, institution building, training, information, research, evaluation and monitoring Since 1982 it has assisted in the installation of large number of tubewells and latrines. NGO Forum enjoys support from the DPHE and UNICEF in implementing sanitation and hygiene programmes in selected thanas The NGO Forum shares with the government a strategy of an "integrated approach" combining water, sanitation, and hygiene education. The themes of NGO Forum and its partner organization include sustainability, improvement of hygiene behaviour, and the involvement of women both in delivering services as well as in managing domestic use.

GROUNDWATER QUALITY

The high level of acceptance of groundwater as a safe source of drinking water is due to the fact that it does not usually contain any disease producing microorganisms. Until recently, high iron content and high salinity in coastal areas were the principal water quality problems of groundwater. However, in recent years presence of elevated levels of arsenic in groundwater has become a major concern in Bangladesh. Other water quality problems include contamination of groundwater by leachates from pit latrine as well as landfills. Another potential source of groundwater contamination is percolation from agricultural land where fertilizers and pesticides are used. High concentration of Boron, which is detrimental to agriculture, is also a problem in some areas.

Iron

Excess iron is associated with bad taste, discoloration of food, teeth and clothes, and stickiness of hair. However, it does not have any serious adverse health effect. It has been found that hand tubewell water in about 65% of the area of Bangladesh contains dissolved iron in excess of 2 mg/l and in many areas, the concentration of dissolved iron is around 15 mg/l (Hossain and Huda, 1996). Some 170 thanas with a population of 15 million fall in the high iron concentration category. The worst affected districts are Manikganj, Gopalganj, Narsingdi, Narayanganj, Rajshahi, Bagerhat, Sylhet, Sunamganj, Noakhali, Khulna and Kurigram (Hossain and Huda, 1997). Figure-3 (Hossain and Huda, 1997) shows areas with iron content exceeding 5 mg/l. According to a study in 1991, the hilly regions of the country were also found have high iron concentration with 77% of all tubewells discharging water exceeding drinking water standard (Mitra, 1992). In comparison to groundwater, pond water is relatively iron free and often competes with tubewell water where iron concentration is very high, and where "physical clarity" of surface water is wrongly perceived as "purity" (LGRD, 1994) It has been found that often private wells have lower iron content than the nearby public wells. The reason behind this is that local drillers often know at what depth iron content is lowest, but DPHE does not benefit from the knowledge (LGRD, 1994).

Salinity

In coastal areas and the regions north of Comilla between Brahmanbaria and Hobiganj, groundwater is generally saline. Consumer tolerance to salinity is high and it is considered a problem if chloride concentration exceed 1000 mg/l. Areas where salinity of groundwater constrains it use for irrigation and water supply are shown in Figure-4. Ponds which store rain water are the principal source of water in these areas. Where feasible, Very Shallow Shrouded

Tubewells (VSSTs) and Pond Sand Filters (PSFs) are constructed. Scattered settlement patterns in these regions is a constraint toward making adequate provision for safe water supply and sanitation.

Arsenic

Arsenic contamination of groundwater has become a major concern in recent years. Toxicological effects due to exposure to high concentration of arsenic include black-foot disease, pregnancy disorders, heart disease, cancer, diarrhoea, nausea, etc. Awareness about the presence of arsenic has been growing since late 1993 when elevated levels of arsenic were detected in the area near the boarder with West-Bengal around the Ganges-deltaic plain. Since then elevated levels of arsenic exceeding WHO drinking water standard of 0.01 mg/l and Bangladesh standard of 0.05 mg/l (GOB, 1997) have been detected in many regions of the country; most recently in the north-eastern zone of the Bangladesh (Ahmed et.al., 1997). In a recent study (Badruzzaman et.al., 1997), more than 1200 tubewell water samples from the country's north-eastern region was analyzed and about 61% of the samples were found to have arsenic concentration exceeding 0.01 mg/l and about 33% exceeding 0.05 mg/l. Arsenic was found both at shallow and high depths in this region. Figure-5 and 6 (Badruzzaman et al., 1997) show range of arsenic concentration in tubewell for two districts (Kishorganj and Netrakona) of the north-east region. Statistics on arsenic affected areas and population are constantly being updated.

ARSENIC CONTAMINATION AND WATER SUPPLY

In Bangladesh, arsenic pollution of groundwater is particularly challenging since groundwater is the primary source of drinking water for the majority of population. The main challenge now is how to provide the millions of people at risk with arsenic free, bacteriologically safe, and aesthetically acceptable alternative source of drinking water. The factors to be considered in formulating strategy to face the challenge include: (i) identification of arsenic free aquifers; (ii) identification of arsenic free tubewells in the known affected areas; (iii) provision for alternative sources of water and treatment of arsenic contaminated water; (iv) Habit, culture and custom of people in relation to water supply and sanitation practices; (v) economic condition of people and their willingness to pay for water services; (vi) research and development programmes; (vii) continuous monitoring of the situation; (viii) awareness and motivation to face the challenge collectively.

Ahmed (1997) presented a strategic remedial action plan and Azad and Badruzzaman (1997) discussed the appropriate strategic responses to combat the situation arising out of arsenic contamination of groundwater. The principal features of the strategic plan/responses are as follows:

i) Establishment of guideline values for arsenic in groundwater. Suggested guidelines are: Safe water: As <10 ug/l, Marginal water: As between 10 and 50 ug/l, Unsafe water: As between 50 and 100 ug/l, and Hazardous water: As greater than 100 ug/l.

ii) Identification of population at risk by examining quality of water in tubewells, starting with those in vulnerable areas. Development of a low-cost and reliable arsenic detection field kit is essential in this regard.

iii) Provision for providing safe drinking water to affected population. This is a pre-requisite for any subsequent action. The alternative options for provision of safe drinking water supply include installation of tubewell in alternative aquifer producing water with low arsenic content, installation of community type surface water treatment plant, installation of community type arsenic removal plant attached to tubewell to produce good quality water. Since iron is prevalent in groundwater of Bangladesh, co-precipitation with iron and/or

adsorption on iron coated media should be given preference for arsenic removal. Development of domestic filters and/or package for household use should be encouraged, but use of unknown chemicals or patented processes without adequate information is totally discouraged.

iv) Identification of affected population and providing them with medical treatment.

v) Building awareness and diagnostic facilities. People should be made aware of the possible health effects of drinking arsenic contaminated water as well as unsafe water from unprotected sources. Skills of health workers in diagnosing cases of arsenic poisoning should be strengthened.

vi) Strengthening of water quality surveillance and monitoring capability.

vii) Establishment of national database on arsenic in groundwater and arsenic toxicity.

viii) Establishment of appropriate research/study programmes of different aspects of arsenic contamination problem.

ix) Establish a national reference library for evaluation of analytical techniques for arsenic determination, evaluation of performance of different arsenic treatment facilities, and evaluation of alternative sources of drinking water.

x) Build capacity of people involved in this area through appropriate training. Training programmes need to be developed for medical practitioners, public health workers, and NGO workers to diagnose and provide treatment to arsenic affected people; for engineers and hydrogeologists to predict and evaluate the magnitude of contamination and develop alternative safe water supplies.

xi) International cooperation and collaboration.

xii) Interdisciplinary and inter-organizational cooperation.

CONCLUSION AND RECOMMENDATION

Water development in Bangladesh has arrived at a phase where it has to proceed progressively from easy-to-develop single purpose water schemes to more complex interrelated projects. This implies a beginning to plan for major infrastructure projects that would utilize unused water resources of major rivers, a step which would need longer period for development. In the meantime, groundwater resources development with the best utilization of existing knowledge and technologies are of utmost importance. From the review of assessments of groundwater resources, conflicting and widely varying estimates of groundwater availability have been observed. The main reasons for these variations are differences in methodology of assessment and use of different data base. In view of the present status of the database, the MPO findings can however be taken as an indicator of the future groundwater development potential. Choice will have to be made among alternative technologies, competing and conflicting usage and allocation. As the expansion of irrigation equipment reaches its economic threshold, the present abstraction goals needs to be reviewed and revised according to realistic seasonal and regional potentials.

It is true that imposition of allowable suction limit constraint to protect potable supplies in rural areas would curtail groundwater irrigation development. The implication of the above is that from

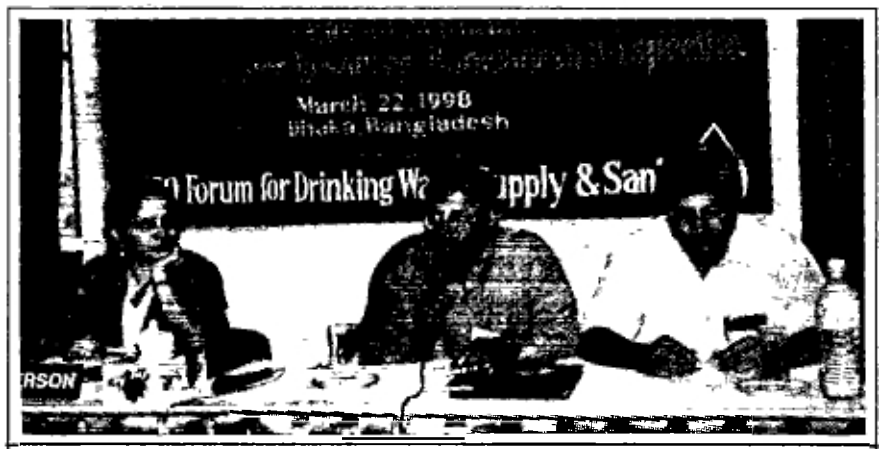
the point of view of unrestricted development of groundwater by private sector, it would be desirable for the government to invest in force-mode technology for domestic supplies. The mechanized suction-mode shallow tubewells, the main stay of irrigation development in Bangladesh are in serious setback contributed by declining water table due to increasing abstraction with other complex hydrogeological conditions. At the same time, for drinking water supply, deep-set Tara handpumps are rapidly expanding and replacing the suction handpumps. There is concern to utilize the maximum available groundwater resources at several regions leading to installation of DTWs for its demanding growth of irrigation requirements. DTWs are too expensive for individual farmers and no expansion in that technology will be observed unless cooperative investment is supported by the government just like other infrastructure development.

Over the last decades, Bangladesh has achieved commendable success in the provision of drinking water supply and sanitation. However, improvements in this sector did not result in a proportionate improvement in the general health and well being of population. An "integrated approach" combining water, sanitation, and hygiene education is essential for achieving greater success in this sector. Proper understanding of social issues/constraints, role of women and the community in question are vital for proper planning in this sector. In this regard, coordinated effort of private sector and NGOs along with government organizations is essential.

Panel Discussion

Discussants : 1. Dr. Mujibur Rahman, Professor, BUET
2. Mr. Haroon-Ur-Rashid, Sector Planner, World Bank, Dhaka

It was discussed in-depth the critical issues pertaining to groundwater utilization and tried to appreciate nature of problem obtained in Bangladesh against the backdrop of unplanned and excessive withdrawal of groundwater with its consequential impact. It is revealed from the panel discussion, groundwater resource has immense potential for utilization for different uses and has already achieved laudable success in water supply sector. Various issues like commendable gains in the sector, role of government, NGOs and the donors, integration of private sectoral role, community peoples' participation, technological alternatives and options, top down approaches has elaborately discussed. Prominent were also the topics like over extraction of groundwater, water table declining, arsenic contamination of groundwater, pollution of groundwater and problem of recharging the aquifers.



Panel discussants speak on the key-note paper presentation

It has come out from the discussion that indiscriminate and over extraction of groundwater pushing water table to go down to such a low level in the most parts of the country that acute shortage of groundwater might be eminent during the prolonged summer due to problem in recharging the aquifer. Panel members expressed their concern on the issues and termed the current groundwater scenario as **Emergency Situation**. Elaborating the situation, both the panel discussants were of opinion that withdrawal of groundwater more than actual recharge level was transforming many shallow-water table area of the country into low-table areas. As a result of this they said at least half of the country's shallow tubewell run the risk of being rendered redundant during prolonged summer further deteriorating the water crisis. Moreover, they questioned, the wiseness of random use of groundwater thought that it needed to be reviewed and re-examined in the light of the increasing threat of arsenic and other toxic contamination in the groundwater. The whole spectrum of societal as well as economic aspects of the issue should not escape our attention in groundwater utilization and allocation among competing users in the country they opined. Their is no denying the fact that a country blessed with plenty of both surface and groundwater there has been apparent conflict and contradiction of using both water sources, they said. The panel members thought that both the sources might play complementary and supplementary role but heavy dependence on groundwater might cause disaster. Panel participants unanimously suggested that surface water treatment, no doubt expensive in comparison with that of groundwater but some innovative low-cost technology could have been experimented and initiated.

From the Floor

The open discussion was lively and interesting with active participation of the participants from the floor. Sharp, technical and relevant questions raised and queries sought from the participants on the key-note paper presentation and panel discussions were answered and explained by the paper presenters and panel discussants in response.

Journalist upholds views from the floor

Mr. Ahmed Mofazzal Hoque of Department of Public Health Engineering raised the question that Bangladesh has been facing problems with groundwater as well as surface water treatment. The groundwater label is declining rapidly; on the otherhand almost every drop of the surface water is somehow polluted. So the rest markable option may be catchment of rain-water. The rain-water harvesting meanwhile has been emphasized in different parts of the country. But the question is whether there is any problem with this technology. In response to this the presenters answered that the rain-water harvesting mechanism was not a problem. But, they opined, that needed some authentic study result for the acceptance and expansion of this technology.

In relation to study on different water issues marked in the key-note paper, the participants expressed their satisfaction on those. Along with this Mr. Abdus Salam of NGO Forum articulated a question whether any study had been conducted in Bangladesh on groundwater contamination with arsenic and other poisoning. In response to this the presenters made it clear that no specific study on pollution of groundwater had not been conducted. But the groundwater quality had been taken into account with several studies. And, they added, it needed to conduct more authentic study to test the groundwater quality with special attention to the arsenic and other poisoning.

Mr. Nayeem Wahra of Disaster Forum commented that recharging rate is poor than the lifting of groundwater through pump technologies and arsenic problem in Bangladesh recently is vital issue to safe water supply through pump technologies. He mentioned that almost all the areas of the country had been affected by arsenic poisoning and people were found very reluctant and afraid of drinking tubewell water So it proves that this is the time to emerge to the right step, and that must be stopping of TW water drinking and sealing out of the TWs, and to go for other suitable and safe options. In response to this the paper presenters and panel discussants articulated that recharging depends on some factors and rain is important among those. Rain is continuously recharging the

groundwater table. But it might be that excessive withdrawal of groundwater through pump technologies is causing rapid declining of groundwater label. But this should be proved with authentic study and research that declining of groundwater label is being caused due to lifting water through pump technologies only. The presenters also opined that it was still to be proved that groundwater declining is ultimately causing the arsenic problem. Moreover, it is not proved that all the tubewells and pumps in Bangladesh are pouring arsenic contaminated water. On the otherhand only drinking of arsenic polluted water is dangerous but its usage to all other domestic purposes is not a threat to public health. So, the presenters expressed themselves, it should consider whether the tubewells should be sealed out immediately or not. The presenters also emphasized on the motivational activities which can help people testing their tubewells if those are arsenic affected or not, and can take necessary steps accordingly.

The panel discussants also concentrated on this issue. They emphasized that it wash problem that the pumps were pouring arsenic contaminated water. But it is true that all the pumps are not affected. And this is why it should not seal out all the pumps immediately. Rather we should give emphasis on the proper hygiene practices of the community people as well as they should be well known to the arsenic issues - its bad effect, symptoms, remedy, etc. They opined that arsenic obviously is a crucial problem now in Bangladesh. But we cannot decide overnight to seal out the pumps. We have to look for the optional technologies for safe water, and we can proceed for those gradually.

Participant shares opinion

Mr. Monwar Hossain from the Financial Express marked that recharging issue was not elaborately discussed in the key-note paper. He expressed himself that recharging varies place to place because of different types of soil conduction. He mentioned that the north-bengal area is very appropriate for recharging but the southern part specially in Khulna and Jessore areas' groundwater recharging is very poor and no Tara or any kind of deep pump is appropriate for getting sweet water. He requested to mention the proper cause behind this, as well as, the water use code in Bangladesh is necessary or not, Mr. Monwar wanted to know that and suggested to incorporate that issue in the Paper.

In answering to this the presenters agreed to the issue and expressed themselves that as because the soil condition is not same in different parts of the country, so the recharging rate is also different in different parts. On the other hand our population density has been increasing day by day, and this is also creating pressure on groundwater use. All these acuting the safe water crisis. And this is making us thinking of water using code. But it needs to develop a well planned integrated system to use the water using code.

Winding up

In the winding up speech the Chairperson of the Working Session of the Seminar Ms. Rasheda K. Chowdhury expressed satisfaction over the outcome of the Session, and she noted with appreciation the intellectual environment and quality of deliberation of the Seminar. She thought that all important and critical issues came up for discussion and expressed the opinion that issues like media role, community and gender participation could have been discussed more extensively. She thanked all for active participation in the deliberation and announced the winding up of the Seminar.

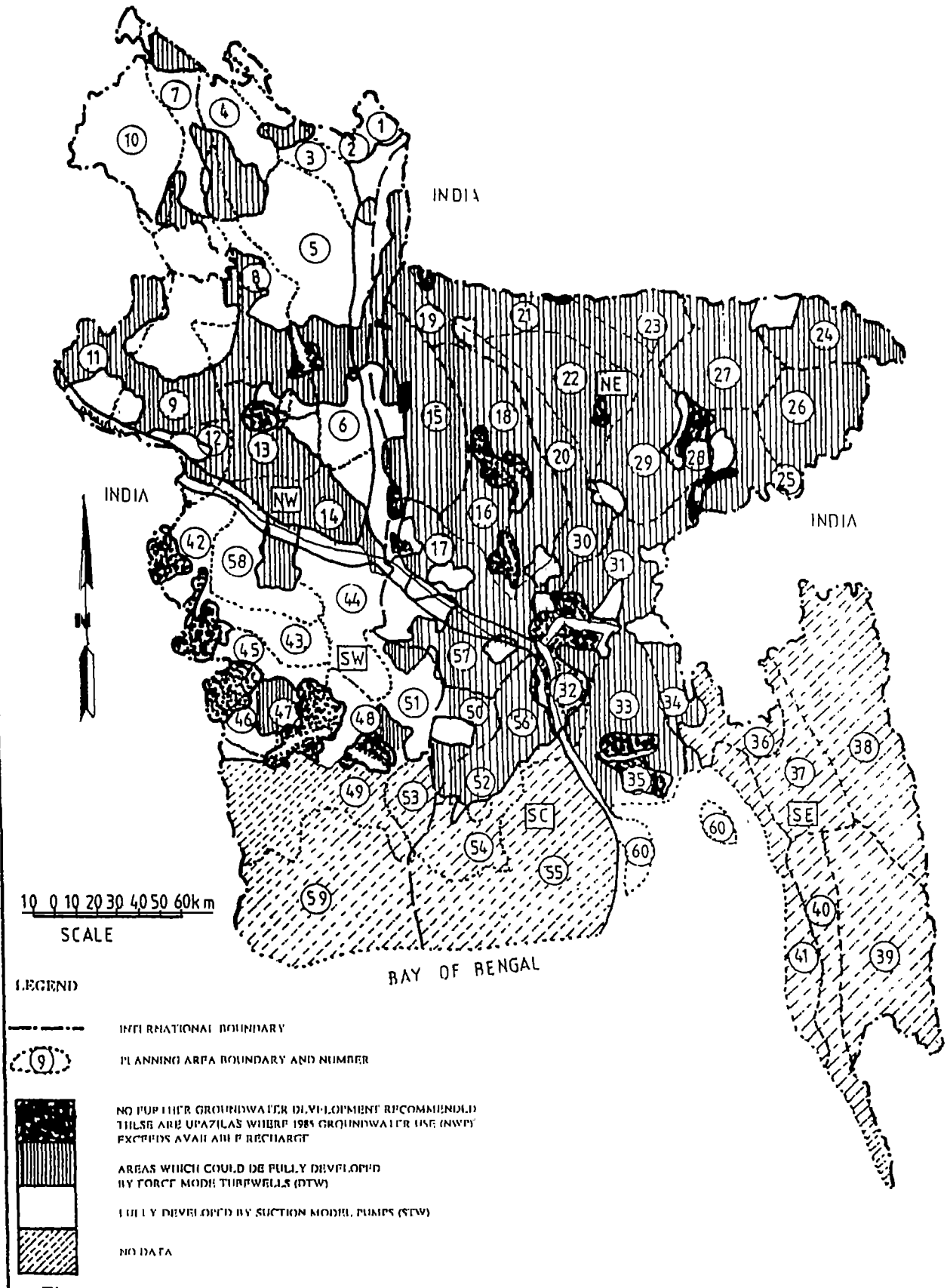


Figure 2: Areas Where Groundwater Resources Potential Could be Fully Developed by Different Technologies (Source: MPO, 1987)

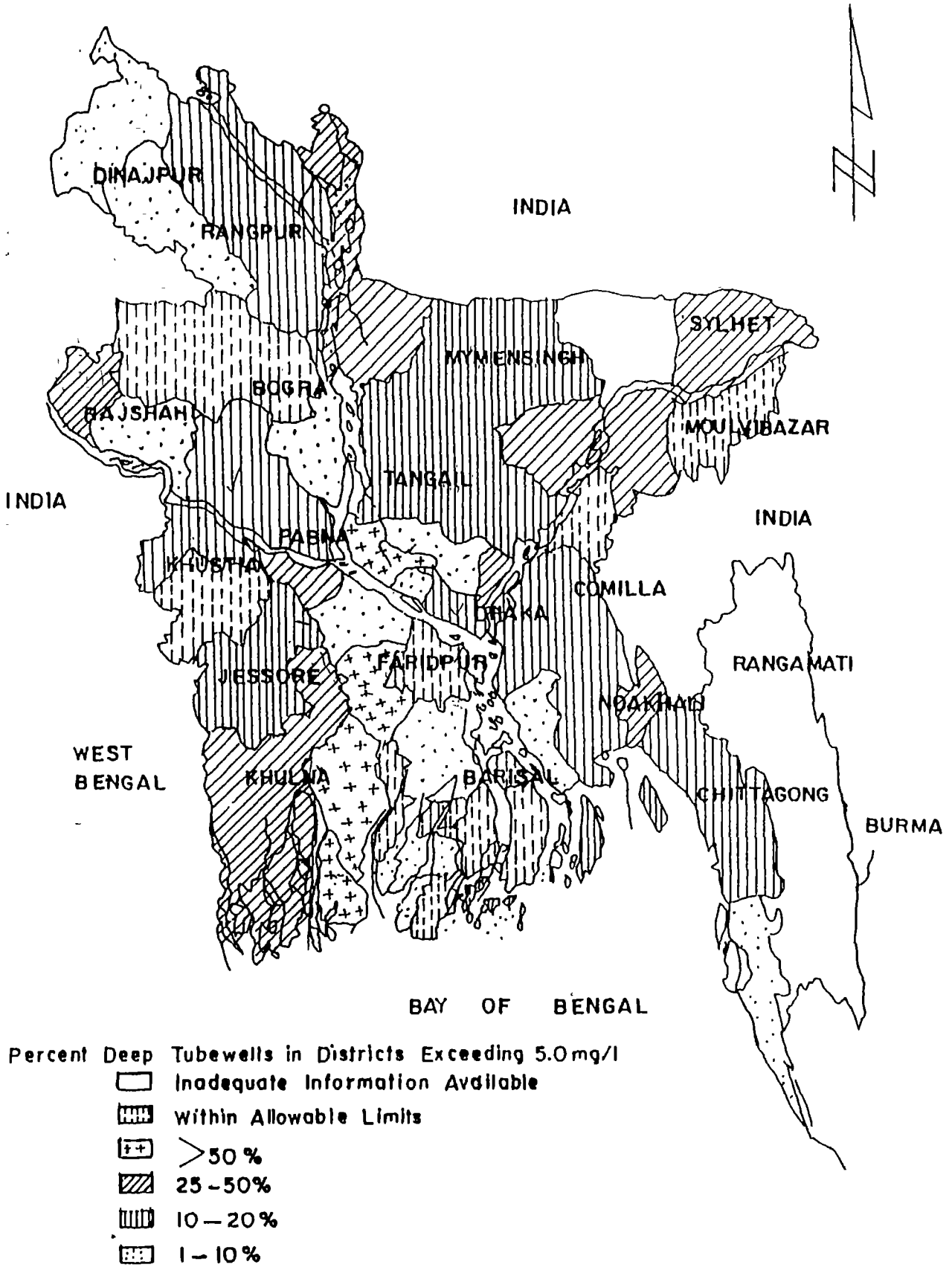


Figure 3 Iron content in deep tubewells water of Bangladesh (Iron > 5.0 mg/l)

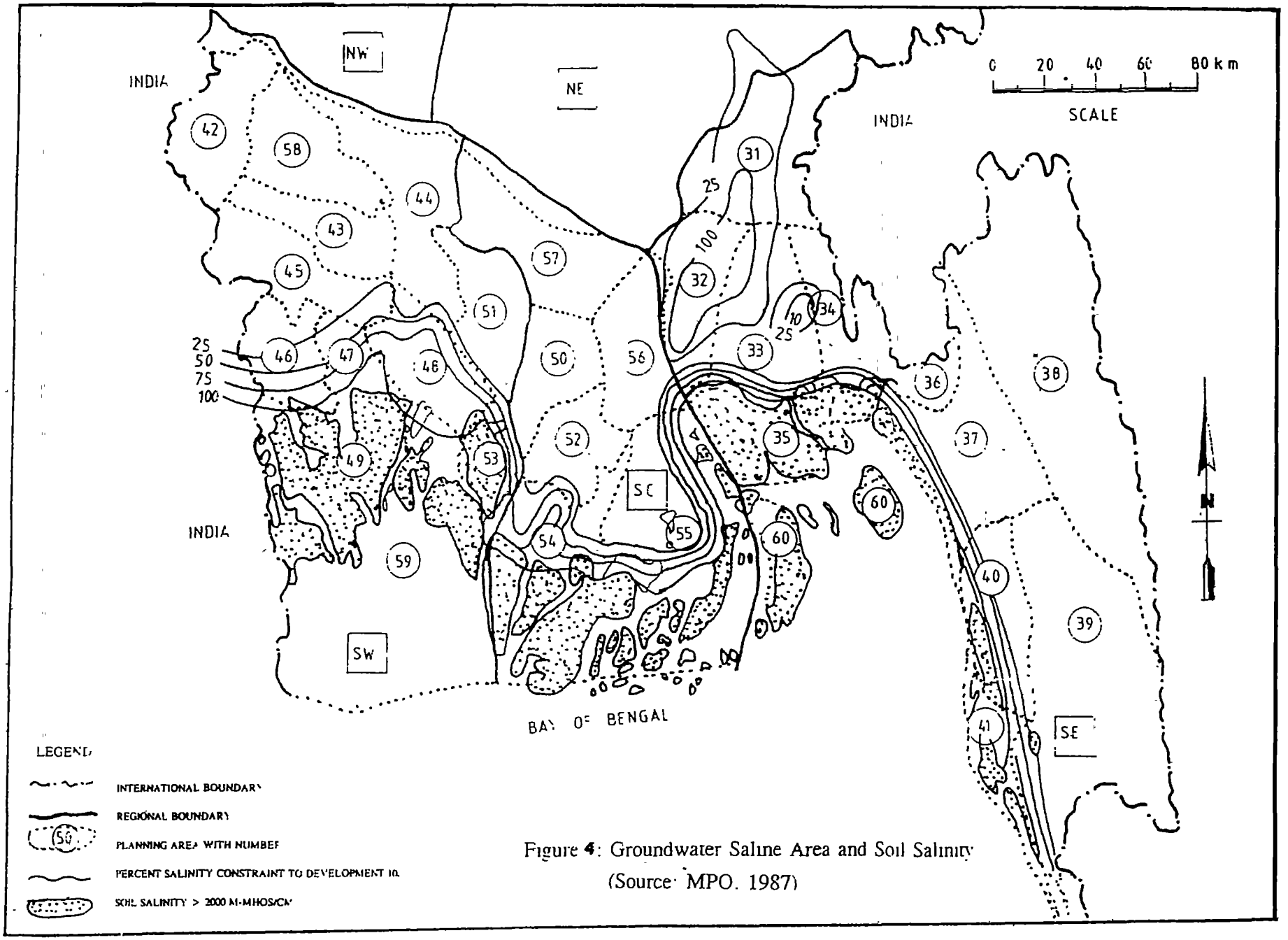
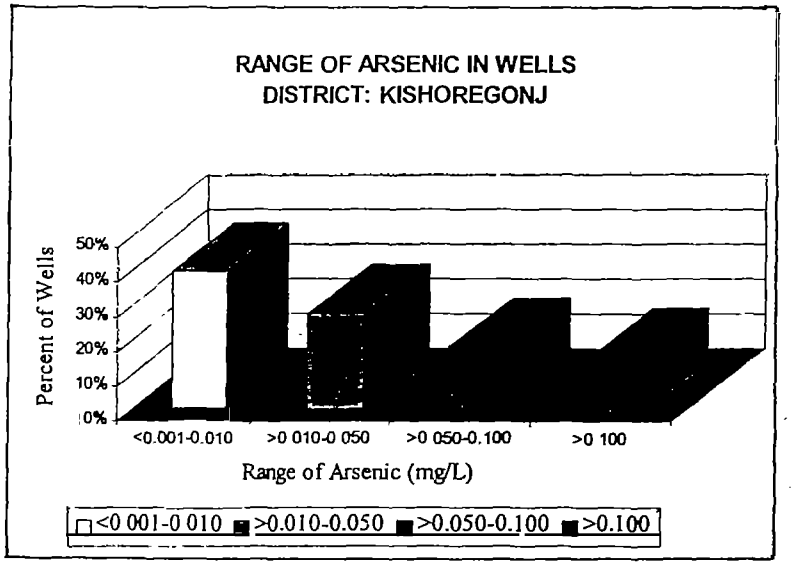


Figure 4: Groundwater Saline Area and Soil Salinity
(Source: MPO. 1987)



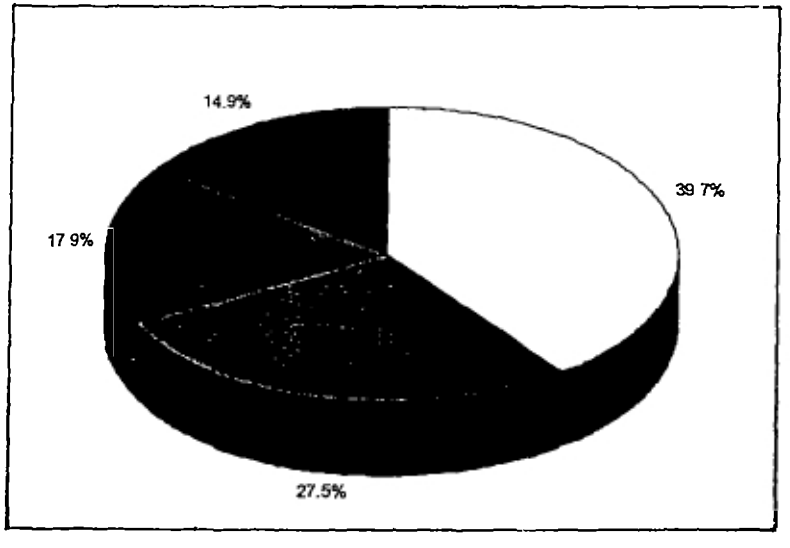
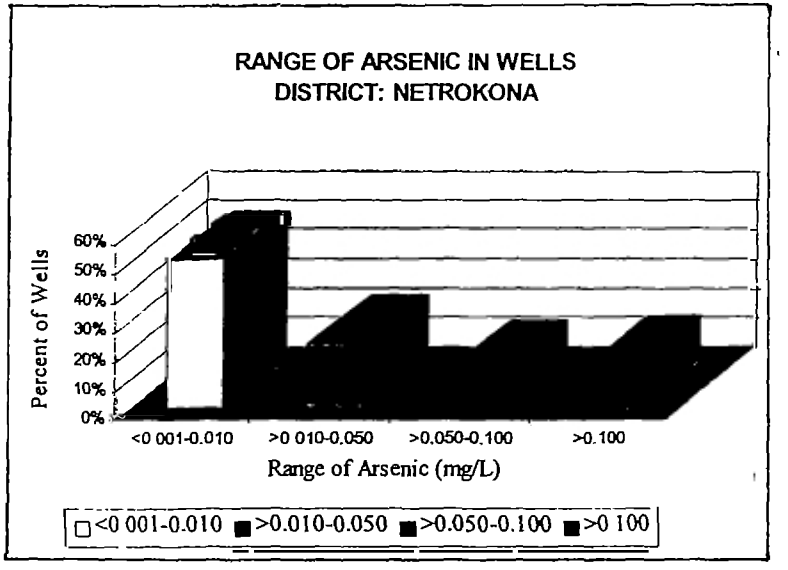


Fig. 5 Range of Arsenic in the tubewells of Kishoregonj District



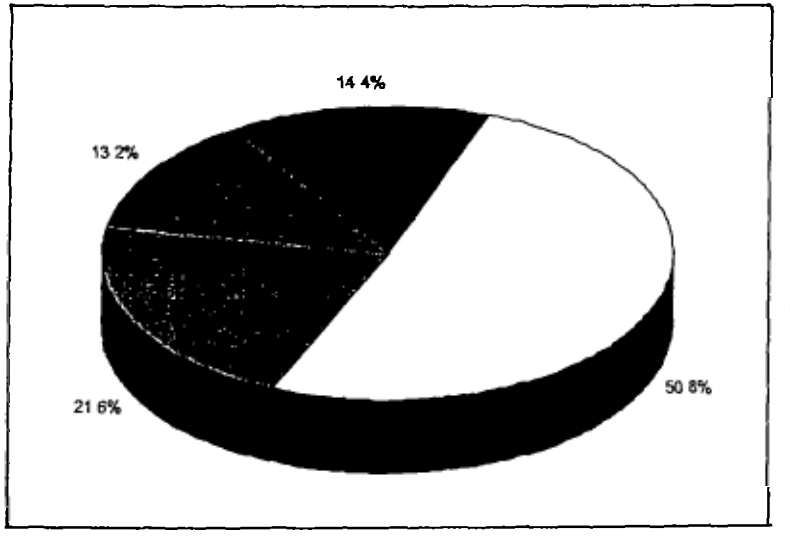


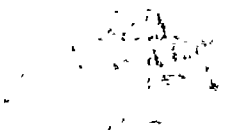
Fig. 6 Range of Arsenic in the tubewells of Netrokona District

Annexure-B

PARTICIPANTS

01. Mr. A.H.M. Abdul Hye, Secretary, Ministry of LGERD&C, Dhaka
02. Mr. A K M. Mr. Shamsul Islam, Superintending Engineer, Water Devt. Board, Dhaka
03. Dr. Fazle Hasan Abed, Executive Director, BRAC, Dhaka
04. Mr. Haroon-Ur-Rashid, Sector Planner, World Bank, Dhaka
05. Mrs. Tahrunnesa Abdullah, Vice-Chairperson, Executive Committee of NGO Forum, Dhaka
06. Mr. S.A.K.M. Shafiq, Chief Engineer, DPHE, Dhaka
07. Mr S.M.A. Rashid, Director, NGO Forum for DWSS, Dhaka
08. Mr. Abdus Salam, Field Coordinator, NGO Forum for DWSS, Dhaka
09. Mr. Deepak Bajracharya, Chief, WES Section, UNICEF, Dhaka
10. Dr M.K. Farooq, Joint Director, Department of Environment, Dhaka
11. Mr. Ruben Gomes, Welfare Director, CARITAS - Bangladesh, Dhaka
12. Mr. Qazi Mahbubul Hasan, Sr. Information Officer, NGO Forum for DWSS, Dhaka
13. Ms. Rehana Akhter, Development Communication Officer, NGO Forum for DWSS, Dhaka
14. Mr Anil Chandra Debnath, Sr. Accounts Officer, NGO Forum for DWSS, Dhaka
15. Mr. M. Ekram Kabir, Feature Writer, The Daily Star, Dhaka
16. Mr. Shaikh Abdul Halim, Executive Director, VERC, Dhaka
17. Mr. Shameem Siddiqi, Head of Programmes Development, ActionAid, Dhaka
18. Mr. Monowar Hossain, Special Reporter, Financial Experess, Dhaka
19. Mr. A.H.M. Enayetul Karim, PC, EDM, Dhaka
20. Mr. Kazi Enayet Hossain, Executive Director, Save the Coastal People
21. Mr. Peter Eppler, Country Representative, DASCOH, Dhaka
22. Mr. Joseph Halder, Associate Information Officer, NGO Forum for DWSS, Dhaka
23. Mr. Saha Dipak Kumar, Asst. Liaison Officer, NGO Forum for DWSS, Dhaka
24. Mr. Abul Kalam, Asst. Publication Officer, NGO Forum for DWSS, Dhaka
25. Mr. Waresul Hoque, Material Development Asst , NGO Forum for DWSS, Dhaka
26. Mr. Bahreen Khan, Staff Layer, BELA, Dhaka
27. Mrs. Mia Haglund Heelas, Socio-Economic Advisor, DPHE-DANIDA Project, Dhaka
28. Mr. Fariduddin Ahmed Mia, Additional Chief Engineer, DPHE, Dhaka
29. Mr. Md. Mohiuddin, Training Officer, SAFER Project, CARE-Bangladesh, Dhaka
30. Mr. Ahmed Mofazzal Hoque, Executive Engineer (VS), DPHE, Dhaka
31. Dr. Jalaluddin Ahmed, Programme Manager, BRAC, Mohakhali, Dhaka
32. Mr. Md. Zakir Hossain, Senior Principal Officer, Grameen Bank, Dhaka
33. Dr. Saleemul Haque, Executive Director, BCAS, Dhaka
34. Mr. Mozaharul Alam, Research Fellow, BCAS, Dhaka
35. Ms. Rashida K. Chowdhury, Director, CAMPE, Dhaka
36. Mr. Sohrab Hassan, Asst. Editor, Dainik Sangbad, Dhaka
37. Mr. Tausf Rahman, Staff Photographer, The Independent, Dhaka
38. Mr. Rabiul Islam, Consultant, SDC, Dhaka
39. Mr. Muhammed A. Bhuiyan, Professor, WRE, BUET, Dhaka
40. Ms. Mohsena Islam, Programme Officer, Royal Danish Embassy, Dhaka
41. Mr. Shahidul Islam, Journalist, The Independent, Dhaka
42. Mr. Gaziur Rahman, Special Correspondent, BSS, Dhaka

43. Mr. Mostofa Kamal, Diplomatic Correspondent, Dainik Sangbad, Dhaka
44. Ms Nazneen Basher Chowdhury, Associate Accounts Officer, NGO Forum for DWSS, Dhaka
45. Ms. Nafisa Islam, Librarian, NGO Forum for DWSS, Dhaka
46. Mr. K.M.A. Aziz, Research Specialist, BRAC-RED, Dhaka
47. Dr. H.K. Das, Research Specialist, BCAS, Dhaka
48. Mr Anthony D' Cruze, Programme Officer, RDRS, Dhaka
49. Mr. Md. Azahar Ali, Sr. Programme Officer, NGO Forum for DWSS, Dhaka
50. Mr Md. Enamul Hoque, Sr. Programme Officer, NGO Forum for DWSS, Dhaka
51. Mr. A.B.M. Ashraful Alam, Executive Engineer, LGED, Dhaka
52 Mr. Nazrul Islam, Programme Officer, SAP - Bangladesh, Dhaka
53. Mr. A.R.M. Kamal, Sr. Training Officer, NGO Forum for DWSS, Dhaka
54. Ms Saleha Begum, Associate Training Officer, NGO Forum for DWSS, Dhaka
55. Ms Syeda Badrun Nahar, Asst. Training Officer, NGO Forum for DWSS, Dhaka
56. Mr. Md. Sakhawat Hossain, Staff Reporter, The Bekal Barta, Dhaka
57 Mr. Iftikhar A Chowdhury, Reporter, The Financial Express
58. Mr. Muhammad Zahid Alam, Monitoring Officer, NGO Forum for DWSS, Dhaka
59. Mr. Saiful Alam Khan, Associate Monitoring Officer, NGO Forum for DWSS, Dhaka
60. Mr. Md. Ashiqul H. Tareq, Env. Researcher, BRAC, Dhaka
61. Mr. Md. Jakariya, Env. Researcher, BRAC, Dhaka
62. Mr Gawhar Nayeem Wahra, Programme Officer, Oxfam, Dhaka
63. Dr. Muzibur Rahman, Professor, ITN, BUET, Dhaka
64. Dr. M. Ashraf Ali, Asst. Professor, DCE, BUET, Dhaka
65. Mr Rafiqul Islam Khan, Consultant, ISDTP, Dhaka
66. Mr. Shakhawat Hossain, Staff Reporter, Dainik Muktakantha, Dhaka
67. Mr Arun Karmaker, Senior Reporter, Dainik Bhorer Kagaj
68. Mr. Abdul Khaleque, Sector Specialist, RDP-EHC, BRAC, Dhaka
69. Mr. S M. Bazlul Hoque, Sector Specialist, RDP-EHC, BRAC, Dhaka
70. Mr. Reaz Ahmad, Staff Correspondent, The Daily Star, Dhaka
71. Mr. Saiful Islam, Staff Reporter, ABAS - A Bangali News Agency, Dhaka



NGO FORUM
FOR DRINKING WATER SUPPLY & SANITATION
4/6, Block-E, Lalmatia, Dhaka-1207, Bangladesh
Tel: 819597, 819599 (PABX). Fax: 880-2-817924
E-mail: ngof@bangla.net, Telex: 642940 ADAB BJ